Journal of Bioresource Management

Volume 9 | Issue 2 Article 14

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Recommended Citation

Mian, F. M., Khan, I., Ullah, N., Gondal, A. H., Ajmal, M. S., Qureshi, M. S., Ihsan, A., Raziq, M., Qazi, I., & Jabbar, A. (2022). Efficacy of Insecticides against Fall Armyworm, Spodoptera frugiperda (Lepidoptera, Noctuidae) in Maize, *Journal of Bioresource Management, 9* (2).
ISSN: 2309-3854 online
(Received: Mar 2, 2022; Accepted: Jun 17, 2022; Published: Jun 29, 2022)

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Cover Page Footnote

The authors highly acknowledge the Institute of Plant Protection, Muhammad Nawaz Shareef University of Agriculture, Multan for providing the research facilities

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EFFICACY OF INSECTICIDES AGAINST FALL ARMYWORM, *SPODOPTERA FRUGIPERDA* (LEPIDOPTERA, NOCTUIDAE) IN MAIZE

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ABSTRACT

Fall armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae) is most destructive specie of genus *Spodoptera* for several agricultural crops. In Pakistan's Sindh province, the invasive fall armyworm *Spodoptera frugiperda* was first documented causing serious maize damage in 2019. There is need to develop management strategies against this pest in the country. The current study was conducted to check the toxicity of different insecticides against FAW in maize field. The results showed among tested insecticides, deltamethrin was recorded most toxic insecticide followed by chlorantraniliprole and emamectin benzoate. At 1d days after first spray, least number of larvae were recorded with deltamethrin (0.07 larvae/plant), chlorantraniliprole (0.11d larvae/plant) and emamectin benzoate (0.13 larvae/plant). After three days application of first spray, significantly a minimum number of larvae were recorded with deltamethrin (1.11bcd larvae/plant) chlorantraniliprole (1.13d larvae/plant) and emamectin benzoate (1.17d larvae/plant). The maximum and minimum population of larvae was recorded at 1st day of first spray and 14 days of spray, respectively. The least number of larvae were recorded at 14 days of second spray. At 14 days after 2nd spray, 0.07ab, 0.10e and 0.10de larvae per plant were recorded with deltamethrin, chlorantraniliprole and emamectin benzoate, respectively.

Keywords: Fall armyworm, *spodoptera frugiperda*, toxicity, insecticides, integrated pest management.

INTRODUCTION

Agriculture is the backbone of Pakistan economy and plays an important part in the gross domestic product (GDP). Maize is the 3rd most annual cross pollinated harif cereal crop of the world while 4th high yielding cereal crop of Pakistan after wheat, cotton, and rice (Arif et al., 2012). Maize is grown well in soil with 6.5–7.5 pH range. It is rick source of nutrients such as proteins (10 %), starch (72 %), fatty acid (10 %), vitamins (3-5 %), and sugar (3 %) (Adnan and Bilal, 2020). It is also use as staple food for human being after potato, as fodder for

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animals and oil in running of industries (Kumar and Jhariya, 2013; Bari et al., 2018). Maize is grown on 1.3 million hectares in diverse ecologies ranging from 30 meters above sea level on the all provinces of Pakistan. It has been reported that Khyber Pakhtunkhwa (KPK) contributes 56 %, Punjab contributes 39 % while Sindh and Baluchistan contribute 5 % of total area (Qadir et al., 2013).

The maize production is decreasing annually due to various biotic and abiotic factors (Gondal et al., 2022; 2021a; 2021b; Kumar et al., 2021; Sohail et al., 2021). Among biotic factors insect pests (maize stem borer, maize shoot fly, cutworms and other lepidopteran) and pathogens are the serious threat in maize production all over the world (George et al., 2003) including Pakistan, China, Nepal, the Philippines, Africa, Brazil, Thailand, India, Vietnam, and Indonesia (Kim et al., 2020; Zarkani et al., 2020). Both vegetative as well as reproductive stages of maize are highly affecting with several insect pests (Khan et al., 2016). Recently, a new *Spodoptera* species, *Spodoptera frugiperda* had reported in many maize growing countries of the world, causing huge crop losses (Goergen et al., 2016; Prasanna et al., 2018; Sharanabassapa et al., 2018; Deole and Paul, 2018; Igyuve et al., 2018; Chormule et al., 2019; Nagoshi et al., 2019) even in Pakistan (Bhatti et al., 2021; Ramzan et al., 2021). This species is becoming major threat to food security in Pakistan, so there is need to develop an effective and best management strategy to control this notorious and destructive pest in the country to protect the economy of Pakistan by minimizing the crop losses. By keeping in view, the high crop losses and considering the insecticides an effective tool, the current study was conducted to control this most dangerous pest by use of insecticides. Before this study, no such study has conducted on this pest in the country (Pakistan) and this will be the baseline for further studies. The results of current study will be proved fruitful for future researchers and also at farms level.

MATERIAL AND METHODS

Study Area, Maize Variety and Insecticides

The current experiment was performed in entomology laboratory at Institute of Plant Protection (IP^2), Muhammad Nawaz Shareef University of Agriculture, Multan and field study at a farmer field located near Nang Shah, Multan Pakistan during the 2020. Hybrid seed of Pak Afgoi was purchased from seed company and sown on 15 June 2020 and 30 June 2020 for field study. All agronomic practices (cultural, physical, mechanical) were maintained during the whole study period.

Insect Colony and Laboratory Bioassay

Each stage larvae of *Spodoptera frugiperda* were collected from nearby unsprayed maize fields and brought to laboratory for rearing purposes. Three insecticides, Chlorantraniliprole (Coragen 20SC, FMC, Pakistan), Deltamethrin (2.5% EC, Jaffer Agrochemicals) and Emamectin benzoate (Proclaim 019 EC, Syngenta Pakistan) were purchased from the pesticides shop for toxicological studies against *Spodoptera frugiperda*. Randomized Block Design (RBD) was used. There were three treatments with three replications. No insecticide was applied before in the study area except during toxicological studies. The manually operated hand knapsack sprayer with hollow cone nozzle was used for spraying. Each treatment was sprayed two times during each planting date. The first

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spray was given at 15 days interval of sowing while second at 15 days interval of the first spray. Data (larval population) were recorded a day before and after 1, 5, 10 and 15 days of the sprays at three randomly selected sites of one meter row length in each treatment leaving border rows.

Data Analysis

The collected data were analyzed statistically using Duncan's Multiple Range test DMRT ($P \leq 0.05$).

RESULTS

The population of larvae was significantly reduced ($P \leq 0.05$, Duncan Multiple Range Test) with the application of insecticides in all replications. The toxicity of insecticides was increased with increase in time duration. The maximum number of larvae were recorded died after application of second spray as compared to first spray. Among tested insecticides, deltamethrin was recorded most toxic insecticide followed by chlorantraniliprole and emamectin benzoate. Three days application of first spray, significantly minimum number of larvae were recorded with deltamethrin (1.11bcd larvae/plant) chlorantraniliprole (1.13d larvae/plant) and emamectin benzoate (1.17d larvae/plant) (Table 1).

Table 1: Toxicity of insecticides against third instar larvae of *Spodoptera frugiperda* on maize under field conditions

Insecticides	Dosage (gai per l.)	1st spray					2nd spray				
		1 DAT	3 DAT	7 DAT	10 DAT	14 DAT	1 DAT	3 DAT	7 DAT	10 DAT	14 DAT
Chlorantraniliprole	37.0	1.87a	1.13d	0.23d	0.19d	0.11a	1.21c	1.11d	0.18d	0.10e	0.10e
Deltamethrin	5.0	1.43a	1.11bcd	0.19c	0.09bc	0.07a	1.18c	1.10cd	0.13bc	0.08ab	0.07ab
Emamectin benzoate	12.5	2.10a	1.17d	0.28d	0.21cd	0.13a	1.23c	1.12cd	0.19d	0.11de	0.10de
Control	-	2.98a	1.85a	2.11a	1.76a	1.61a	1.54a	1.43a	1.38a	0.54a	0.59a

At 1d days after first spray, least number of larvae were recorded with deltamethrin (0.07 larvae/plant), chlorantraniliprole (0.11d larvae/plant) and emamectin benzoate (0.13 larvae/plant). The maximum and minimum population of larvae was recorded at 1st day of first spray and 14 days of spray, respectively. The least number of larvae were recorded at 14 days of second spray. At 14 days after 2nd spray, 0.07ab, 0.10e and 0.10de larvae per plant were recorded with deltamethrin, chlorantraniliprole and emamectin benzoate, respectively. The number of larvae was found low in all treatments as compared to control ($P \leq 0.05$). At 4 days after treatment, pest population was decreased in all insecticide treatments in comparison with the control. At 7 days after the second spray, the least number of larvae per plant was recorded in deltamethrin (0.13bc larvae/plant), chlorantraniliprole (0.18d larvae/plant) and emamectin benzoate (0.19d larvae/plant).

DISCUSSION

The different insecticides were tested against larvae of this destructive and invasive alien species, fall armyworm, *S. frugiperda* in field conditions. The findings of this experiment can become the baseline data to control this emerging pest in the

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study area like Pakistan. This is the first toxicological study on this pest in Pakistan which become baseline to control the pest under laboratory as well as field conditions on different host plants especially maize crops. The current study showed that population of pest was recorded significantly lower in all treatments such as emamectin benzoate, deltamethrin and chlorantraniliprole compared with the control. The mortality percentage of pest was increased with respect to application time. Deshmukh et al. (2020) had tested chlorantraniliprole, spinetoram, emamectin benzoate, lambda-cyhalothrin and flubendiamide against larvae of *S. frugiperda* under field conditions. They had reported the similar findings about mortality of larvae with time duration. Hardke et al. (2011) found that novaluron, chlorantraniliprole and flubendiamide had given 2.5, 2.5 and 5.9 percentage mortality, respectively after 7 days of treatment. They had reported that only lambdacyhalothrin given 40% larval control. Similarly, according to Khan et al., (2017) the synthetic insecticides significantly reduce the borer infestation in pomegranate orchards.

According to Daves et al. (2009), insecticides spinosad, methoxyfenozide, carbaryl and methomyl had proved effective insecticides after 13 days of post treatment. The reduction in pest population due to applications of insecticides can enhance the crop production. Our findings are in line with Gutierrez-Moreno et al., (2019) had reported that reduction in pest population enhance the yield. They concluded that emamectin benzoate was most toxic chemical while pyrethroids least. The mortality percentage of larvae can increase if insecticides apply at early stage of pest as well as crop. The effect of insecticides can reduce at later stage of crop because larvae hide under the leaves and escape away from insecticides residues. They cannot come in contact with insecticides and can survive. Another study was conducted by Belay et al. (2012), showed 80% larval mortality after 96 hours of post treatment. In this study different insecticides such as chlorantraniliprole, indoxacarb, spinosad, fenvalerate and flubendamide were applied directly on third instar larvae. In another study, chlorfenapyr (1.2 ppm), fipronil (2.4 ppm), tebufenozide (0.95 ppm) and emamectin benzoate (0.0029 ppm) were applied in diet incorporated assay to check their effect against larvae of FAW (Argentine et al., 2002). The study showed significantly lower LC50 values of spinetoram (0.066 µg mL^{-1}) and chlorantranilprole (0.068 µg mL^{-1}) than values of flubendiamide (0.930 µg mL^{-1}) and indoxacarb (0.392 µg mL^{-1}) (Hardke et al., 2011). The method of Hardke et al., (2011) was highly different from current research bioassay method but results of chlorantraniliprole toxicity are almost similar.

The damage percentage of this pest is increasing day by day on various hosts especially maize in Pakistan but still no proper management strategy has adopted except biological studies (Ahmad et al., 2021; Ramzan et al., 2021). Farmers on their behalf using available chemicals which can become the cause of resistance against this pest. The excessive application of chemicals against this pest is not only become the cause of resistance but also pollute the environment and insecticides residues directly or indirectly can become health problems. There is need to adopt ecofriendly and alternative chemicals which can not affect the human health and environment. Further toxicological studies are needed to test against this pest.

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CONCLUSION

The best performance is attributed to the treatment using deltamethrin insecticide followed by chlorantraniliprole and emamectin benzoate, regardless the instar of the target insect and the mode of application. This study will be helpful for farmers and provide basic knowledge to future researchers.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

AUTHOR'S CONTRIBUTION

FMM, IK and AHG conceived the idea, IQ, MR and MSQ performed the experiment AHG wrote the manuscript. NU, MR and AJ reviewed the manuscript. All authors read and approved the final version.

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