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SHORT COMMUNICATION

COMPARATIVE EFFICACY OF SOME INSECTICIDES UNDER LABORATORY CONDITIONS AGAINST 5TH INSTAR LARVA OF SWALLOWTAIL BUTTERFLY, *Papilio demoleus* (Linn.)

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ABSTRACT

The swallowtail butterfly, *Papilio demoleus* (L.), is a serious insect-pest that causes huge losses to citrus crop. The caterpillars of *P. demoleus* are voracious feeder of citrus leaves. In order to control caterpillars, the lethal dose (LD_{50}) and relative toxicity of three groups of insecticides i.e. synthetic pyrethroids (deltamethrin, cypermethrin and fenvelerate), organochlorine (endosulfan) and organophosphate (monocrotophos, phosphomidon and quinalphos) were estimated against 5th instar larva of *P. demoleus*. The LD_{50} values were worked out by topical method using acetone as solvent. The synthetic pyrethroids gave much lower LD_{50} values as compared to the organophosphate and organo-chlorine insecticides. Deltamethrin proved most toxic insecticide against 5th instar larvae of *P. demoleus* showing the LD_{50} of deltamethrin, cypermethrin, fenvalerate, endosulfan, quinalphos, monocrotophos, and phosphamidon as 0.00753836, 0.0098852, 0.021728, 0.179888, 0.3027134, 0.997872, and 2.518973 μg g^{-1}, respectively. The relative toxicity of test insecticides against 5th instar larvae was in descending order as deltamethrin > cypermethrin > fenvalerate > endosulfan > quinalphos > monocrotophos > phosphomidon.

Keywords: Infestation, insecticides, larvae, voracious feeder, relative toxicity

INTRODUCTION

Citrus plants are grown in subtropical region all over the world. Amongst the fruit crops it worldwide stands at 2nd position (Ghose, 2007). In India citrus stand next to mango and banana in crop area, and occupies 90.3 million ha land area, thereby cover about 7% of the total area under all fruits. (Anonymous, 2020). In world, India ranks 5th in area and production of citrus (Anonymous, 2020). Citrus is an excellent source of fruit acids, minerals and alkaline salts together with fruit sugars. The citrus fruits are rich in vitamin C and also are adequate source of vitamin A and B (Adi *et al.*, 2022). Citrus fruit is a good source of antioxidant compounds (Adenaike and Onyukwo, 2021).

A number of insect-pests attack citrus plants both in nurseries and orchards, thereby inflict heavy economic losses. Pruthi and Mani (1945), Reddy *et al.* (1989) and Rama Krishna Rao (2015) have reported that citrus crops are infested by 165 insect-pests in India causing around 30% yield loss. The *Papilio* larva is a most devastating pest of citrus nursery and fruit bearing plants resulting in poor yield and low quality fruits (Mangrio *et al.*, 2020). Several citrus orchards were seriously defoliated and some reduced to mere skeleton due to the wide spread occurrence of leaf eating citrus caterpillars (Singh and Rao, 1978). *P. demoleus* attacks almost all kinds of citrus plants but prefers *Citrus limon* and *C. sinensis* (Mangrio *et al.*, 2020). The damage caused by the caterpillars seems to be severe as it multiply at very fast rate and defoliate the young plants as a result of breeding throughout the year.

A number of chemicals have been recommended for the effective control of *P. demoleus*. Several modern synthetic organic insecticides and inorganic compounds like arsenicals, fluosilicates and fluorides have also been applied for the purpose. Monocrotophos, dimethoate, sulphur malathion, endosulfan, quinalphos, carbaryl and methamedophos have successfully been used against *P. demoleus* (Siddhapaji *et al.*, 1977). Working on the comparative toxicity of various pyrethroids, Nandihali *et al.* (1991) found deltamethrin most toxic in comparison to cypermethrin, fluvalenate and other synthetic pyrethroids. Recently, a number of new generation insecticides have been evaluated against insect pests (Sahu, 2014; Jadhav *et al.*, 2017; Afzal *et al.*, 2018). Singh (1978) applied some synthetic pesticides on citrus butterflies to establish their comparative efficacy and relative residual toxicity of insecticides. Several workers evaluated the comparative toxicity of some novel pesticides against different insect pests under laboratory and field conditions (Muhammad *et al.*, 2019; Pragati and Solankey, 2021; Mangrio and Sathio, 2023). In view of the huge losses caused by *P. demoleus*, the present study was aimed to assess the efficacy and relative toxicity of some synthetic pyrethroids and a few modern insecticides against 5th instar larva of *P. demoleus* in Shamli district of Western Uttar Pradesh (India).

MATERIALS AND METHODS

The larvae of *P. demoleus* were collected from citrus fields located in Shamli district of Uttar Pradesh (India). The rearing of insects was carried out in glass jars. Fresh green citrus leaves were provided as food to the growing insects every morning. The excreta of larvae were separated with the help of fine camel hair brush. The process was continued till the caterpillars reached under pupation. The pupae were transferred in trays and kept in various rearing cages (90 cm x 90 cm) which were provided with potted citrus cultivar plants and other seasonal flowering plants. The adults emerged from pupae were allowed in pairs to lay the eggs in same cages. Female laid the eggs on fresh young twigs of citrus cultivars bearing flush of leaves that were kept daily inside the cage to replace the stack leaves of the previous day. The culture of lemon butter fly, *P. demoleus*, was maintained in laboratory by following the rearing techniques as suggested by Watanabe (1992) and Ashoken (1997).

To determine the lethal doses of tested insecticides i.e. deltamethrin (Hoechst India, Mumbai), cypermethrin, endosulfan and monocrotophos (National Organic Chemical Industries, Mumbai); fenvalerate and phosphamidon (Sandoz India, Mumbai) and quinalphos (Sudarsan Chemical Industries, Pune) against 5th instar larvae, the individuals of same size and weight were selected. Stock solutions were prepared of each tested insecticides by using formula:

$$\text{Required volume of insecticide} = \frac{\text{Required concentraion x Required volume}}{\text{EC of insecticide}}$$

Where EC is the emulsified concentration of insecticide.

Acetone (AR grade) was used to prepare various concentrations of test insecticides. With the help of micropipette, 1 µL insecticide was topically applied on the thoracic region of each larva. The treated larvae were released on fresh leaves in Petri-dishes. Each replication comprised of 10 insects and each treatment was replicated thrice. Controlled larvae were treated only with acetone before starting or changing over to next insecticides. The micro-pipette was washed with a mixture of acetone and water (50:50). The observations for mortality were taken after 24 h. The moribund larvae were counted as dead. The percentage of mortality under different treatments was calculated to work out mortality in control. The corrected percent kill was calculated by using Abbott's formula (Abbott, 1925):

$$\text{Corrected mortality } = \frac{A - B}{100 - B} \times 100$$

Where A is mortality in treatment and B is mortality in control.

The statistical analysis of data, LD_{50}, fiducial limit and regression equation were worked out as per Finney (1971) and Raghupathi and Dhamu (1986).

RESULTS AND DISCUSSION

Deltamethrin was at top position among all tested groups of insecticides with lower LD_{50} whereas endosulfan occupied intermediate position. Among pyrethroids, deltamethrin was highly toxic with 0.00743836 µg g^{-1} LD_{50} value against 5th instar larvae, followed by cypermethrine and fenvalerate having LD_{50} values of 0.0098852 and 0.021728 µg g^{-1}, respectively. The lethality (LD_{50}) of endosulfan was 0.1798882 µg g^{-1} which was better than quinalphos and monocrotophos with LD_{50} values of 0.302713 and 0.997872 µg g^{-1}, respectively. The organophosphate insecticides were not as toxic as synthetic pyrethroids and endosulfan against *P. demoleus* larvae, as they have high LD_{50} values. The quinalphos proved effective than monocrptophos and phosphamidon. It was slightly less toxic than endosulfan, while pyrethroids were highly toxic. Muhammad *et al.* (2019), Pawandeep and Anita (2020) and Sharma *et al.* (2021) reported LD_{50} of synthetic pyrethroids i.e. deltamethrin, cypermethrin and fenvalerate against 4th instar larvae of Noctuidae as 0.0475399, 0.2316726 and 0.01789697 µg g^{-1}, respectively; Further, the efficacy of synthetic pyrethroids were evaluated against Lepidopteran insect *Lymantria marginata*, and LD_{50} were reported as 0.04006, 0.17028, 0.18929 and 0.98014 µg g^{-1} for deltmethrin, cypermethrin, fenvalerate and permethrin, respectively.

The relative toxicity of synthetic pyrethriod deltamethrin was highest (24.10 µg g^{-1}), followed by cypermethrin (18.20 µg g^{-1}) and fenvelrate (8.30 µg g^{-1}) [Table 1]. The organochloride pesticides like quinalphos, monocrotophos and phosphamidon were less toxic than synthetic pyrethroid and organophosphate with relative toxicity of 0.59, 0.18 and 0.07 µg g^{-1}, respectively. The lethality of endosulfan was moderate with 14.0 µg g^{-1} against 5th instar larvae of *P. demoleus*.

The relative toxicity of test insecticides against 5th instar larvae of citrus butterfly revealed that cypermethrine was 0.75 times and fenvalerate 0.34 times less effective than deltamethrine (Table 2). A comparison with phosphamidon revealed that cypermethrine, fenvalerate and deltamethrine were 336.6, 254.8 and 115.9 times more toxic than phosphamidon, respectively. Deltamethrin proved effective treatment followed by cypermethrin and fenvalerate. Among the 3 pyrethroids, fenvalerate was least effective treatment in reducing the citrus larvae populations. Endosulfan was less effective than synthetic pyrethroids, but it proved more toxic than quinalphos, monocrotophos and phosphamidon. The insecticides of organophosphate group were less toxic than organochlorine and synthetic pyrethroids in controlling *P. demoleus* larvae. The data showed similarity with those of Jacob (1976) and Singh and Rao (1978)]and established that the mean lethal doses of deltamethrin,

Table 1: Lethal dose and relative toxicity of test insecticides to 5th instar larvae of *Papilio demoleus* (L) as per topical method

Insecticides	Heterogeneity*	Regression equation	LD_{50} (µg g^{-1})	Fiducial limits	Relative toxicity
Deltamethrin	$x^{2(3)} = 1.53667$	Y = 14.3929 x – 9.34594	0.007538	+ 0.00811422 – 0.00601437	24.10
Cypermethrin	$x^{2(3)} = 1.4987$	Y = 2.48693 x – 0.21027	0.0098852	+ 0.0091548 – 0.0097522	18.20
Fenvalerate	$x^{2(3)} = 1.40299$	Y = 2.88897 x – 1.75409	0.021728	+ 0.022975 – 0.053234	8.30
Endosulfan	$x^{2(3)} = 0.22986$	Y = 1.37512 x – 1.87109	0.179888	+ 0.2426461 – 0.13513837	1.00
Quinalpho	$x^{2(3)} = 0.85244$	Y = 1.60795 x – 0.97788	0.302713	+ 0.376533 – 0.243367	0.59
Monocrotophos	$x^{2(3)} = 1.08509$	Y = 2.40321 x – 1.53048	0.997872	+ 1.04312 – 0.98627	0.18
Phosphamidon	$x^{2(3)} = 1.73439$	Y = 3.74956 x – 6.14868	2.518973	+ 2.609941 – 2.398100	0.07

*In none of the case the data were found to be significantly heterogeneous at P = 0.05; x^2 = chi squire; Y = Probit kill; x = Log concentration).

Table 2: Relative toxicity of test insecticides at LD_{50} against 5th instar larvae of *Papilio demoleus*

Insecticides	Del	Cyp	Fen	End	Qui	Mon	Pho
Deltamethrin (Del)	1.000	1.330	2.920	24.180	40.170	134.150	336.640
Cypermethrin (Cyp)	0.750	1.000	2.760	18.200	30.620	100.950	254.820
Fenvalerate (Fen)	0.340	0.450	1.000	8.280	13.980	45.930	115.930
Endosulfan (End)	0.040	0.050	0.120	1.000	1.680	5.550	14.000
Quinalpho (Qui)	0.020	0.030	0.070	0.690	1.000	3.290	8.320
Monocrotophos (Mon)	0.007	0.010	0.020	0.180	0.300	1.000	2.520
Phosphamidon (Pho)	0.003	0.004	0.009	0.070	0.120	0.400	1.000

cypermethrin and permethrin against *Heliothis virescens* 0.044, 0.241 and 1.44 µg g^{-1} while that of fenvalerate was 0.168 µg g^{-1} against *Trichoplusia*. The larvae of *Spodoptera litura* were treated with permethrin and the mean lethal dose was reported as 1.64 µg g^{-1} (Singh, 1983). The study established the relative toxicity of test insecticides against 5th instar larvae of *P. demoleus* in descending order was deltamethrin > cypermethrin > fenvalerate > endosulfan > quinalphos > monocrototophos > phosphamidon against *P. demoleus* larvae**.**

The synthetic pyrethroid insecticides were most toxic than other tested insecticides. The rate of mortality was remarkably higher with least LD_{50} values against all stages of treated insect larvae. The organophosphate group insecticides were less toxic than synthetic pyrethroid and their evaluated LD_{50} values were higher than pyrethroids. Endosufan was intermediate in toxicity as its LD_{50} value was higher than pyrethroides but less than organophosphates. The relationship among tested groups of insecticides in descending order was observed as synthetic pyrethroid > oragnochlorine > organophosphate.

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REFERENCES

Abbott, W.S. 1925. A method of computing the effectiveness of insecticides. *Journal of Ecology and Entomology,* **18**: 260-267.

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

Adenaike, O. and Onyukwo, A. 2021. Antioxidant compounds and health benefits of citrus fruits. *European Journal of Nutritional & Food Safety,* **13***:* 27-32.

Afzal, M.B.S., Zaheer, S., Ansa, B., Muhammad, N.K., Abdul, A., Muhammad, R.S. and Shaukat, N. 2018. Efficacy of different insecticides under laboratory conditions against *D. mangiferae* collected from citrus orchards of Sargodha. Pakistan. *Journal of Entomology and Zoology Studies,* **6**(2): 2855-2858.

Anonymous 2020. *Area Production Statistics*. National Horticulture Board, Gurgaon, India. [*http://nhb.gov.in*].

Ashoken, R. 1997. Mass rearing and additional instars of *Papilio demoleus* L. *Insect Environment,* **2**(4): 128-129.

Ebeling, W. 1959. *Subtropical Fruit Pests*. Division of Agriculture Science, University of California, Berkeley, University California Press, Los Angeles, USA.

Finney, D.J. 1971. *Probit Analysis*. Cambridge University Press, Cambridge, London, UK.

Ghose, S. P. 2007. *Citrus Fruits*. Indian Council of Agricultural Research, New Delhi. India.

Jacob, M. 1976. *Insecticides of the Future.* Marcel Dekker Inc., New York, USA.

Jadhav, Y.T., Zanwar, P.R. and Shinde, D.S. 2017. Evaluation of newer pesticides against leafhopper population and it select on summer okra yield. *International Journal of Current Microbiology and Applied Sciences*, **6**(3): 2520-2526.

Mangrio, W.M., Sathio, H.A., Mal, B., Kousar, T., Sah, Z.H. and Jatoi, F.A. 2019. Food and feed consumption of lemon butterfly, *Papilio demoleus* (L) under laboratory conditions. *Pure and Applied Biology,* **9**: 340-351.

Mangrio, W.M., Sathio, H.A., Mal, B., Kousar, T., Sah, Z.H. and Jatoi, F.A. 2020. Incidence and distribution of lemon butterfly, *Papilio demoleus* (L) on five alternate citrus hosts at Sahati region, Sindh, Pakistan. *Pure and Applied Biology,* **9**(4): 2637-2647.

Mangrio, W.M. and Sathio, H.A. 2021. Morphometrics life stages of a lemon butterfly, *Papilio demoleus* (L) on *Citrus limon* (L) Osbeck. *International Journal of Bioscience*, **18**: 188-199.

Mangrio, W.M. and Sathio, H.A. 2022. Biology, weight measurement and larval time consumption of lemon butterfly, *Papilio demoleus* (L) on *Citrus limon* leaves under laboratory conditions. *Annals of the Romanian Society for Cell Biology,* **26**(1): 282-297.

Mangrio, W.M. and Sathio, H.A. 2023. Comparative toxicant efficacy of some novel insecticides against metamorphosis of *Papilio demoleus* (L) larvae. *Journal of Applied Research in Plant Sciences,* **4**(1): 425-433.

Muhammad, R., Ghulam, M., Muhammad, J., Nadeem, I., Taqi, R., Abdulla, A. and Muhammad, A. 2019. Comparative efficacy of newer insecticides against *P. xylostella* and *S. litura* on cauliflower under laboratory conditions. *International Journal of Pure Applied Bioscience,* **7**(5): 1-7.

Nandihalli, B., Somsekher, S., Hugar, P. and Patil, B.V. 1991. Efficacy of different insecticides against citrus butterfly, *Papilio demoleus* (L). *Madras Agricultural Journal,* **78**(14): 96-97.

Pawandeep, K.S. and Anita, S. 2020. Management of *Papilio demoleus* (L), using insecticides on Kinnow nurssary plants at Talwandi Sabo, Punjab. *Journal of Pharmacolognosy and Phytochemistry.* **9**(5): 3368-3369.

Pragati, N. and Solankey, H. 2021. Pesticides and Indian agriculture: *A Review. International Journal of Research. Granthalaya,* **9**(5): 250-263.

Pruthi, H. and Mani, M.S. 1945. *Our Knowledge of Insects and Mite Pests of Citrus in India and Their Control.* Imperial Council of Agric. Res. Sc. Monograph. ICAR New Delhi, India.

Rama Krishna Rao, 2015. Studies on the biology and morphometrics of citrus butterfly, *Papilio demoleus* (L) on sweet orange *Citrus sinesis* (Swingle). *International Journal of Current Research of Life Sciences*, **4**(3): 168-171.

Reddy, R.K., Savithri, P. and Rao, P. 1989. Pest complex of citrus in Rayalseema region. *The Andhra Journal*, **36**(1): 68-71.

Regupathi, A. and Dhamu, K.P. 1990. *Statistics Work Book for Insecticide Toxicology.* Surya Desktop Publishers, Coimbatore, Tamil Nadu, India.

Sahu, R., Kumar, A., Khan, H.H., Habil, D., Dhaked, N.S. and Naz, H. 2014. Efficacy of chemical insecticides against shoot and fruit borer, *Leucinodes orbonalis* (G) and economics of treated crops in Allahabad. *Journal of Pharmacognosy and Phytochemistry,* **7**(1): 31-36.

Sharma, S. 2021. *Management of Major Insect Pests of Citrus with Emphasis on Safety of Beneficial Insects.* M. Sc. Ag. Thesis. SK University of Agricultural Science and Technology, Jammu, India.

Siddapaji, C., Prabhu, H.S. and Desai, G.S. 1977. Ovicidal effect of some insecticides on the egg of citrus butterfly, *P. demoleus* L. *Mysore Journal of Agricultural Sciences,* **11**(4): 554-558.

Singh, R. and Kumar, V. 1986. Efficacy of some insecticides in controlling citrus butterfly, *Papilio demoleus* L. *Research. Developmental Reporter*, **3**(2): 85-86.

Singh, S.P. and Rao, N.S. 1978. Comparative efficacy and relative residual toxicity of some insecticides to the citrus butterfly caterpillars, *Papilio demoleus* L. *Entomology,* **3**(1): 51-56.

Watanabe, M. 1992. Egg maturation in laboratory reared females of the swallowtail butterflies, *Papilio demoleus* (Linn.), feeding on different concentrations solution of sugars. *Zoological Science*, **9**(1): 133-141.