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Determination of Toxicity of various Groups of Insecticides against different Larval Stages of Lemon Butterfly, *Papilio demoleus* (Linn.)

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ABSTRACT: The relative toxicity of three groups of insecticides, synthetic pyrethroids, organochlorin and organophosphate, against the 1st, 3rd and 5th instar caterpillars of *P. demoleus* (Linn), a serious pest on citrus plants were studied. The lethal concentrations (LC50) were worked out by dry film method using Aceton AR as solvent. Synthetic pyrethroids gave much lower LC50 values as compared to Organophosphate and Organochlorine groups of insecticides. In present study Deltamethrin proved the most toxic insecticide against the all stages of tested caterpillars fallowed by other insecticides. Monocrotophos was least toxic against all stages larvae *Papilio demoleus*. The Endosufan was intermediate in toxicity against the tested insect larvae. The study of used insecticides may be promising in the population suppression of *Papilio caterpillars* infestation on citrus orchards hence an urgent and effective control measures need to introduce against this pest to secure the citrus fruits. For safe and superior quality and quantity of citrus production, an appropriate controlling strategy and proper pest management applications are recommended.

Keywords: Insecticides, pest, citrus, toxicity, *Papilio demoleus,* caterpillars, larvae. LC50.

INTRODUCTION

Citrus, the most popular cosmopolitan fruits belonging to the family Rutaceac (Shakour *et al.,* 2020). These species are not only well admired in the agro-food industry due to economic values but also in the pharmaceutical importance (Addi *et al.,* 2022). More than 120 million tons per annum of citrus fruit production is produced in the world (Karn *et al.,* 2021). Citrus fruits contribute in human diet and ornamental products, globally (Hans-jaochime, 2021). Citrus is a main source of vitamin 'C'. It is a health-promoting and antioxidant agent (Otoni *et al.,* 2017), reduced inflammation, and prevents cardio-vascular disorders (Maugeri *et al.,* 2019). It also decreased the chance of cancer diseases (Xingmiao *et al.,* 2021).

The caterpillars of lemon butterfly, *P. demoleus* (L) is a serious pest of citrus plants sp. In north hill region and in northen plane as well. It caused a significance loss to citrus plants which is an important representative amongst the group of medicinal plants. Earlier, number of insecticides like DDT, BHC, GAMA BHC, Aldrin, Dieldrin, Malathion, Parathion, Mevinphos, Monocrotophos, Diamethoate etc. have been evaluated for the control of this pest by Barar (1959), Seth (1965); Saini and Sharma (1968). Later on Radke and Kandalkar (1986); Nandihalli *et al.* (1991); Narayanamma and Savithri (2003); Hatim (2009); Lewish Denalo (2011) also successfully used various chemical insecticides against the different stages larvae of lemon butterfly. Sharma (1968) reported the use of DOT, BHC, Eldrin, Endrin, Dieldrin, Telodrin, Gama BHC, Mevinphos, Parathion, Malathion and Carbaryle to assessed in laboratory by direct spray against the 5th instar caterpillars of *Papilio demoleus* (Linn). Various insecticides of organochlorine and organophosphate groups were also tested by Atwal (1965); Anon (1962); Butani (1973) against the larvae of *Papilio demoleus* (Linn). Avery *et al.* (2021) also used the white oil and spinetoram for the management of the citrus psyllid. Several modern insecticides were also tested against the larvae of butterflies by Break *et al*. (2018). Ghafoor *et al.* (2019); Carmo-Sousa *et al.* (2020); Chakarboti and Das (2021) assessing the potentiality of different groups of insecticides to control the *Papilio caterpillar* in field and laboratory conditions.

Relative efficacy is an attribute which express the relative toxicity position of different insecticides against an injurious insect or organism. The relative position of a particular insecticide in order of toxicity may vary with different species, different physical conditions and many other factors. With regards to this variation Smith (1956) has rightly remarked that for want a standard experimental technique. It is difficult to compare and interpret the result of toxicological studies. Bagle & Prasad (1979) also stated that it is not surprising when toxicological relations are determined by different methods may show total different results. Goel and Singh (1990) were also stated that the effectiveness of insecticides may vary species to species.

A detailed review of relevant literature reveals that no concerned efforts have so far been made to determine the relative toxicity of synthetic pyrethroid, some important organochlorine and organophosphate insecticides against the different larval stages of *Papilio demoleus*. However, some efforts have been made in the past to determine the lowest effective dose of some insecticides against the caterpillar under field and laboratory conditions. The big discrepancies are probably not exceptional. Keeping in view these facts, efforts have been made to carry out the present studies under similar set of conditions.

MATERIAL AND METHODS

Eggs were collected from citrus orchards and reared in suitable petridishes in laboratory by using the incubator. Eggs hatched into the neonate caterpillars were fed on the fresh citrus leaves as food and cultured were made Ashoken (1997). One day old 1st, 3rdand 5th instar larvae of same weight and size were selected to be used for application on experimented insecticides against them. Various concentrations of tested insecticides, i.e. deltamethrin, cypermethrin, fenvalerate, quinalphos, endosulfan, monocrotophos and phosphamidon were made in the technical grade Aceton (AR).

One ml. quantity of tested insecticides of different concentrations were used to make the dry film inside the petridishes then ten (10) larvae were released over dry film for 20 minutes exposure. Each treatment was replicated three times. For control treatment the dry film was made by acetone only. The treated larvae transfered on the fresh leaves of host plant into another petridishes (Abbott (1925). After 24 hours of exposure, mortality of larvae was counted in treated and controlled petridishes. The LC50 of all used insecticides calculated statistically by Probit analysis (Finney, 1971). The insecticide Endosulfan was used as compared insecticide.

OBSERVATION AND RESULTS

Effectiveness & LC50 values of insecticidesagainst 1st instar larvae: Deltamethrine, cypermethrine and fenvalerate belongs to the groups of synthetic pyrithriods. Quinalphos, monocrotophos and phosphomidon of organophosphate insecticides and endosulfane of organochlorine, as unit insecticide have been used against the 1st instar larvae of *P. demoleus*. The dry film method was adopted to determine the LC50 values of used pesticides. Experiments were conducted, at laboratory conditions. The calculated data is given in Table 1.

The data were indicated that the LC_{50} values of pyrethroids are very low in comparative to organochlorin and organophosphate insecticides to 1st instar caterpillars. Deltamethrin was highly toxic with least LC_{50} value (0.00016227%) and phosphomidon was least effective with highest percentage of LC_{50} (0.0016917). It was observed that quinalphos (0.0002335%) and monocrotophos (0.0001187%) were also less toxic while fenvalerate & endosulfan were moderately toxic being to be 0.0000205% and 0.00001883 percent. It was recorded that 0.00000420153% cypermthrine was also more potent to the 1st instar caterpillars of *Papilio demoleus* (Linn.). The relationship between used insecticides at the level of LC50 has been assigned and calculated the relative efficacy of insecticides against 1st instar caterpillars of demoleus were placed in Table 2.

The findings were indicating that fenvalerate was 0.157 times less toxic than deltamethrin, while 0.412 times less effective than cypermethrin. But it was 11.637, 22.892 and 165.850 times as high potent as quinalphos, monocrotophos and phosphomidons, respectively. Deltamethrin was 2.625, .6.375, 74.184, 145.937 and 1057.71 times more effective the cypermethrin, fenvalerate, quinalphos and phosphamidon, while endosulfane as a compared insecticide was 1.843, 4,476, 11.750 times less effective than fenvalerate, cypermethrin, deltamethrin and 0.158, 0.080 and 0.011 times more effective as compared with quinalphos, monocotophos and phosphomidon respectively.

Effectiveness & LC50 values of insecticides against 3rd instar larvae: Of same age, weight and size, 3rd instar caterpillars of lemon butter fly were selected and treated with various insecticides by adopting the dry film and topical methods. The mortality data of different insecticides at different level of concentrations against the third stage larvae were recorded and presented in Table 3.

After the treatment of 3rd stage larvae of citrus butter fly with various insecticides, the data were proove statistically regression equation line. It was found that deltamethrin was the super toxic being 0.000027381 percent LC_{50} achieved first position in their group and followed by cypermethrin and fenvalerate having 0.00071701 & 0.00015391 percent LC_{50}, respectively. Among the tested pesticides LC_{50} values of organophosphate group's insecticides i.e. quinalphos, monocrotophos & phosphamidon) were calculated as 0.0015644, 0.0018354 & 0.0231783 percent, while endosulfane as an organochlorine pesticide shows the 0.0006148 percent LC_{50}. The mean lethal concentration of treated pesticides against 3rd instar caterpillars of *P. demoleus* (Linn.) were summarised in Table 3, above. The relationship between and relative toxicity of tested insecticides against the third instar caterpillars of *Papilio demoleus* (L), at the level of LC50 were also calculated and placed in the Table 4.

Findings were further calculated and relative efficacy of insecticides among themselves at the level of LC_{50}, carried out. The data were revealed that fenvalerate was least toxic insecticide in the group of tested synthetic pyrethroids which was 0.178 and 0.466 times less toxic than deltamethrin & cypermethrin. But deltamethrin was the best pyrethroid because it was 2,617, 5.617, 22.438,57.095, 66.985 and 845.923 times more potent than cypermethrin, fenvalerate, endosulfane, quinalphos, monocrotophos and phosphamidon. The quinalphos was superior in their group (organophosphate), it was 1.173 and 14.816 times highly effective than monocrotophos and phosphamidon, while endosulfane which was used as unit insecticide compared with pyrethroids & organophosphte groups, it exhibited 0.250, 0.117 & 0.045 times less toxic the trivalent cypermethrin and deltamethrin. But 2.545, 2.985 and 37.700 times highly more potent than quinalphos, monocrotophos and phosphamidon respectively.

Effectiveness & LC50 values of insecticides & LC50 values against 5th instar larvae: To estimate the mean lethal concentrations (LC_{50}) of insecticides against the last instar (5th) larvae of *Papilio demoleus.* The experiments were conducted in laboratory conditions. Various concentrations of different insecticides were applied on the same age, size and weighted 5th instar larvae by using dry film methods as in previous experiments. The calculated and statistically proven data of tested insecticides were depicted in Table 5.

It was resulted that 0.00068029% deltamethrin proved again superior in effectiveness while rest of the tested pyrethroids and organophosphate insecticides were lower in toxicity than deltamethrin. The LC_{50} values of cypermethrin and fenvalerate being 0.0011902 and 0.0022575 percent. Endosulfan, quinalphos, monocrotophos and phosphamidon were less potent and their estimated values were 0.010327, 0.025872, 0.3395 and 0.3648045 percent.

The relative toxicity of testified insecticides of various groups against the last instar larvae of lemon caterpillars have been assigned in the Table 6.

The observed data revealed that deltamethrin was 1.749 and 3.318 times as toxic as cypermethrin and fenvalerate. Further calculated data were indicated that the deltamethrin was 38.030, 49.904 and 536.241 times higher toxic than quinalphos, monocrotophos and phosphamidon, respective. When endosulfan, an organochlorin insecticide co-paired with other testified insecticides, it was established that quinalphos 0.399 monocrotophos 0.304 and phosphamidon was 0.028 times less effective while fenvalerate, cypermethrin and deltamethrin were 4.574, 8.677 and 15.180 times most toxic than endosulfan.

Table 1: Relative toxicity of different insecticides to First instar larvae of *Papilio demoleus* by adopting Dry Film method.

Insecticides	Heterogenity*	Regression equations	LC_{50} (%)	Fiducial limits	Relative toxicity
Deltamethrin	$X^2_{(3)}$= .77272	Y = 1.7559 + 1.4677 x	0.0000016227	+ 0.0000018511 – 0.0000014225	11.750
Cypermethrin	$X^2_{(3)}$=0.10267	Y = 1.0586 + 1.5023 x	0.0000042015	+ 0.0000051859 – 0.0000034039	4.476
Fenvalenate	$X^2_{(3)}$ =0.14080	Y = 0.9974 + 1.3350 x	0.000010205	+ 0.000011968 – 0.000087014	1.567
Endosulphan	$X^2_{(3)}$ =0.62917	Y = 2.9308 + 1. 6218 x	0.00001883	+ 0.00002163 – 0.00001645	1.00
Quinalphos	$X^2_{(3)}$ =1.99296	Y = 3.1419 + 1.7288 x	0.0001187	+ 0.0001357 – 0.0001039	0.158
Monocrotophos	$X^2_{(3)}$ =0.50759	Y = 3.0164 + 1.4495 x	0.0002335	+ 0.0002723 – 0.0002004	0.080
Phosphamidon	$X^2_{(3)}$ =0.20013	Y = 3.3184 + 1.3689 x	0.0016917	+ 0.0019515 – 0.0014665	0.011

* In none of the case the data were found to be significantly heterogeneous at P = 0.05

Table 2: Relative toxicity of used insecticides among themselves at LC_{50} level against the First instar larvae of *P. demolieus* (Linn.).

	Delta.	Cyper.	Fenv.	Endo.	Quin.	Mono.	Phospha.
Deltamethrin	**1.00**	2.625	6.375	11.750	74.187	145.937	1057.71
Cypermethrin	0.381	**1.00**	2.429	4.476	28.267	55.595	402.79
Fenvalenate	0.157	0.412	**1.00**	1.843	11.637	22.892	165.85
Endoosulfan	0.085	0.223	0.542	**1.00**	6.314	12.420	89.984
Quinalphos	0.013	0.035	0.086	0.158	**1.00**	1.967	14.252
Mononocroto	0.007	0.018	0.044	0.080	0.508	**1.00**	7.245
Phosphamidon	0.009	0.0025	0.006	0.011	0.138	0.138	**1.00**

Table 3: Relative toxicity of different insecticides to 3rd instar larvae of *P. demoleus* (Linn.).

Insecticides	Heterogenity*	Regression equation	LC_{50} (%)	Fiducial limits	Relative toxicity
Deltamethrin	$X^2_{(3)}$ = 0.23805	Y = 1.98566 + 1.2366 x	0.000027381	+ 0.000031815 – 0.000023566	22.438
Cypermethrin	$X^2_{(3)}$ = 0.01774	Y = 1.10528 + 1.3639 x	0.000071701	+ 0.000096246 – 0.000053345	8.575
Fenvalenate	$X^2_{(3)}$ = 1.47005	Y = 0.98054 + 1.2610 x	0.00015391	+ 0.00018519 – 0.00027792	3.995
Endosufan	$X^2_{(3)}$ = 0.65981	Y = 3.89770 + 1.3975 x	0.00061481	+ 0.00072461 – 0.00052165	1.00
Quinalphos	$X^2_{(3)}$ = 0.25163	Y = 3.34049 + 1.3312 x	0.0015644	+ 0.0025391 – 0.0012261	0393
Monocroto	$X^2_{(3)}$ = 0.39678	Y = 3.62087 + 1.1363 x	0.0018354	+ 0.0020891 – 0.0012802	0.335
Phosphamidon	$X^2_{(3)}$ = 1.02831	Y = 3. 21229 + 1.3095 x	0.0231783	+ 0.0275943 – 0.0194691	0.260

* In none of the case the data were found to be significantly heterogeneous at P = 0.05

Table 4: Relative toxicity of used insecticides among themselves at LC_{50} level against the Third instar larvae of *P. demolieus* (Linn.).

	Delta.	Cyper.	Fenv.	Endo.	Quin.	Mono.	Phospha.
Delta.	1.00	2.617	5.617	22.438	57.095	66.985	845.923
Cyper.	0.382	1.00	2.145	8.575	21.819	25.598	323 268
Fenv.	0.178	0.466	1.00	3.995	10.165	11.926	150.606
Endo.	0.045	0.117	0.250	1.00	2.545	2.985	37.700
Quin.	0.017	0.046	0.098	0.393	1.00	1.173	14.816
Mono.	0.015	0.039	0.084	0.335	0.853	1.00	12.628
Phospha.	0.001	0.003	0.007	0.026	0.068	0.079	1.00

Table 5: Relative toxicity of different insecticides to Fifth instar larvae of *Papilio demoleus* by adopting Dry Film method.

Insecticides	Heterogeneity*	Regression equation	LC_{50}(%)	Fiducial limits	Relative toxicity
Deltamethrin	$X^2_{(3)} = 1.09591$	Y = 2.5658 +1.3281 x	0.00068029	+ 0.00083264 – 0.00055582	15.180
Cypermethrin	$X^2_{(3)} = 0.23804$	Y = 2.3666 + 1.2687 x	0.0011902	+ 0.0014142 – 0.0097937	8.676
Fenvalenate	$X^2_{(3)} = 1.03138$	Y = 2.1168 + 1.2249 x	0.0022575	+ 0.0028223 – 0.0018057	4.57
Endosufan	$X^2_{(3)} = 1.03755$	Y = 3.6132 + 1.3637 x	0.010327	+ 0.014085 – 0.009271	1.00
Quinalphos	$X^2_{(3)} = 0.23353$	Y = 2.7382 + 1.6008 x	0.025872	+ 0.031386 – 0.021325	0.399
Monocrotophos	$X^2_{(3)} = 0.72480$	Y = 2.7415 + 1.4752 x	0.03395	+ 0.038346 – 0.030056	0.304
Phosphamidon	$X^2_{(3)} = 0.35169$	Y = 4.15649 + 1.0896 x	0.3648045	+ 0.4320195 – 0.3080471	0.028

* In none of the case the data were found to be significantly heterogeneous at P=0.05

Table 6: Relative toxicity of used insecticides among themselves at LC_{50} level against the Fifth instar larvae of *P. demolieus* (Linn.).

	Delta.	Cyper.	Fenv.	Endo.	Quin.	Mono.	Phospha.
Delta.	1.00	1.749	3.318	15.180	38.030	49.904	536.241
Cyper.	0.572	1.00	1.897	8.677	21.737	28.525	306.480
Fenv.	0.301	0.527	1.00	4.574	11.460	15.039	161.597
Endo.	0.066	0.115	0.219	1.00	2.505	3.287	35.325
Quin.	0.026	0.046	0.087	0.399	1.00	1.312	14.100
Mono.	0.020	0.035	0.066	0.304	0.762	1.00	10.745
Phospha	0.002	0.003	0.006	0.028	0.071	0.093	1.00

DISCUSSION

The study on the toxicity of synthetic pyrethroids, organochlorine and organophosphate insecticides were made with the object to exposure the possibility of the control of lemon caterpillar, *P. demoleus* (Linn.), which is a serious pest of citrus plants. During the present course of investigations the toxicity of seven (7) insecticides *viz.,* Deltamethrin, Cypermethrin, Fenvalerate (all are synthetic pyrethroids); Quinalphos, Monocrotophos, Phosphamidon (all are organophosphate) and Endosulfan which is being to the group of organochlorine insecticide have been tested against the 1st, 3rd and 5th instar larvae, by adopting the direct spray (dry film method). The efficacy of different insecticides has been compared on the basis of their LC_{50} values. The values of Endosulfan were taken as unity. The data showed that the LC_{50} values of used insecticides are significantly low against 1st instar caterpillar and these were increased with the growth of insect (3rd and 5th stage larvae).

The consolidated data is given in table, which showed the calculated LC_{50} values of Deltamethrin, Cypermethrin, Fenvalerate, Endosulfan, Quinalphos, Monocrotophos and Phosphamidon, against 1st instar caterpillars, were 0.0000016227, 0.0000420153, 0.000010205, 0.00001883. 0.0001187. 0.00023335 and 0.0016917 percent, respectively. The LC_{50} values of tested insecticides against 3rd instar larvae were higher than 1st instar which were recorded as 0.000027381, 0.000071701, 0.0001391, 0.00061481, 0.0015644, 0.0018354 and 0.0231783 percents whereas these were more higher against 5th instar caterpillars, recorded as 0.00068029, 0.0011902, 0.0022575, 0.010327, 0.02587, 0.03395 and 0.3648045 percent LC_{50} of Deltamethrin, Cypermethrin, Fenvalerate, Endosulfan, Quinalphos, Monocrotophos and Phosphamidon respectively.

On the basis of relative toxicity it was found that Deltamethrin was super toxic pyrethroid than other tested insecticides against all the stages of lemon caterpillars. Among the group of synthetic pyrethroid the Cypermethrin and Fenvalerate were the least toxic than Deltamethrin. The results were indicated that Deltamethrin, Cypermethrin and Fenvalerate were found to be more toxic than Endosulfan, being, respectively, 11.750, 4:476 and 1.567 times against 1st stage and 22.438, 2.575 and 3.995 times against 3rd stage whereas 15.180, 8.676 and 4.574 times as toxic as Endosulfan against 5th stage larvae caterpillar of *Papilo demoleus* (Linn.) Haque *et al.* (2019); Arun Kumar and Pawan Kumar (2022) evaluate new management of this pest by using some pyrethroids and found the almost similar results during his course of work.

Endosulfan was higher toxic than the tested organophosphate insecticides, among these the phosphamidon was the least and quinalphos was the higher toxic in their group. The sequence of toxicity of quinalphos, monocrotophos and phosphamidon were similar against 1st, 3rd and 5th stage caterpillar, as Quinalphos > Monocrotophos > Phosphomidon > Endosulfan was significantly high toxic than the organophosphate insecticides. Mahmood *et al.* (2016); Khan and Molla (2021); Gorinstein *et al.* (2021) also found that it was the best one insecticide which used in agricultural fields. In addition to its agricultural used in control of Tse-Tse Fly, Endosulfan is also used for the control of home garden pests (Cando NRC, 1975). After DOT was banned the use of endosulfan increased rapidly. At the present world production is in the order of more than 1000 tons per year Karn *et al.* (2021).

Thus, it is evident from the data that deltamethrin was most effective treatment followed by cypermethrin and fenvalerate. Among the three pyrethroids fenvalerate was least effective treatment reducing the citrus caterpillar populations. Endosulfan was less effective than the synthetic pyrethroids but it was higher toxic than the quinalphos, monocrotophos and phosphamidon. The insecticides of organophosphate groups are less toxic then the organochlorine and synthetic pyrethroids in respect of controlling the *Papilio demoleus* larvae. The findings evaluated the sequence of relative toxicity of tested insecticides against all tested stages as Deltamethrin > Cypermethrrin > Fenvalerate > Endosulfan > Quinalphos > Monocrotophos > Phosphamidon. There is no published informations about the LC_{50} and LD_{50} of synthetic pyrethroids and other insecticides for *P. demoleus* (Linn.) with which the present findings could be compared.

Earlier Manimegalai and Sundarajan (1995) were used the cypermethrin and fenvalerate against 4th and 5th instar of *Spodoptera litura* (Fab.). The LC_{50} were 0.004451 and 0.005384 percent whereas these were 0.00522 and 0.00636 percent for 5th instar larvae. The LC_{50} values of cypermethrin, deltamethrin and fenvalerate against 3rd stage were as 0.002787, 0.002930, 0.00559 and 0.006700 percent respectively. The pyrethroids were also used by Goel and Singh (1990) against 4th instar caterpillar of *Lymentria margenala* (Wlk.), they reported that the deltamethrin was super toxic than cypermethrin, fenvalerate and fenpropethrin, were 0.000204, 0.001149, 0.001215 and 0.00464 percent, respectively and the order of relative toxicity showed in the same faishon like present investigations, Deltamethrin > cypermethrin > fenvalerate > fenpropethrin. But according to Goel and Singh (1990) the sequence of applied pyrethroids against the Lipaphiserisimi was Deltamethrin > Fenvalerate > Cypermethrin > Fenpropethrin. Similar results were recorded by Rajvanshi *et al.* (1982) against Ades egypti. Wen *et al.* (2021); Iqbal *et al.* (2022) also made a study on comparative efficacy of synthetic insecticides against Citrus psylla, (Homoptera: Psyllideae) under laboratory and field conditions.

The synthetic pyrethroid were found to be superior to endosulfan, conformity the findings of Murugushan *et al.* (1979); Shrivastva *et al.* (1983); Nimbaker and Ajari (1981b). Deltamethrin 15.0 gm. Ac/hac is effective in reducing Boll worm damage in cotton, while Dhahig*et.al.* (1983) reported that deltamethrin was effective in reducing the Pod borer larvae in Gram is in agreement to present findings. Earlier, Barar (1959); Atwal (1965); Sethi (1965); Saini and Sharma (1968); Anon (1962); Butani (1973); Singh and Rao (1978); Singh and Kumar (1986), Muhammad *et al.* (2019); Pawan Deep and Anita (2020) tested several insecticides of organochlorine and organophosphate groups against different stages of *Papilio demleus* caterpillars and found much effective for control. Application of different insecticides by adopting the dry film method against 1st, 3rd and 5th instar caterpillars of *P. demoleus* were similar in sequence of LC_{50} values.

CONCLUSIONS

From the present study, it can be concluded that the values of LC_{50} of tested insecticides were gradually increased with growth of insect larval stage which was least at 1st instar stage and higher at last stage larvae. The relationship between insecticides of synthetic pyrethroids, organochlorine and organophosphate groups is represented as Synthetic pyrethroids > Organochlorine > Organophosphate.

FUTURE SCOPE

Present research work was aimed to investigating the relative efficacy of various groups of modern insecticides against different developmental larval stages of *Papilio infestation*. Therefore, the present study was carried out the control strategies against this pest under protected conditions, so that timely management practices have been utilized for its effective and economic control.

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Conflict of Interest. None.

REFERENCES

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *J. Eco. Ent., 18*(2), 265-267.

Addi, M. A, Elbouzi, M. Abid, D. Tungmunnithum, A. Elamrani and C. Hano (2022). *An overview of bioactive flavonoids from Citrus fruits*. *Applied Sciences, 12*(1), 1-15.

Anon (1962). Host list of insect recorded in south East Asia and Pacific region, *Citrus* sps. Technical document food and agricultural organization, Plant protection committee for the South East Asia and Pacific Region. No..22, 1-9.

Arun Kumar and Pawan Kumar (2022). Integrated approach for management of Citrus Butterfly, *P. demoleus* (Linn.). *Agriculture & Food; E- News letter,* 31-35.

Avery, P. B., E. B. Duren, J. A. Qureshi, J. R. Adair, M.M. Adair and R. D. Cave (2021). Field efficacy of *Codycep javanica.* White oil and spinetoram for the management of Asian citrus psyllid*., Diaphorina citri. Insects, 12*(9), 824.

Ashoken, R. (1997). Mass rearing and additional instar of *Papilio demoleus* L. on the acid lime, *Citrus aurentifolia* (Swingle). *Insect Environment, 2(*4), 128-129.

Atwal, A. S. (1965). Insect pests of Citrus in Punjab–Biology and Control of citrus caterpillar, *P. demoleus* (L). *Punjab. Hotr. J., 4*(1), 40-44.

Bagle & Prasad V. G. (1979). Comparative of of insecticides for the control of mango shoot borer. Pewsticides. Bombay: *24*(10) 10-11.

Barar, T. S. (1959). Bionomics and control of *Papillio demoleus* (Linn). *M.Sc. Agri. Thesis, Punjab Agri. Univ. Ludhiana.*

Break, N. N. Rebecca, K. J. Andrew, G. Melanie and J. B. Casper (2018). The effects of insecticide on butterflies. *A review. Environmental Pollution, 242,* 507-518.

Butani, D. K. (1973). Insect pest of fruit crops- *Citrus. Pesticides, 13*(14), 15 – 21.

Carmo-Sousa, M. R. B, Garica, N. A. Wuiff, A Fereres and M. P. Miranda (2020). Drench application of systematic insecticides disturb probing behavior of *Diaphorina citri* and inoculation of Candidatus Liberibacter asiaticus. *Insects, 11*(5), 314.

Chakraborti, S. A. and Das, A. (2021). Assessing the potentiality of safer ways to managed citrus leaf minor and lemon butterfly. *Journal of Entomological Research, 45*(2), 254-259.

Finney, D. J. (1971). Probit analysis. *Cambridge University Press, London*, 333pp.

Ghafoor, H. A., M. Afzal, M. Luqman and M. Z. Mazid (2019). Comparative toxicity of some selected novel chemistry insecticides against mealybug *Drosicha mangiferae* (Homiptera: Pseudococcidae) infesting citrus orchards in Pakistan. *Pakistan Journal of Agricultureal Research, 32*(2), 428-434.

Goel, S.C. and Singh, J. (1990). Susceptibility and persistant toxicity of four syntheticpyrethroides against the hairy caterpillars of mango defoliator. *Pesticides. Feb/March,* pp 17-20.

Gorinstein, S. Martin, B. O., Park, Y. S., Y. S. Haruenkit, R, Lojek, A., Ciz, M., Caps, A. Libman, I. and Trankhtenberg, S (2021). Comparison of some biochemical characteristics of different citrus fruits. *Food Chem., 74*(3), 309-315.

Hans – Jaochim, E. (2021). Taxonomic notes on the Rutaceae of Thailand. *The Forest Bulletin, Botany, 49*(1), 27-31.

Haque, R., M. A.Malique, S. M. L. Rehman, A. U., Khan and M. A. H. L. Bhuiyan (2019). Evaluation of new management approaches against lemon butterfly (*P. demoleus* L.) infesting Jara lemon in Sylhet. Bangladesh. *Bangladesh Journal of Entomology, 29*(2), 1-2.

Hatim, G. M. (2009). Effect of nimbicidin 0.03% and Agrin on the larvae of lemon butter fly. *J. Sci. Tech., 10*(2), 100-104.

Iqbal, M., A. Sahahbaz, D. G. Muhammad, A. Bilal and J. N. Muhammad (2022). Comparative efficacy of synthetic insecticides against citrus Psylla, *Diaphorina citri* kuwayama (Homoptera : Psyllideae) under laboratory and field conditions. *Plant Protection, 6*(1), 43-50.

Karn, A., C. Zhao, F. Yang, j. Cui, Z. Gao, M. Wang, F. Wang, H. Xiao and J. Zheng. (2021). In-vivo biotransformation of citrus functional components and their effects on health. *Critical Review in Food Science and Nutrition, 61*(5), 756-776.

Khan, M. M. H. and Molla, M. N. (2021). Damage potential and control of the common mormon butterfly, *Papilio polytes* Cramer on citrus*. Journal opf the Asiatic Society of Bangladesh science. 47*(1), 35-46.

Lewis and Delano, S. (2011). Efficacy of certain pesticides against citrus caterpillars, *P. demoleus.* (Linn.). *J. Eco. Entomology, 104*(6), 1986-1990.

Manimegalai, R. and Sundarajan, R. (1995). Persistant toxicity of some synthetic pyrethriods against the larvae of *Spodoptera litura* (Fab.) and their residue dissipation on cabbage crop. *Appl. Zool. Res. Assoc., 3*(2), 45-49.

Maugeri, A. A., S. A. Cirmi, P. L. B. Minciulto, S. B. Gangemi, G. C. Calapai, V. D. Mollaceand M. A. Navara (2019). Citrus fruit and inflammaging. *A Systemic review. Phytochemistry Reviews, 18*(40), 1025-1049.

Muhammad, R., Ghulam, M., Muhammad, J., Nadeem, I., Taqi, R., Abdullah, A. and Muhammad, A. (2019). Comparative efficacy of newer Insecticides against P. xylostella and S. litura on cauliflower under laboratory conditions. *Ind. J. Pure App. Bio., 7*(5), 1-7.

Nandihalli, B. S., Somsekhar, Hugar, P. and Patil, B. V. (1991). Efficacy of different insecticides against citrus butter fly *P. demoleus* (Linn.). *Madras Agric. Journal, 78* (14), 96-97.

Narayanamma, V. L. and Savithri, P. (2003). Evaluation of biopesticides against citrus butter fly, *P. demoleus* (Linn.) on sweet orange. *Indian Journal of Plant Protection*, *31*(2), 105-106.

Otoni, C. G., R. J. Avena-Bustillos, H. M. C. Azeredo, M. V. Lorivice, M. R. Moura and L. H. C. M. Mattoso (2017). Recent advance vin edible films based on the fruits and vegetables. *A review. Comprehensive review in Food Science and Food Safety, 16,* 1151 – 1169.

Pawan deep K. S. and Anita, S. (2020). Management of a *Papilio demoleus* L. using insecticides on Kinnow nursery plant at Talwandi Sabo, *Punjab. J. Pha. Phy., 9*(4), 3368-3369.

Radke, S. G. and Kandelkar, H. G. (1986). Chemical control of lemon butter fly, *Papillio demoleus* (Linn.) In Verdha. *PKV. Research. Journal, 10* (2), 157-159.

Saini, M. L. and Sharma (1968). The relative efficacy of insecticides against lemon butter fly, *P. demoleus* (Linn.). *Journal of research, 2,* 203-207.

Sethi, S. L. (1965). Insecticides for the control of citrus caterpillars, *Papilio demoleus* (Linn.). *J.Res. Punjab Agr. Univ., 2,* 205-207.

Singh, R. and Kumar, V. (1986). Efficacy of some insecticides in controlling citrus butterfly, *Papillio demoleus* (Linn.). *Research and Development Reporter, 3*(2), 85-86.

Singh, S. P., and Rao, N. S. (1978). Comparative efficacy and relative residual toxicity of some insecticicdes on citrus butterfly, caterpillars, P. demoleus L. Ento. 3(1): 51-56.

Shakour, Z. T. A., N. M. Fayek and M. A. Farag (2020). How do biocatalysis and bio transformation affects citrus dietary flavonoids chemistry and bioactivity ? *A Review . Critical Review in Biotechnology, 40*(5), 689-714.

Wen, Y., Huayue, M., Chen, Z., Fei, L. and Hanghong, X. (2021). Evaluation of flupyradifurone for the management of the Asian citrus psyllid D. citri via dripping irrigation system. *Pes. Man, Sci., 77,* 2584 – 2590.

Xingmiao, L., Z. Chengying, S. Huan, L. Yongcheng, X. Fei, D. Hengium, X. Hang and Z. Jinkai (2021). Nutrients and bioactive in citrus fruits. Different citrus varieties, Fruits parts and growth stages. *Critical review in Food Science and Nutrition.* Pp. 1-24.

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