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Laboratory evaluation of selected natural plants extracts on the mortality of the Fall Army Worm Spodoptera frugiperda (Lepidoptera: Noctuidae)

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Abstract

The Fall Army Worm Spodoptera frugiperda is an invasive destructive pest causing great losses in crops. The need for clean, safe and eco-friendly strategy for controlling this pest is the research goal. This study was designed aiming at the evaluation of selected plants extracts as a manipulation for suppressing FAW larvae under laboratory conditions. The plants extracts used in this study were: Ocmimum basilicum, Mentha piperita, Solenostemma argel Del, the botanicals extract and Ziziphus spina comparing with water as control. The parameter used for the assessment of this study was the reduction percentage of FAW larvae population. Results of this study revealed that, all the tested extracts caused mortality for treated larvae after varying days of treatment recording different reduction percentages.

Keywords:

Laboratory evaluation- natural plants- Fall Army Worm

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Introduction

Over the ages, agriculture is faced by many challenges especially with the current climate changes which affect the yield. One of those challenges is the infestation with different pests mainly the invasive Fall Army Worm (FAW) Spodoptera frugiperda (Lepidoptera: Noctuidae). This polyphagous pest invades more than 350 botanical hosts belonging to 76 families, threating agricultural crops leading to great losses for the economic crops (Cruz et al. 2010 and DeAlmeida et al. 2002). This invasive pest is saturated with a broad spectrum of manufactured insecticides which increased its resistance to those compounds (SJ. Yu 1991). So, the management of this pest with natural, safe, effective alternative strategy is very important goal to reduce the dangerous impacts on plantations and on the surrounding environment. Our nature is rich in plants possessing bioactive compounds (Hernandez and Leon, 1994; Isman, 2006; Tembo et al. 2018; Mkindi et al. 2020 and Mukanga et al. 2022) acting as natural pesticides which could reduce reliance on chemical insecticides. In this work, we hypothesized that certain plants extracts could have a potential on the S. frugiperda larvae populations based on previous studies of many authors like those of (Rioba and Stevenson 2020) who reviewed the act of many plant species against S. frugiperda populations to control that pest. This study investigated whether the selected aqueous extracts of certain locally plants could be used as bio pesticides under laboratory conditions, depending on earlier studies for researches who worked on such plants for the management of different pests. The tested plants in this work were: Solenostemma argel (Del.), Ocimum basilicum, Ziziphus spina, Mentha piperita and the botanicals extract (Siam and Othman, 2020). O. basilicum (Family: Lamiaceae) is an annual aromatic herbaceous plant, used extensively in daily purposes in addition, it could be used as a bio-pesticide against different pests (Javanmardi et al. 2002; Ibrahim 2007; Mohamed 2015) while (Phambala et al. 2020) reported that Ocimum plant extract showed high FAW larvae mortality. In the present work, the Ocimum plant extract is modified by adding the agricultural K soap to it based on previous trials and experts in laboratory and field experiments on different lepidopteran pests carried out by the present authors.

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The plant Solenostemma argel (Family: Apocynaceae) is an herbaceous plant, it is used for certain medicinal purposes as it comprises several active compounds, so it could be used as bio insecticide (Isman 2006; Farah and Ahmed 2017 and Farah 2018). Ziziphus spina (Family: Rhamnaceae) is widespread perennial shrub or drought hardy medium trees, its leaves contain various active compounds as alkaloids and saponins which used in many daily purposes as edible fruits, timber or in traditional medicine and agricultural applications (Neama et al. 2007; Elaloui et al. 2016, 2019 and 2021). Mentha piperita (Family: Lamiaceae) is a perennial aromatic herb, used widely for flavoring, medicinal and pharmaceutical purposes, many workers tried its extract on suppressing S. frugiperda larvae as those of (Redempta et al. 2020 and Emmanuel et al. 2022). In this work, the tested extracts were prepared according to different authors as those of (Ascher 1981; Harborne 1984; Al-Lawati et al. 2002; Suman et al. 2008; and Beddou et al. 2015) but some minor modifications have been made to suit the potential of small farmers as a rapid method as soon as they notice the presence of S. frugiperda larvae in their plantations by using the available raw materials with the simplest preparations processes and with the lowest costs aiming at the prevention of the spread of that dangerous pest. More works on those extracts are needed in the open field to evaluate their impacts on the pest and the associated natural enemies, in addition, the tested plants extracts will be analyzed to identify the active components which are responsible for the mortality of the FAW larvae populations, plus the costs of preparing must be included as this item is considered the key driver for the farmers and the decision makers. This study aimed at the evaluation of the lethal effects of the above-mentioned plants extracts on the FAW larvae under laboratory conditions with the least impacts on the agro-ecosystem aiming at the sustainable agricultural productions.

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Materials and Methods

A laboratory colony of S. frugiperda (Lepidoptera: Noctuidae) was established to be a starter for this work and to assure provision of sufficient colony of insect samples free of any contamination with insecticides. This experiment was conducted at the laboratory of Trichogramma mass rearing at Fayoum Governorate, Plant Protection Research Institute, Agricultural Research Centre. Egypt.

1- Insects' colony preparation

Infected maize plants from maize fields at Garfes village, Sinnourus District, Fayoum Governorate, were taken to laboratory inspection and separation of collected larvae individually. Daily larvae feeding with clean maize leaves cultivated in laboratory garden till the pupal stage. The life cycle was completed till the moth's emergence and lying egg masses which were put in separate boxes. Newly larvae hatching fed on clean maize leaves till the 4^{th} instar, the base of the experiments, as it was treated with the tested extracts. Rearing FAW was performed at the optimum rearing conditions (25±2°C and 70±5%RH).

2- Preparation of the plants extracts

The selected tested plants extracts were prepared at the laboratory. The aqueous extraction for all selected plants were prepared according to (Harborne 1984; Al-Lawati et al. 2002; Suman et al. 2008; and Beddou et al. 2015) where 100 gm. Of cleaned, dry and fine-grinded leaves, soaked in 2000 ml distilled water, the mixture was Shaked well, left for 48 hrs., then filtered through two layers of muslin cloth and filtered again with Whatman filter paper no 1, then stored as a stock for use. About 5cm of agricultural K soap was added to the supernatant of O. basilicum extract as a minor modification based on trials carried-out by the present authors. The botanicals extract which consists of ginger, garlic, hot pepper and aloe gel was prepared as described by (Siam and Othman 2020).

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3- Experimental techniques

The dipping method was accomplished as following, maize leaves were prepared as pieces of 20 cm^2, dipped in the tested compounds separately for 10 seconds. Seven treatments including the controls with three replicates were used to evaluate each treatment. Each replicate comprised 30 larvae of the same age. Tap water was used for dipping maize leaves samples as controls. The treated maize leaves were dried at room temperature, then offered to the larvae, then covered with cotton cloth for ventilation. Daily inspection and counting live and dead larvae. It must be noted that larvae with no life symptoms or gained strange color or even can't convert to its normal movement when placed on its dorsal surface was considered dead.

Data collection and statistical analysis

This work was conducted to assess the tested compounds under laboratory conditions on S. frugiperda larvae. Daily inspection was accomplished pre-treatment and post-treatment. The evaluation of the tested compounds based on reduction percentages in larvae and it was determined according to Henderson and Tilton (1955) equation as following:

$$\text{Reduction \%} = [1 - \frac{\text{No. in Control before Treatment} \times \text{No. in Treatment after Treatment}}{\text{No. in Control after Treatment} \times \text{No. in Treatment before Treatment}}] \times 100$$

Obtained data of the tested compounds was compared to those of Emamectin benzoate (Speedo 5.7% WG) with the recommended rate 80gm/200L and controls. Analysis of variance (ANOV) was used on obtained data and Duncan's multiple range tests (Duncan, 1955) was used to separate means ($P<0.05$) (Snedecor and Cochran 1980). Statistical analysis for the subjected data was done using software package IPM SPSS version 19.

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Results and Discussion

Mean number of FAW population

The pre-count mean number of FAW larvae was 30 in all treatments. Compared to the controls larvae which was the superior in counting live FAW larvae number, they survived and completed their life cycle normally. The treatment with the extract of O. basilicum mixed with agricultural K soap differed significantly in the alive mean numbers of FAW larvae as it recorded the least mean number of 4.0 larvae / replicate, followed by the botanicals extract treatment with the mean number of 5 individuals / replicate. Z.spina counted the mean value of 6 individuals/replicate, Mentha extract treatment counted 7.5 / replicate, while S. argel had little effect on FAW larvae as it counted the mean of 18.5 / replicate. The chemical insecticide counted 4.5 larvae / replicate. (Fig. 1)

Reduction percentage of FAW larvae

The reduction percentages of FAW larvae after treatments with the tested compounds varied among the treatments. Compared to the chemical insecticide Emamectin-benzoate which reduced FAW larvae indicated 84.17%. The obvious reduction percentage was calculated after the treatment with the mixture of O. basilicum extract with the agricultural K soap indicated 83.33%, followed by the botanicals extract and Z. spina extracts which indicated 83.33% and 80% respectively. Mentha extract reduced FAW larvae population to 75% while S. argel extract had the least effect on FAW population as it recorded reduction percentage of 38.33%. (Fig. 2)

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Discussion

This work was based on many previous trials and experiments on the pest control under laboratory and field conditions. The present results of this work revealed that, the tested extracts had a potential on the FAW larvae fed on the treated leaves with the tested compounds. O. basilicum extract mixed with the agricultural K soap reduced FAW population to 86.66%, this mixture was applied previously by the authors on different lepidopteran pests in different sites as a manipulation to control those pests, so the authors aimed to evaluate this mixture on that invasive pest as a manipulation to help small farmers with the use of the available plants for reducing costs and to keep the environment intact keeping healthy plantations with no harmful traces of synthetic insecticides. It is known that the agricultural K soap is used as a fertilizer in addition to its lethal effect on many pests (Tremblay et al. 2009). Many authors evaluated O. basilicum on different pests like those of (Ibrahim, 2007; Mohamed, 2015; Marhns, et al. 2016 and Traka et al. 2018) who evaluated the effects of O. basilicum on Aphis gossypii and Tetranychus urticae and certain lepidopteran pests, they reported that Ocimum extract had potential on the tested pests. (Benelli et al. 2019) reported that the aqueous extract of Ocimum was characterized by many active compounds as carvacol 13%, thymol 11%, shikimic acid 3% and rosmarinic acid 2%. (Peta and Rani 2008) in their study on the effects of O. basilicum for controlling certain lepidopteran pests, they found that, it had moderate effects on the tested pests and could be used as pesticides alternatives. The present results revealed that, the botanicals extract (Siam and Othman 2020) reduced FAW populations to 83.33% as it comprises many active ingredients as garlic, ginger, hot red pepper and aloe vera which suppress many pests with no harmful effects on natural enemies (Siam and Genaidy 2021). Also, obtained results revealed that Z. spina had a lethal effect on FAW larvae. In pervious works as those of (Neama et. al. 2007; Elaloui et al. 2016 and Kadidia et al. 2017 Elaloui et al. 2019 and Alotibi et al. 2020) who reported that, the aqueous extract of Z.

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spina had antibacterial and antifungal activities, and they recommended with its use as a bioinsecticide. Also, presented data revealed that Mentha plant extract reduced FAW larvae to 75%. Many Works declared that Mentha extract had shown insecticidal properties like those of (Kumar et al. 2011; Melanie 2018; Redempta et al. 2020; Peprah-Yamoah et al. 2022) when they evaluated Mentha extract on the invasive FAW worms and reported that it could be potent alternatives to synthetic insecticides. In addion, obtained data reveals that the lowest effect on the tested S. frugiperda larvae was shown with that with S. argel extract. Our results were consistence with many authors whose works on that extract but against different pests like those of (El-Sheikh et al. 2021) who reported that the extract of S. argel had little effect on the mortality of tested FAW larvae and El-Tayeb et al. (2020) who reported that S. argel had the lowest effect on the great wax moth, while it was effective against mosquito Culex sp. (El-Kamali, 2001). Further studies on the tested extracts need to be continued on wide scale to evaluate that extracts on FAW larvae infesting economical crops mainly the corn crop to assess its impacts on the pest and the associated beneficial insects under field conditions, and to analyze their active components causing mortality for FAW larvae.

Conclusion

The selected tested plants extract mainly the mixture of O. basilicum with the agricultural K soap had potentials for controlling S. frugiperda larvae under laboratory conditions as those plants are locally available and can be prepared by the farmers themselves with the easiest methods to be used as an alternative to the chemical insecticides saving money, health and time fighting and controlling such danger pest before its distribution in the plantations.

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