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Toxicity of Four New Chemistry Insecticides against Spodoptera litura (Noctuidae: Lepidoptera) under Controlled Laboratory Conditions

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Cover Page Footnote

Highly thankful to concern institutes.

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TOXICITY OF FOUR NEW CHEMISTRY INSECTICIDES AGAINST *SPODOPTERA LITURA* (NOCTUIDAE: LEPIDOPTERA) UNDER CONTROLLED LABORATORY CONDITIONS

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ABSTRACT

Leaf worm, *Spodoptera litura* is one of the most destructive insect pests of several agricultural and horticultural crops all over the world including Pakistan. Insecticides have been widely used against different instar larvae of *S. litura* to minimize the pest population on various crops. New chemistry insecticides were tested to check their toxicity against *S. litura* on cabbage under laboratory conditions during 2019. Emamectin benzoate was highly toxic followed by chlorantraniliprole, flubendiamide and fipronil. LC_{50} and LC_{90} values of emamectin benzoate were 30.54, 19.73 ppm and 459.07 and 275.65ppm after 24 and 48 h, respectively. 100% mortality of larvae was recorded at all concentrations of emamectin benzoate after 72 h of treatment. The lethal concentration, 50 % (LC_{50}) values of chlorantraniliprole after 24, 48 and 72 h were 47.03, 32.49 and 17.58 ppm, respectively. Chlorantraniliprole was found to be extra lethal insecticide than flubendiamide and fipronil. Both (LC_{50} and LC_{90}) values of fipronil after 24, 48 and 72 h were 55.76, 46.26, 28.47, and 801.03, 647.27, 510.44 ppm respectively. The results concluded that emamectin benzoate has potential to be used in integrated pest management strategies to significantly reduce the pest population.

Keywords: *Spodoptera litura*, new chemistry insecticides, cabbage, leaf dip method, Pakistan.

INTRODUCTION

Genus *Spodoptera* consist of thirty species throughout the globe including Pakistan (Pogue, 2002). The most common species of *Spodoptera* are *Spodoptera exigua*, *S. frugiperda*, *S. litura*, *S. lituralis*, *S. pectin* and several others. Among them, *S. litura* is the most destructive insect pest of horticultural, agricultural and cash crops all over the world (Khan et al., 2011; Kaur, 2012; Ahmad et al., 2013) especially cotton and cabbage growing areas of Pakistan (Ahmad et al., 2007).

It is widely distributed in tropical and subtropical areas of the world (Tenywa et al., 2018). The pest can feed on more than 100 host plants due to polyphagous in nature, high reproduction and high migrating potential (Fu et al., 2015). Among host plants, cotton, cabbage and maize are the most preferable hosts of this destructive species (Yinghua et al., 2017; Ramzan et al., 2019). Both vegetative (leaves) and reproductive parts (seed, fruits) of hosts are fed by its larvae (Zhang et al., 2006; Tuan et al., 2014; Yooboon et al., 2019). The crop production can reduce 26 to 100% during high pest attack in field at favorable environmental conditions (Dhir et al., 1992).

Several management strategies like cultural, botanical, mechanical, physical, biopesticide and chemical had been adopted at large and small level to minimize the pest attack (% incidence) and protect the crops (Murtaza et al., 2019). The management methods except chemicals are ecofriendly and need more time to give pest control. The most commonly adopted strategy against insect pests is the use of chemicals (insecticides) that give quick and best control. The application of the same group of insecticides has led to development of insect resistance especially in *S. litura* (Saleem et al., 2008; Tong et al., 2013). The excessive applications of same insecticide not only have developed insect resistance but also proved harmful for biological fauna such as predators and parasitoids and even caused environmental pollution like health hazards. To avoid such harmful effects of insecticides, there is need to develop alternative control measures of insect pests. An alternative strategy is very important to manage the pest population with less harmful effect. Therefore, the current work was carried out to determine the toxicity of new chemistry insecticides against *S. litura*. These new chemistry insecticides can cause less harmful effect on environment and beneficial fauna but with maximum pest mortality.

MATERIALS AND METHODS

Study Site

The study was conducted in Insect Rearing Laboratory at Institute of Plant Protection, MNS-University of Agriculture, Multan, during 2019.

Insect Collection, Rearing and Maintenance of Mass Culture

Different larval instars of *S. litura* were collected from different unsprayed cabbage fields in Multan and brought to laboratory for rearing and further toxicological studies. The leaves were washed in flowing water and air dried for an hour before use. Collected larvae were placed into separate petri dishes with fresh, air dried and washed cabbage leaves. On daily basis old leaves were removed and fresh new leaves were given to feed. The larvae were kept separate from each other to avoid cannibalism. The pupae were collected from all petri dishes and placed into plastic containers for adult emergence. A pair of adults was released into adult rearing cage for mating and egg laying on the tissue papers hanged inside the cage. The egg batches were collected and shifted into separate petri dishes for hatching. The culture was continued till six generations and F_6 was used in toxicological study.

Insecticides, Bioassay, Concentration Preparation and Endpoint Observations

Four insecticides namely emamectin benzoate (Proclaim 019 EC, Syngenta Pakistan), chlorantraniliprole (Coragen 20SC, FMC, Pakistan), fipronil (Regent 5 % SC, Bayer Crop Science) and flubendiamide (Belt 480 SC, Bayer Crop Science) were purchased from the nearby market to perform the toxicological studies against newly hatch (12 h old) 2nd instar larvae. There were five concentrations of each insecticide (causing <100 and >0 % mortality), prepared in distilled water and each replicated ten times. Leaf dip method was used to perform the bioassays. New and fresh cabbage leaves were detached from cabbage plant with the help of a pair of scissors. Leaves were washed air dried for before using in bioassays. Ten leaves disc of equal size (approx. 6 cm) were dipped into each prepared concentration for 30 second and afterward kept at tissue paper for 1 h to dry. Treated leaf disc was placed into each glass petri-dish (6 cm diameter) with the help of forceps. One larva per glass petri-dish containing treated leaf disc was released by using camel hair brush and petri-dishes were covered with lid to avoid larvae escape. Total ten insects were tested in each treatment. Untreated leaf discs were placed in equal number of petri-dishes as control. Mortality data were recorded with specific time (after 24, 48 and 72 hours) of post treatment.

Statistical Analysis

If the larval mortality rate in the control was more than 5 % then data were amended by using Abbott's formula (Abbott, 1925). Lethal concentrations (LC_{50} and LC_{90}) of insecticides were calculated from Probit analysis using SPSS software (IBM SPSS Statistics for Windows, Version 23.0, IBM Corp, Armonk, NY, USA).

RESULTS

Toxicity of tested insecticides against second larval instars of *S. litura* after 24, 48 and 72 hours is given in Table 1. Emamectin benzoate was extremely toxic insecticide followed by chlorantraniliprole, flubendiamide and fipronil. LC_{50} values of emamectin benzoate after 24 and 48 h were 30.5(24.7-64.8) and 19.7(13.5-24.3) ppm, respectively. The LC_{90} values of emamectin benzoate after 24 and 48 h were 459.07(165.87-10248.06) and 275.65(202.45-10040.35) ppm, respectively. After 72 h of treatment, 100% mortality of larvae was recorded at all concentrations of emamectin benzoate. All tested larvae were found dead after 72 h at almost all of the concentrations of Emamectin benzoate. The LC_{50} values of chlorantraniliprole after 24, 48 and 72 h were 47.03, 32.49 and 17.58 ppm, respectively. Chlorantraniliprole was observed high lethal insecticide than flubendiamide and fipronil. The LC_{50} and LC_{90} values of fipronil after 24, 48 and 72 h were 55.76, 46.26, 28.47 and 801.03, 647.27, 510.44 ppm, respectively (Table 1).

Table 1: Toxicity of four insecticides against 2nd larval instars of *Spodoptera litura* under laboratory conditions.

Insecticides	Time(h)	LC_{50}[a] (ppm) (95% FL)	LC_{90}[b] (ppm) (95% FL[c])	df	X^{2d}	P	N
Chlorantraniliprole	24	47.03(34.67-76.43)	502.41(164.23-324504.21)	3	0.54	0.54	10
Fipronil	24	55.76(46.34-92.05)	801.03(167.88-1467.89)	3	0.42	0.67	10
Emamectin benzoate	24	30.54(24.78-64.89)	459.07(165.87-10248.06)	3	0.23	0.75	10
Flubendiamide	24	52.43(41.05-65.01)	509.00(168.35-60002.34)	3	0.32	0.87	10
Chlorantraniliprole	48	32.49(29.54-41.91)	353.32(187.37-13021.22)	3	0.55	0.61	10
Fipronil	48	46.26(40.81-52.79)	647.27(287.47-12056.33)	3	0.33	0.83	10
Emamectin benzoate	48	19.73(13.57-24.29)	275.65(202.45-10040.35)	3	0.31	0.34	10
Flubendiamide	48	41.42(34.54-52.22)	428.29(321.87-12065.78)	3	1.40	0.67	10
Chlorantraniliprole	72	17.58(11.34-29.32)	234.16(119.54-338.76)	3	0.45	0.54	10
Fipronil	72	28.47(21.56-33.38)	510.44(123.39-987.41)	3	0.56	0.43	10
Emamectin benzoate	72	-	-	-	-	-	-
Flubendiamide	72	21.35(19.63-27.37)	298.11(135.99-4011.43)	3	0.40	0.78	10

** Hour= Time, [a] LC_{50} = Lethal concentration to kill 50% population, [b] LC_{90}= Lethal concentration to kill 90 % population, [c] FL= = Fiducial limits, [d] X^2= Chi-square.*

DISCUSSION

The order of toxicity of four insecticides against 2nd instar larvae based on LC_{50} is as follows, emamectin benzoate (proclaim) 019EC > cyantraniliprole (coragen) 20 SC > flubendiamide 480 SC > fipronil (regent) 5%. The LC_{50} and LC_{90} values of tested insecticides, emamectin benzoate, flubendiamide, chlorantraniliprole and fipronil against 2nd instar larvae of *S. litura* revealed that emamectin benzoate to be the most toxic and effective insecticide. Imran et al. (2017) had tested toxicity of Emamectin benzoate not only against 2nd instars but also 1st and 3rd instars also. They revealed the similar results about toxicity of emamectin benzoate against first, second and third instar larvae of *S. litura*.

Toxicity of emamectin benzoate is more because it is a novel semi-synthetic derivative of the natural product. It has proved more toxic insecticide with least LC_{50} values against different instar larvae of *S. litura* on different crops. Satyanarayana et al. (2010) have given the relative toxicity 6.93 and 390.0 when compared to other tested insecticides such as flubendiamide. Almost similar toxicity values have presented by many others scientists (Gupta et al., 2004 and Dhawan et al., 2007; Shankarganesh et al., 2007; 2009). Maximum mortality has given by emamectin benzoate against 2nd instar larvae. Our results about toxicity of emamectin benzoate were in line with other researchers findings (Prasad et al., 2007; Firake and Rachna, 2009). There is somehow contrast with the findings of Singh et al. (1990) about toxicity of insecticides which tested against *S. litura* on sunflower and maize. The dissimilarities in results may be due to use of different crops in their experiments as used in the current study. The relative toxicity of some modern insecticides had been checked against *S. litura* on other crops like groundnut by Nukala et al. (2015). They reported the similar results that emamectin benzoate found most toxic than other standard insecticides.

The current study results of median lethal concentration (LC_{50}) are similar to previous studies performed by various researchers in various countries (Stanley et al., 2006; Karuppaiah and Chitra, 2013) while Hardke et al. (2011) reported chlorantraniliprole as most toxic insecticide which is not in line with our findings. The difference in results may be due to use of other *Spodoptera* species like *S. frugiperda* in their experiment. The differences in results may be due to residues present on pest before use in experiment or bioassay or may be due to geographical variations. The toxicity of insecticides was increased with increase in the time. The similar findings about time mortality have been reported by previous studies.

The resistance had been reported in *S. litura* against several insecticides belonging to pyrethroids, organophosphates and carbamates groups (Ahmad et al., 2007). The application of insecticides had proved harmful impact on human health, environment and biological fauna (Nawaz et al., 2014). There is need to adopt an alternative strategy like new chemistry insecticides to control insect pests on various crops. To some extent, these cannot harm the biological fauna like natural enemies (Predators and Parasitoids) of insect pests all over the world including Pakistan. These can be proved effective and less toxic to human and animal health. These can cause less hazard or pollutants in the environment (Nawaz et al., 2014). The resistant population can be minimized by the use of such insecticides in laboratory as well as field conditions. The resistant pest population can be decreased by the application of alternative insecticides and productivity of crop can also enhance with the reduction in pest population (Ahmad et al., 2009). Due to low eco-toxicological effect, the tested insecticides can prove best option in integrated pest management of *Spodoptera* species especially *S. litura* and *S. frugiperda* destructive pests of various crops in Pakistan.

CONFLICTS OF INTEREST: The authors declare no conflict of interest.

AUTHOR'S CONTRIBUTION:

MR conducted the research. AA, NKB, MAI, NH, and MRS critically reviewed the manuscript while MUA and, AA statistically analyzed the data.

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