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Research Article

Performance of Synthetic Pesticides against *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) under Laboratory Conditions

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Abstract: Fall armyworm (FAW), *Spodoptera frugiperda* is a native insect pest of maize crop in South America. It has become an invasive species after its introduction in Sindh, Pakistan. Considering various options for its management, this study was conducted to determine the effectiveness of different pesticides (Proclaim 0.19EC, Coragen 28SC, Match 50EC and Runner 240SC) against 3rd, 4th, and 5th instar larvae of fall armyworm. The pesticides were prepared at half and full recommended doses as per the specifications of the manufacturer. The results regarding mortality percentage were recorded after 24, 48, 72, 96, 120, 144 and 168 hrs. The results indicated that the mortality percentage of FAW in all pesticides at both doses increased with time duration and reached a maximum at 168 hrs. Similarly, all pesticides mostly killed 50 to 100% larval population of FAW after 48 to 168 hrs at half and full doses. The Proclaim shows 100% mortality percentage on half and full dose against 3rd, 4th, and 5th instar larvae, followed by Coragen and Runner. Among pesticides, Match was found least effective. Among doses, maximum mortality of FAW in all pesticides was recorded at full dose as 5th instar larvae were found most susceptible, followed by 4th and 3rd instar. Therefore, it is suggested that a proper application schedule of pesticides, especially Proclaim and Coragen, should be included in the integrated management of FAW in maize to reduce its damage.

Keywords: Maize, Pesticide, *Spodoptera frugiperda,* Synthetic.

1. INTRODUCTION

Maize (*Zea mays* L.) belongs to family Gramineae and native to central America. The crop has always been used by mankind for survival and development, providing medicinal, dietary, herbal, pharmaceutical, economic, industrial, and research benefits [1]. Maize crop is the third cereal crop after wheat and rice in Pakistan and a staple food of many countries [2]. The United States produces 43% of global maize, while China contributes 20%. In comparison, Pakistan produces about 7.5 million metric tonnes annually. Maize is gaining importance in Pakistan due to its use in food, poultry feed, and industry. Unlike the U.S., Pakistan's farming is small-scale and traditional. Therefore, testing pest control products locally is crucial to ensure effectiveness under Pakistani conditions and protect this increasingly valuable crop. [3].

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Insect pests are among the most important factors contributing to the low yields facing corn production today. The crop is attacked by 140 different types of insects with varying percentage (%) damage. Out of these insects, 12 species are serious pests of maize, causing damage from sowing to harvest and also under storage conditions [4]. In field condition, maize stem borer is one of the major insect pests causing significant losses but with recent appearance of another new species known as fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) these losses exerted speedily [5, 6].

The application of novel synthetic pesticides is a most effective control method is emergency based that could be a necessary strategy of integrated pest management to bring down invasive *S. frugiperda* in China [7]. For this reason, assessing the efficacy of chemical insecticides in contrast to *S. frugiperda* laboratory populations is a top priority [8]. Agricultural managers and farmers lack of experience with *S. frugiperda*, which is essential for the development of efficient management approaches [9]. As an emergency response to the situation, governments distributed and promoted heavy use of chemical pesticides among smallholder farmers to fight *S. frugiperda* in various countries. The improper application of chemical insecticides by untrained farmers improved concerns for health and the environment. The goal of this study was to evaluate the performance of locally available synthetic pesticides against the 3rd, 4th, and 5th instar larvae of *S. frugiperda*. Thus, the present study was conducted to determine the toxicity of synthetic pesticides against *S. frugiperda* larvae and to determine the most susceptible larval instars against synthetic pesticides.

2. MATERIALS AND METHODS

2.1. Place of Work

The Experiment was conducted at the Stored Grain Research Laboratory, Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tando Jam, Pakistan.

2.2. Insect Collection and Rearing

The larvae were collected from the maize field in the surroundings of Tando Jam and then reared on natural diet (maize) at 27±2 ºC and relative humidity of 60-70%. The different instar larvae were separated in plastic cups to avoid cannibalism. Fresh maize leaves were provided as food to FAW larvae and changed on a daily basis until pupation. The pupae were placed in plastic cages with sand to facilitate adult emergence. After emergence, adults were kept in the cages and given an artificial diet (20% honey and 80% water). The adults were then coupled in insect rearing cages for mating and oviposition, where they were provided with fresh maize leaves for egg laying. As females lay eggs in clusters in leaves, which were separated with the help of scissors and then put into petri dishes for further rearing, which was used for the experiments [10].

2.3. Experimental Set-up and Data Collection and Analysis

The experiment was laid out in a completely randomized design (CRD) with five treatments and each treatment replicated three times. The following pesticides were used in experiment (Table 1). All the pesticides were used at their recommended and half of the recommended dose to determine whether they can even be effective at the reduced dosage to get desired control of FAW larvae with minimum environmental contamination. All the calibrations for the individual insecticides were done accordingly to make 10 ml solutions using the disposable syringes, separate for each dose and insecticide. Afterwards, each dose of the respective insecticides was applied on fresh maize leaves using a disposable micro syringe (50 µL capacity). A volume of 30 µL was uniformly applied on a 4 cm^2 area of the leaf surface and allowed them to dry completely before the release of FAW larvae.

A control treatment (sprayed with water) on maize leaves was also used. Ten freshly moulted 3rd, 4th, and 5th instar *S. Frugiperda* larvae were transferred in respective treatments separately to avoid cannibalism in plastic cups. Observations on the larval mortality was recorded at 24-hours interval for seven days (168-hours). The collected data on mortality was analysed using Analysis of Variance (ANOVA), whereas the Least Square Difference (LSD) was used for mean comparison. All analyses were done using STATISTIX 8.3 computer software.

Table 1. Details of pesticides used against *Spodoptera frugiperda* larvae during the study.

Treatments	Brand name	Active ingredient	Formulation	Dose (ml/acre)	Distributer	Source of purchase
T1	Coragen 28SC	Chlorantraniliprole 28.8%	Suspension Concentrate (SC)	50	FMC Pakistan Ltd.	Agrochemical Shop, Hyderabad
T2	Proclaim 0.19EC	Emamectin Benzoate 1.9%	Emulsifiable Concentrate (EC)	100	Syngenta Pakistan Ltd.	Agrochemical Shop, Hyderabad
T3	Match 50EC	Lufenuron 5%	Emulsifiable Concentrate (EC)	100	Syngenta Pakistan Ltd.	Agrochemical Shop, Hyderabad
T4	Runner 240SC	Methoxyfenozide 24%	Suspension Concentrate (SC)	100	Bayer Pakistan (Pvt.) Ltd.	Agrochemical Shop, Hyderabad
T5	Control					

3. RESULTS

3.1. Mortality Percentage of 3rd Instar Larvae of *Spodoptera frugiperda*

The effect of different synthetic pesticides at half and full doses against 3rd instar larvae of *S. frugiperda* is shown in (Figure 1). The results showed significant difference ($P < 0.05$) in mortality percentage of *S. frugiperda* at different intervals. In half dose all the pesticides were found effective to cause *S. frugiperda* mortality immediately after their application as maximum mortality after 24 hrs was recorded in Proclaim 90%, followed by, Match 30% and, whereas the lowest mortality was observed in Coragen 10%, followed by Runner 20%. Afterwards, a gradual rise was observed in *S. frugiperda* mortality as 100% mortality was recorded in Proclaim and Coragen after 48-hrs and 120 hrs, respectively. In remaining treatments, the maximum mortality percentage (%) was recorded in Runner 80% and Match 80%, after 120-hrs and 144-hrs, respectively. The all pesticides mostly killed 80% to 100% larval population of FAW at 120, 144 hrs. At full dose, the 100% percentage mortality was recorded in Proclaim within 24 hrs, followed by Coragen with 30% whereas lowest mortality was observed in runner 10% followed by match with 20%. After that, a gradual rise was observed in *S. frugiperda* mortality as 100% mortality was recorded in Proclaim and Coragen after 24 hrs and 96 hrs, respectively. In remaining treatments, the highest mortality percentage of 80% was observed in Runner and Match after 120-hrs and 168-hrs, respectively. The all pesticides mostly killed 80% to 100% larval population of FAW at 120, 144 and 168 hrs.

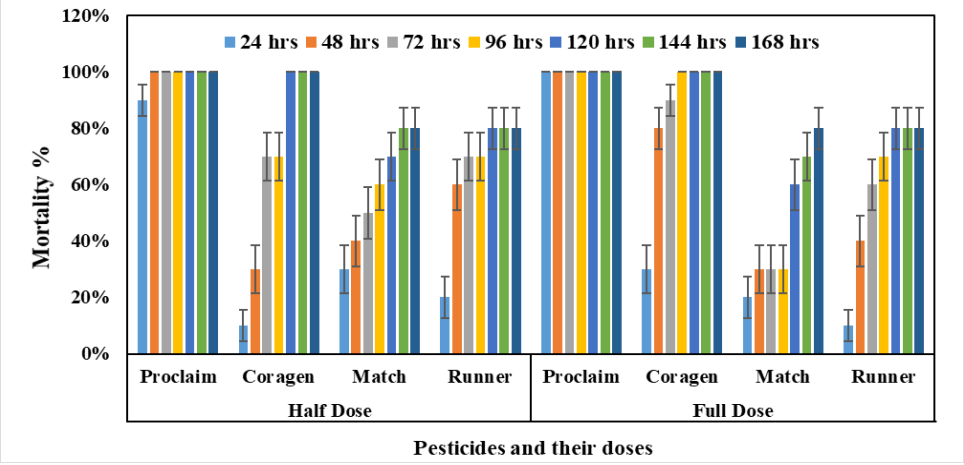

Fig. 1. Mortality of 3rd instar larvae of *Spodoptera frugiperda* on different pesticides at different intervals.

3.2. Mortality Percentage of 4th Instar Larvae of *Spodoptera frugiperda*

The effect of different synthetic pesticides against 4th larval instar of *S. frugiperda* at half and full dose is shown in (Figure 2). The results of mortality percentage were showed significant in *S. frugiperda* difference (P<0.05) at different intervals. In half dose, all the pesticides were found effective to cause *S. frugiperda* mortality immediately after their application as maximum mortality after 24 hrs was recorded in Proclaim 90%, followed by Coragen 50% and the lowest mortality was observed in Runner 10%, followed by Match 20%. Afterwards, a gradual rise was observed in *S. frugiperda* mortality as 90% and 100% mortality were recorded in Proclaim and Coragen after 48 hrs and 96 hrs, respectively. In remaining treatments, the maximum mortality percentage % was recorded in Match 70% and Runner 90%, after 96 hrs and 168 hrs, respectively. The all pesticides mostly killed 70% to 100% larval population of FAW at 72, 96, 120, 144 and 168 hrs. At full dose, the 90% percentage mortality was recorded in Proclaim within 24 hrs, followed by Coragen with 80% whereas lowest mortality was observed in runner 30% followed by match with 40%. After-that, a gradual rise was observed in *S. frugiperda* mortality as 100% mortality was recorded in Proclaim and Coragen after 48 hrs and 72 hrs, respectively. In remaining treatments, the highest mortality percentage was observed in Match 100% and Runner 90%, within 144 hrs. The all pesticides mostly killed 90% to 100% larval population of FAW at 48, 72, 96, 144, and 168 hrs.

3.3. Mortality Percentage of 5th Instar Larvae of *Spodoptera frugiperda*

The effect of different synthetic pesticides against 5th instar larvae of *S. frugiperda* at half and full dose is shown in (Figure 3). The results of mortality percentage were showed significant difference (P<0.05) in *S. frugiperda* at different intervals. In

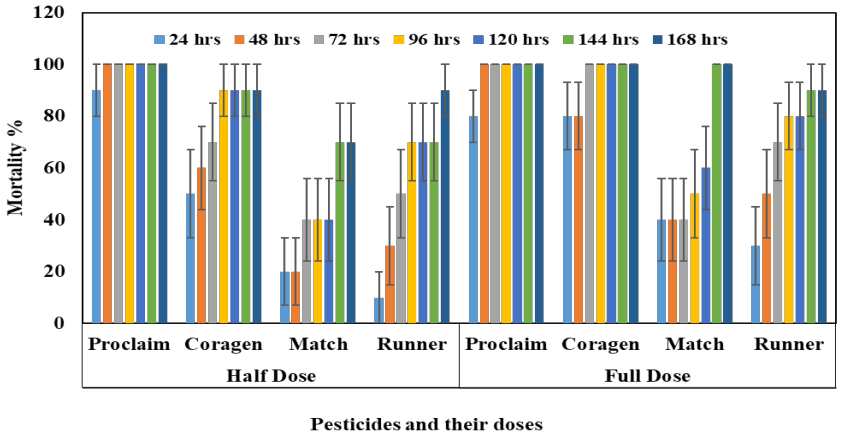

Fig. 2. Mortality of 4th instar larvae of *Spodoptera frugiperda* on different pesticides at different intervals.

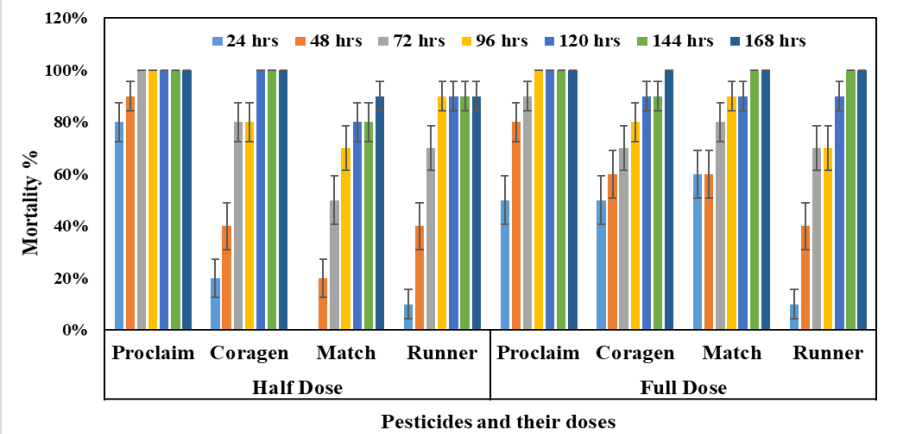

Fig. 3. Mortality of 5th instar larvae of *Spodoptera frugiperda* on different pesticides at different intervals.

half dose all the pesticides were found effective to cause *S. frugiperda* mortality immediately after their application as maximum mortality after 24 hrs was recorded. At half dose, the highest mortality 80, 90 and 100% was observed in Proclaim and the lowest was 0, 20, 50 and 70% mortality in Match at 24, 48, 72 and 96 hrs, followed by Coragen with 20, 40 and 80% and Runner with 10, 40, 70 and 90%. Similarly, after 120, 144, and 168 hrs, the maximum mortality 100% was recorded in Proclaim and Coragen, while the minimum mortality was 80% and 90% in Match and Runner, respectively. At full dose, the highest mortality of 50% was observed in Match at 24 hrs and the lowest was 10% mortality in Runner, followed by Proclaim and Coragen with 50% mortality. Similarly, all pesticides mostly killed the FAW population at 96, 144 and 168 hrs. All the pesticides were found most effective against 5th instar larvae of FAW on half and full doses at all intervals.

4. DISCUSSION

Synthetic insecticides play a vital role in the management of *S. frugiperda*, given confirmed reports of the development of insecticide resistance in FAW populations [11, 12] as well as other adverse effects due to the sole dependence on synthetic insecticides. It is imperative to use an integrated pest management strategy for FAW. The present study conducted to determine the toxicity of synthetic pesticides (Proclaim 0.19EC, Coragen 28SC, Match 50EC, and Runner 240SC) against 3rd, 4th, and 5th instar larvae of *S. frugiperda*. The all pesticides showed that high mortality percentage at half and full dose. Similarly, these results are in accordance with previous findings of Sisay *et al.* [13], as they reported that all of the tested synthetic pesticides were toxic to larvae of *S. frugiperda,* and some pesticides proved high larval mortality in the laboratory.

Those authors reported in some countries for control with synthetic pesticides, As is common with other insect pest species, synthetic pesticides are important management options for control fall armyworm in the Americas [14]. In Florida, fall armyworm is one of the major insect pests of sweetcorn, and synthetic pesticides are applied in vegetative and reproductive stages of corn to protect by fall armyworm [15] and in southern United States, synthetic pesticides are applied against fall armyworm on sweetcorn, regularly 3 to 4 times weekly. In Mexico, fall armyworm control with chemical method in maize crop is achieved by the application of chlorpyrifos, methyl parathion, phoxim, methamidophos, and along with other synthetic pesticides [16].

Although, our findings indicated that the highest larval mortality % observed in proclaim and Coragen pesticide at half and full doses at all intervals. However, Mallapur *et al.* [17] also observed 96.55% and 94.82% mortality of fall armyworm on Proclaim and Coragen at 72 hours. Similarly, Sisay *et al.* [13] also reported fall armyworm 87.5% mortality after 72 hours in Coragen pesticide. Though, our findings indicated that the maximum mortality of 100% 3rd larval instar of *S. frugiperda* was recorded in Proclaim and Coragen after 72 and 96 hours and minimum 30% was recorded in Match, followed by runner with 60% and 70%. However, the after 144 and 168 hours, the highest mortality 100% of 4th larval instar of *S. frugiperda* was observed in Proclaim and minimum mortality was 70% and 90% in Coragen, runner and Match. At half and full dose, the highest mortality 100% and 90% of 5th instar larvae of FAW was observed in Proclaim and Coragen at 168 hours. All the pesticides found most effective against 3rd, 4th, and 5th instar larvae of FAW on half and full dose at all intervals.

As the pervious findings reported by those authors to effectiveness of various pesticides against fall armyworm, the related of the present study on other lepidopteran insect pests have been studied. Kumar *et al.* [18] who observed mortality 72.82% to 91.88% of *Spodoptera litura* in proclaim. However, the mortality of *S. litura* between various dosages of proclaim ranged from 94.30% to 100% and 88.10% to 100% at 3 and 7 days [19]. Similarly, Karthik *et al.* [20] and Rabari *et al.* [21] also reported 100 and 87.49 mortality percentages of *Helicoverpa armigera* and *S. litura* in proclaim and Spinosad.

5. CONCLUSIONS

It is concluded that all pesticides were effective against 3rd, 4th and 5th instar larvae of *S. frugiperda*. The Proclaim shows that 100% mortality percentage on half and full doses against 3rd, 4th and 5th instar larvae of *S. frugiperda*, followed by Coragen and

Runner. Among pesticides, Match was found least effective. Among doses, maximum mortality of *S. frugiperda* in all pesticides was recorded at full dose as 5th instar larvae were found most susceptible, followed by 4th and 3rd instar larvae. Therefore, it is suggested that a proper application schedule of pesticides, especially Proclaim and Coragen, should be included in the integrated management of *S. frugiperda* in maize to reduce its damage. Further study is much needed to observe more synthetic pesticides against *S. frugiperda* in laboratories as well as fields.

6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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