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Research Paper

# Field Investigation on Control of *Spodoptera frugiperda* (FAW) using Aqueous Plant Extracts in Owerri, southeast Nigeria

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***Abstract***— Study to determine the efficacy of selected botanicals on *Spodoptera frugiperda* (FAW) through direct contact toxicity bioassay and feeding toxicity bioassay was conducted at the demonstration site, Imo State University Owerri from March 2021 to February 2022 to establish a green technology that is effective in the control of the insect pest. Aqueous extracts from turmeric leaf, turmeric rhizome, orange leaf, orange peel, pawpaw leaf, pawpaw seed, and control treatments were investigated to evaluate their effects on *Spodoptera frugiperda*. In the first round of investigation, 10ppt, 5ppt, 3ppt, 1ppt, and 0.5ppt treatment concentrations were investigated. Treatments were replicated three times while data generated from field investigations were statistically analyzed. The extent of foliar damage on host crops was recorded while data was collected daily beginning from the first day after applying treatments. It is evident from this study that pawpaw seed and orange peel treatment options gave better results on FAW larval mortality and are more effective than other treatment options. This shows that they are potential sources for plant-based biopesticide in FAW control.

***Keywords***— Green technology, Toxicity, Aqueous plant extracts, Biopesticide, Pest

## 1. Introduction

Biopesticides are biological materials made from naturally occurring substances used in pest control. They are eco-friendly and pose less threat to the environment. Biochemical pesticides include various extracts such as phytochemicals (extracts from plants), some vegetable oils, and sex pheromones (that interfere with pests mating) [1]**.** Early investigations have already proved the potential of plant extracts as an alternative to chemical pesticides in pest control thus it is relevant to state that there has been a gradual shift from the use of chemical pesticide to biopesticides in pest management because organic pesticide is cheap, economically viable, and can be produced locally by smallholders. Also, knowledge of the adverse effects of continuous use of chemical pesticides has increased the preference for biopesticides by local farmers. Meanwhile, several investigations have revealed the importance of environmental sustainability when considering insect pest treatment options [2]. Biopesticides do not only degrade rapidly but are also effective at low concentrations and are environmentally friendly with less toxicity to humans and animals [3].

A reflection of environmental degradation and its effects on human health calls for concern as the environment is daily been bombarded with xenobiotic materials partly orchestrated by human activities. The reality of this impasse is not just a rude awakening but a call to give environmental issues a top priority and treat them as urgent. Scientific investigations have established that the uncontrolled application of chemical pesticides to control pests is one of the numerous causes of environmental contamination. No doubt, the persistent use of chemical pesticides by some smallholders for increased food production have benefited humanity but at the cost of environmental degradation as majority of chemical pesticides are non-biodegradable and thus persist in the environment for a long period. Sadly the prevalence of threats to human health persists as farmers try to minimize economic loss and maximize profit. Therefore, controlling *Spodoptera frugiperda* using chemical treatment is not an option [4]**.**

As of September 2018, *Spodoptera frugiperda* had invaded a vast majority of African countries causing economic loss to smallholders. Hence, an aggressive approach that would easily manage the invasive pest is required without necessarily compromising environmental sustainability. Overall, this study will seek to establish a green technology to control FAW.

 

## 2. Related Work

Literature abounds with various interventions borne out of the desire for food security to the benefit of humanity using different agrochemicals. Hence, the abuse of the environment by the continuous use of chemical pesticides in pest control has been identified as a challenge in many countries. Therefore, one is no doubt inclined to agree that the environment is at the receiving end of persistent interference with nature. Meanwhile, the efficacy and sustainability of biochemical active ingredients registered for use against *Spodoptera frugiperda* have been documented. Bugitol for example is a commercial pesticide product that contains allylisothiocyanate derived from mustard seed. Literature has shown laboratory evidence of the efficacy of this active ingredient against other *Spodoptera* species [5]. Investigation revealed that allylisothiocyanate was effective against *S. litura* and can be a substitute for chemical pesticides in controlling the pest. Azadirachtin, a widely used botanical extract in Africa is derived from the neem tree *Azadirachta indica*. Study has shown that plant material from *Azadirachta indica* has been used successfully to control a wide range of pests and there is evidence from laboratory and field investigations on the efficacy of azadirachtin against FAW. Study by Crocker and Wei revealed that 3% azadirachtin applied to newly hatched FAW larvae may cause high mortality [6].

Similarly, maize leaf treated with neem extracts repelled FAW feeding under laboratory conditions [7]. *Bacillus thuringiensis* is one of the most widely used microbial biopesticides around the world and investigation has revealed the efficacy of this microbe against *Spodoptera* species [8]. This research aims to determine the pesticidal efficacy of study plant extracts on *Spodoptera frugiperda* through direct contact toxicity bioassay and feeding toxicity bioassay without compromising environmental sustainability.

## 3. Experimental Procedure

***Description of study site***

Field investigation was conducted at the demonstration site, Imo State University Owerri located at latitude 5° 30' 13" N and longitude 7° 2' 37" E, Nigeria.

***Plant extract preparation***

Extraction of plant material was done by decoction method as described by [9]. Pawpaw, orange, and turmeric leaves were collected from the demonstration site, Imo State University while turmeric rhizome, orange, and pawpaw fruits were obtained from a local market in Owerri. The plant materials were shredded into pieces with the aid of an electric grinder. Lowering particle size increases surface contact between samples and extraction solvents. Grinding into powder will have a more homogenized and smaller particle, leading to better surface contact with extraction solvents. A weight balance was used to obtain 100g of the pulverized powder. The 100g pulverized powder was soaked in 1 litre of water for 3 days and then boiled for 20 minutes [10, 11]. The extract was filtered out and the filtrate was transferred into a conical flask. To get 10ppt, a pipette was used to draw out 10 volumes of the extract and placed in a measuring cylinder. The cylinder was then filled with water to the 100 mark and transferred into a spraying bottle. After preparation, codes were assigned to the different treatment concentrations.

***Experimental details (field investigation)***

The field experiments were conducted during the 2020 and 2021 farming seasons at the demonstration site, Imo State University Owerri. The investigations were conducted in a complete randomized block design. 7 treatment options and 3 replications were investigated during the field study. Yellow maize seeds were cultivated on 27th April 2020 with a seed rate of 20 per bed at 8cm depth and 50cm × 30cm spacing between and within the rows. Other agronomic practices were applied according to established guidelines. Similarly, during the 2021 farming season, maize crop was sown on the 6th of April while soil and crop management were the same as practiced in the previous year (2020). Five FAW larvae (Figure 1) were introduced to host crops 20 days after seedlings emerged [12]. Treatment was applied 24 hours after FAW larvae were introduced to the healthy maize plants while subsequent treatments were applied at two days intervals [13]. A spray bottle was used when applying the different treatment options to the host crop (Figure 2). Later, the beds were tagged to indicate the type of treatment applied to them. Larvae mortality was evaluated daily after exposure using Abbott's formula [14]**.**

Figure 1: Photograph of FAW larvae

Figure 2: Plant extract application

 

***Foliar damage observations***

Foliar damage was daily observed while data was collected and recorded. The extent of foliar damage on each host crop was recorded on a scale of 1-6 as described by [15]**.**

## 4. Results and Discussion

In this present study, the results of the bioassay tests showed that the extracts of turmeric leaf, rhizome, orange leaf, orange peel, pawpaw leaf, and pawpaw seed were effective against the FAW larvae. The plant extracts were evaluated in controlled trials using FAW-infested maize plants to determine whether the treatments reduced foliar damage during the field investigations.

***Foliar damage assessment***

*Spodoptera frugiperda* foliar damage (Figure 3) was recorded during the 2021 and 2022 farming seasons as seen in Table 1 and Table 2. Foliar damage assessment showed that control treatment had the highest average number of damaged leaves with large elongated lesions of at least 42mm. Meanwhile, pawpaw seed treatment option had the least average number of damaged leaves with only pin-hole and small lesions of about 6mm–12mm. This was closely followed by orange peel treatment. As is evident from the data, pawpaw seed treatment gave better results in managing *Spodoptera frugiperda* when compared to other treatment options followed by orange peel extract. Similarly, results obtained from Table 1 and Table 2 revealed that an increase in treatment concentration resulted in a significant reduction in foliar damage. The results of the field trial are not surprising considering that the study was undertaken during the rainy season which corresponds with the cropping season in Nigeria.

Figure 3: Photograph of control treated maize plants showing the extent of foliar damage

Table 1: Results of treatments at different concentrations for field trials (2021 farming season)

| Treatment | Host crop | Replicate | Concentration/severity of foliar damage | | | | | Number of damaged leaves |
|---|---|---|---|---|---|---|---|---|
| | | | 10% | 5% | 3% | 1% | 0.5% | |
| T1- Turmeric leaf extract | A | I | 3 | 4 | 5 | 6 | 6 | 9 |
| | | II | 2 | 4 | 6 | 6 | 6 | 11 |
| | | III | 3 | 5 | 6 | 5 | 5 | 13 |
| T2- Rhizome extract | B | I | 3 | 4 | 5 | 6 | 6 | 12 |
| | | II | 3 | 4 | 5 | 5 | 6 | 10 |
| | | III | 2 | 3 | 5 | 5 | 5 | 9 |
| T3- Orange leaf extract | C | I | 3 | 3 | 4 | 5 | 5 | 11 |
| | | II | 3 | 3 | 4 | 5 | 6 | 10 |
| | | III | 2 | 4 | 5 | 5 | 5 | 9 |
| T4- Orange peel extract | D | I | 2 | 3 | 4 | 6 | 5 | 9 |
| | | II | 2 | 3 | 4 | 5 | 6 | 7 |
| | | III | 3 | 3 | 4 | 5 | 5 | 7 |
| T5- Pawpaw leaf extract | E | I | 3 | 4 | 5 | 6 | 6 | 10 |
| | | II | 2 | 3 | 5 | 5 | 6 | 8 |
| | | III | 3 | 3 | 4 | 6 | 6 | 9 |
| T6- Pawpaw seed extract | F | I | 2 | 3 | 4 | 6 | 6 | 8 |
| | | II | 2 | 4 | 4 | 5 | 5 | 7 |
| | | III | 3 | 3 | 4 | 5 | 6 | 7 |
| T7- Control | G | I | 6 | 6 | 6 | 6 | 6 | 20 |
| | | II | 5 | 6 | 5 | 6 | 5 | 18 |
| | | III | 5 | 5 | 5 | 6 | 6 | 25 |

Key

1 represents no visible damage to the leaf
2 represents pin-hole damage
3 represents small lesions on the leaf (6mm–12mm)
4 represents midsized lesions on the leaf (12mm–32mm)
5 represents large lesions on the leaf (32mm – 42mm)
6 represents large elongated lesions on the leaf (> 42mm)

Table 2: Results of treatments at different concentrations for field trials (2022 farming season)

| Treatment | Host crop | Replicate | Concentration/severity of foliar damage | | | | | Number of damaged leaves |
|---|---|---|---|---|---|---|---|---|
| | | | 10% | 5% | 3% | 1% | 0.5% | |
| T1- Turmeric leaf extract | A | I | 4 | 5 | 6 | 5 | 6 | 13 |
| | | II | 4 | 5 | 6 | 6 | 6 | 12 |
| | | III | 3 | 5 | 5 | 6 | 6 | 9 |
| T2- Rhizome extract | B | I | 4 | 5 | 5 | 6 | 6 | 11 |
| | | II | 3 | 4 | 5 | 6 | 6 | 10 |
| | | III | 2 | 5 | 6 | 5 | 6 | 9 |
| T3- Orange leaf extract | C | I | 4 | 3 | 5 | 5 | 6 | 13 |
| | | II | 3 | 4 | 5 | 6 | 6 | 9 |
| | | III | 3 | 5 | 4 | 6 | 5 | 11 |
| T4- Orange peel extract | D | I | 3 | 4 | 5 | 6 | 5 | 9 |
| | | II | 3 | 4 | 4 | 5 | 5 | 10 |
| | | III | 2 | 4 | 5 | 6 | 6 | 8 |
| T5- Pawpaw leaf extract | E | I | 2 | 5 | 6 | 6 | 6 | 10 |
| | | II | 2 | 4 | 5 | 5 | 6 | 9 |
| | | III | 3 | 5 | 5 | 6 | 6 | 12 |
| T6- Pawpaw seed extract | F | I | 3 | 4 | 5 | 5 | 5 | 9 |
| | | II | 3 | 3 | 4 | 6 | 6 | 8 |
| | | III | 2 | 4 | 4 | 5 | 6 | 9 |
| T7- Control | G | I | 5 | 5 | 6 | 6 | 6 | 18 |
| | | II | 5 | 6 | 5 | 6 | 5 | 23 |
| | | III | 5 | 5 | 6 | 6 | 6 | 26 |

 

Key
1 represents no visible damage to the leaf
2 represents pin-hole damage;
3 represents small lesions on the leaf (6mm–12mm)
4 represents midsized lesions on the leaf (12mm–32mm)
5 represents large lesions on the leaf (32mm – 42mm)
6 represents large elongated lesions on the leaf (> 42mm)

Several studies have revealed the efficacy of botanicals as potent biochemical materials in the control of insect pests. Similarly, studies have also demonstrated the anti-pesticidal potential of plant extracts against *Spodoptera frugiperda* owing to their effectiveness and eco-friendly nature [16, 17, 18]. Meanwhile, sixty-nine botanicals with significant effects on *Spodoptera frugiperda* have been identified and their biochemicals documented [19]. This present study demonstrates the degree of efficacy of turmeric leaf, turmeric rhizome, orange leaf, orange peel, pawpaw leaf, and pawpaw seed aqueous extracts treatments on *Spodoptera frugiperda*. Findings from this study agree with the reports of previous investigations which revealed that shredded pawpaw seed at 10% and 15% concentrations have effects on insect pest larvae [20]. Similarly, investigators have observed the insecticidal activity of pawpaw extracts on FAW [21]. The anti-feedant effects of orange seeds have also been attributed to the presence of biochemical compounds in the active ingredient [22]. These metabolites may disrupt the normal cellular metabolic activities thereby resulting in the death of the insect pest.

## 5. Conclusion and Future Scope

Plants synthesize phytochemicals as a defense mechanism. These chemicals may have inhibitory effects on many insects, acting as a repellent, anti-feedant, insecticide, mortality inducer, and growth inhibitor. Results from this investigation demonstrate the anti-pesticidal potential of the aqueous extracts in study plants. This makes them viable sources for plant-based biopesticides in the control of *Spodoptera frugiperda*. Generally, this study concludes that:

- The common response to FAW infestations by smallholders has been to apply chemical pesticides despite the risks associated with the use of such chemicals
- Pawpaw seed and orange peel treatments gave better results compared to other treatment options
- The treatments are not only environmentally safe but can also be produced by local farmers as this product is cheap and economically viable
- Larval mortality was directly proportional to an increase in treatment concentration
- Application of treatments does not require any technicality

***Recommendations***

In other to advance a more effective environmentally friendly treatment options against *Spodoptera frugiperda*, this study recommends:

- Supporting the development of local production of botanical pesticides
- Educating extension workers and smallholders on the dangers of chemical pesticide
- Though aqueous extracts from study plants are environmentally friendly, a combination of integrated pest management strategies will give better results against *Spodoptera frugiperda*.

**Data Availability**

Data generated in this investigation are indicated in the manuscript

**Conflict of Interest**

The authors of this manuscript titled: "Field Investigation on Control of *Spodoptera frugiperda* (FAW) using Aqueous Plant Extracts in Owerri, southeast Nigeria" declare that there are no conflicts of interest regarding the publication of this paper.

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**Authors' Contributions**

All authors read the manuscript and approved it for publication.

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