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Biocidal Effects of Some Plant Extracts against the Red Rust Flour Beetle *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) in Northeastern Nigeria

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Abstract:- The current study was conducted in Laboratory of Department of Crop Protection, Modibbo Adama University of Technology, Yola to evaluate the biocidal effects of different concentrations of extracts of *Azadirachta indica, Hyptis souveolens* and *Moringa oleifera* against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) at different time interval. Three applications of 5, 10 and 15% were used to assess the mortality of *T. castaneum* at five different periods of 24, 48, 72, 96 and 120 hours. The results revealed that the mortality of *T. castaneum* increased with increase in concentration of plant extracts. *Tribolium castaneum* gave highest mortality (36.0 %) at 15%, while least mortality (7.32 %) was obtained in *M. oleifera* at lower concentration (5%). Comparing the relative efficacy of these plant extracts in relation to time, highest percent mortality (38.9 %) was also observed in *A. indica* after 24 hours compared to the extracts of *H. souveolens* and *M. oleifera* which gave high mortality of 33.33 and 10.0 %, respectively. Regarding interaction between concentration and time, mortality increases with respect to increase in concentration, but reduces with passage of time. This shows that toxicity effects of these plant extracts is directly affected by concentration and time. Therefore, this study confirmed that these plant extracts are effective in the management of *T. castaneum* and most effectively at higher concentration with longer duration of time.

Keywords*: Tribolium Castaneum, Plant Extracts, Mortality, Biocidal.*

I. INTRODUCTION

Cereals are one of the major sources of carbohydrate thus constituting the major dietary sources of energy to man. They also contain other essential nutrient such as protein, fats, minerals (potassium and calcium) and vitamins (vitamin A and C) (Idem and Showemimo, 2004). In Nigeria, the major cereal crops are rice, maize, sorghum, wheat and pearl millet [19]. These important cereal grains are consumed in a variety of forms, including pastes, noodles, cakes, breads, drinks etc, depending on the ethnic or religious affiliation [12]. Stored cereal grains suffer severe attack by diversity of insect pests both in storage as raw grains or when processed into fine flour [26]. The rust red flour beetle *T. castaneum* is a serious secondary storage pests of all important cereal grains flour in Nigeria. Infestation by this pest could result in direct quality as well as quantity loss [18] or indirectly, by imparting brownish tinge and pungent smell through secretion of benzequinones [10].

Management of these pests has been predominantly by the use of chemical pesticides, it causes many worse effects on environment which in turn [21] have a definite impact on health of living organisms including humans [16]; [8]. Extracts of plant origin have shown to be biocidal to many stored grains insects like *Tribolium castaneum* [23]. These plant extracts are reported to have insecticidal properties [9]. About 211 plant species have been shown to have different types of pest management properties [13]. When incorporated into integrated pest management programs, botanical pesticides can greatly decrease the use of conventional pesticides [22].

Botanical pesticides play a vital role as an eco-chemical and sustainable strategy and hence have been widely used in the management of insect pests. One of the most important advantages of these pesticides is that they decomposed quickly and leaves the food residue free, provide a safe environment to live and affect only target pests and closely related organisms [4]. However, this research is focused on the evaluation of bio-toxicity potentials of three plant leaf extracts against *T. castaneum* and also to determine the bio-efficacy of these plant leaf extracts in the mortality of *T. castaneum*.

II. MATERIALS AND METHODS

2.1. Description of study area

The experiment was conducted in the Laboratory of the Department of Crop Protection of Modibbo Adama University of Technology, Yola. Yola is located in the Northern Guinea Savannah Agro-Ecological Zone of Nigeria at latitude 90º 14`N, longitude 12º 28`E and altitude 190.5m and has the minimum and maximum rainfall, temperatures and relative humidity of 0.80 and 4.92ml; 27ºC and 42ºC and 35% and 75%, respectively [3].

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2.2. Collection and preparation of samples

Leaves of *Azadirachta indica* (Neem) and *Moringa oleifera* (Drum stick) and *Hyptis souveolens* (Pig weed) were collected from around the University Staff Quarters, Modibbo Adama University of Technology, Yola, Adamawa state, Nigeria. The plant materials were washed in water and then Shade dried. The plant leaves were crushed to fine powder and sieved with fine mesh. Extracts were made by mixing 50 g of the fine powdered sample in 100 ml of ethanol then shaken for 24 hours with Rotary Shaker (IRMICO OS-10) at 120 rpm. After 24 hours, filtration was made with the use of filter paper. Preliminary extract was subjected to the Rotary evaporator to get 100% stock solution as described by Sagheer *et al*. [23]; Haidri *et al*. [5].

2.3. Source of insect and insect culture

The test insect (*Tribolium castaneum*) used to establish a Laboratory colony was collected from naturally infested wheat flour obtained from Girei market Adamawa state, Nigeria. It was brought to the laboratory and cultured on disinfected wheat flour to obtain similar aged weevils for the experiments at ambient room temperature. This was done by placing 50 pairs of unsexed *T. castaneum* adults into 1 litre capacity bottle containing 500g wheat flour. The bottles were covered with muslin cloth and secured with rubber band to prevent escape of insects and to allow aeration (Plate 1). After seven (7) days, when oviposition had been noticed, the parent stock of *T. castaneum* was removed. The flour with the oviposited eggs was then left under laboratory conditions until emergence of F_1 progeny. The F_1 progeny 1 – 3 days old from the cultures was then used for the experiment [15].

2.4. Experimental Procedure and Bioassay

Different concentrations (0%, 5, 10 and 15 %) were made by diluting the concentrated stock with ethanol. These dilutions were then applied on the half of Whatman no.1 filter paper with the help of micropipette while the other half was treated with ethanol only (control). In order to evaporate the solvent from treated and untreated halves, the filter papers were air dried for 60 minutes. Once dried, the treated filter papers were clipped and adjusted in Petri dishes [24]; [4]; [25]. For examining the percent mortality, twenty adults *T. castaneum* (1-3 days old) were released and the Petri dishes covered. Mortality of adult weevils was recorded at (0%, 5, 10 and 15 % concentration and at 24, 48, 72, 96 and120 hours duration of time on both halves of filter paper (treated and untreated) [4]; [23]; [25]. Experiment was laid in a Split plot Design replicated three times. The percentage mortality was corrected using Abbott's (1925) formula and calculated according to the method of Obeng-Ofori and Reichmuth [20] as;

$$\% \text{ PT} = \frac{(\text{Po} - \text{Pc})}{(100 + \text{Pc})}$$

Where:
PT = corrected mortality (%);
Po = observed mortality (%);
Pc = control mortality (%).

2.5. Data Analysis

Mortality was corrected using Abbott's formula and data obtained were analyzed with Analysis of Variance (ANOVA) Statistica 7.0 software. Treatments means were separated using Tukey-HSD test at 5% level of significant.

III. RESULTS

The result proved positive toxic effects of plant extracts on the overall mortality *T. castaneum*. Table 1 indicates that there was significant difference among the three plant extracts at different application rates on mortality of *T. castaneum*. Toxicity effects at different concentrations on the adult beetle shows highest mortality at 15% concentration of *A. indica* (83.17%) followed by *H. souveolens* (77.33 %) and *M. oleifera* (59.21 %). Lowest mortality was obtained at 5% concentration of *M. oleifera*, *H. souveolens* and *A. indica* of 33.57; 52.91 and 55.14 %, respectively. Generally, all the concentrations tend to affect the adult stage. However, by increasing the concentration the increase in mortality was visible in all the plant extracts.

Table 2 demonstrates the effect of time intervals on the mortality of the *T. castaneum*. This table indicates significant bio-effectiveness of the plant extracts towards mortality of the adult beetle *T. castaneum* at five different intervals (24, 48, 72, 96 and 120 hours). Though, significant differences were observed among the plant extract at different intervals. It was found that *A. indica* was more efficient as compared to *H. souveolens and M. oleifera* at all the time intervals. Highest mortality of 70.29 % and 68.83 % was observed on *A. indica* and *H. souveolens*, respectively and lowest mortality (5.57 %) was observed on *M. oleifera* after a period of 120 hours. The result also showed that mortality was lowest at 24 hours after exposure on all the plant extracts of 35.27, 343.38 and 55.12 % of *M. oleifera, H. souveolens and A. indica*, respectively. This result indicates that mortality increases with increase in time (Table 2).

The results further revealed that the comparative analysis of mean percent mortality of *T. castaneum* is showed in Figure 1. The results indicated that at highest concentration and longer time interval, higher mortality of *T. castaneum* can be achieved under optimum temperature and relative humidity.

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Table 1 Toxicity effects of three plant extracts at three different rates (5, 10 and 15%) on mortality of *Tribolium Castaneum*

	Mortality (%) ± SE		
Rate (%)	***H. souveolens***	***M. oleifera***	***A. indica***
5	52.91 ± 1.55	33.57 ± 1.47	55.14 ± 1.97
10	61.13 ± 2.11	47.33 ± 1.76	63.51 ± 2.80
15	77.33 ± 1.98	59.21 ± 2.68	83.17 ± 1.77

Table 2 Effects of three plant extracts at various exposure periods (24, 48, 72, 96 and 120 hours) on mortality of *Tribolium castaneum*

	Mortality (%) ± SE		
Time (hrs.)	***H. souveolens***	***M. oleifera***	***A. indica***
24	43.38 ± 1.54	35.27 ± 1.53	55.12 ± 1.88
48	53.71 ± 1.68	43.21 ± 1.71	58.45 ± 2.81
72	59.41 ± 2.97	46.49 ± 1.81	63.67 ± 1.74
96	64.19 ± 1.69	54.70 ± 1.94	67.83 ± 1.73
120	68.83 ± 1.73	61.43 ± 2.98	70.29 ± 2.13

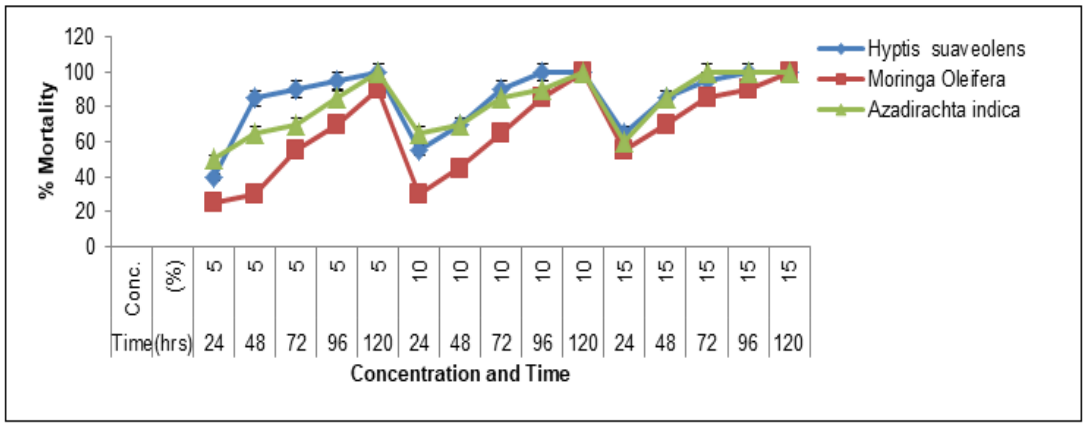

Figure I Effects of toxicity of three plant extracts at different concentrations (5, 10 and 15%) and exposure periods (24, 48, 72, 96 and 120 hours) on mortality of *Tribolium castaneum*

IV. DISCUSSION

The results further revealed that the mortality of *Tribolium castaneum* increased by increasing the concentration of *A. indica*. *Tribolium castaneum* gave highest mortality (83.17%) at 15%, while 10% gave 63.51% mortality. Least mortality (55.14%) was observed at 5% concentration. By comparing the relative efficacy of extracts of *Hyptis suaveolens*, *Moringa oleifera* and *Azadirachta indica*, highest percentage value of mortality (70.29%) regarding time was after 120 hours by *A, indica*, while minimum percent mean mortality (35.27%) was observed after 24 hrs by *M. oleifera.* This results contradict that of Islam and Talukder [9]; Haq *et al.* [6]; Ahmed *et al.* [1] and Musabyimana *et al.* [17] who worked on various neem extracts. This inconsistency in the results may be possibly due to the difference of the plant extracts used.

Overall, *A. Indica* proved to be more effective causing 83.17 % knockdown followed by *H. souveolens* 77.33 % and *M. oleifera* 59.21 % at 15% concentration. The maximum mortality was caused by *A. Indica* after 120 hours (70.29 %) while the minimum though appreciably high, was indicated by *M. oleifera* after 24 hours of exposure (61.43 %). Our results are close to that of Kim *et al.* [14] who checked the effects of Methanol extracts from 30 aromatic medicinal plant species and five essential oils for their insecticidal activities against adults of *Callosobruchus chinensis* and *Sitophilus oryzae* using fumigation methods and direct contact application. However, our result showed that responses varied with concentrations, exposure time and plant materials. This study proved the effectiveness of *A. indica* and *H. souveolens* extracts to possess mortal effects to *T. castaneum* which is similar to studies conducted by Sagheer *et al.* [23], Fawad *et al.* [4], Shireen *et al.* [25], Hasan *et al.* [7] and Asghar *et al.* [2] who also found out that, plant extracts have repellent, antifidant and mortal effects against various stored grain insect pests.

Haidri *et al.* [5] also checked for the effectiveness of *Azadirachta indica* and *Murraya koenigii* towards pulse beetle and found the definite potential of the plants towards causing mortality of test insect. Kim *et al*. [14] tested for the effects of some plant extracts against adults of *Sitophilus oryzae* and *Callosobruchus chinensis* and found the definite effect of extracts towards the biology of insects. Haidri *et al*., [5] also checked for the effectiveness of *Azadirachta indica* and *Murraya koenigii* towards pulse beetle and found the definite potential of the plants towards causing mortality of the test insect. In this study, bio-toxicity effects of all the plant extracts were significant though lower in *M. oleifera* as compared to *A. indica* and *H. souveolens.*

Islam and Talukder [9] conducted experiments on the toxicity of the neem powder on the mortality of *T. castaneum* where 53.13% mortality was observed on an average but in the present experiments, the mortality is higher 83.17% as compared to their experiments which contradicts the result of this study. However, the results of this study are also in agreement with the experiments conducted by Ahmed *et al.* [1] who worked on three neem formulations and observed its impact on progeny inhibition of *T. castaneum.* Similar experiments were conducted by Musabyimana *et al.* [17] which indicated its effects to be

significant against *T. castaneum*. In this study, natural plant extracts of *Hyptis suaveolens, Moringa oleifera* and *Azadirachta indica* were evaluated as biocidal against *T. castaneum*. Therefore, due to the safe potential of these biocides, these can be utilized for effective control of storage pests especially *T. castaneum.*

V. CONCLUSION

This study clearly indicated differences in toxicity of these plant extracts in relation to exposure period and concentration used. The findings of the study predict the potential of plant extracts towards the stored grain insect pest management.

Based on the high mortality results of the present study, it is concluded that the application of *A. indica, H. souveolens* and *M. oleifera* leaf extracts as plant derived insecticides on *T. castaneum* can control the damage caused by this beetle. *A. indica* is the most effective plant extract because it had the highest mortality effects among the three plant extracts used in this study while, *M. oleifera* had the least mortality effects therefore, it is not recommended for use on this insect. However, *Hyptis souveolens* can be used in place of *A. indica* because it had the second highest effects even though it's not as effective as *A. indica.* Therefore, this study suggest that *Azadirachta indica* and *H. souveolens* are active plants extracts towards control of stored grain insect pests especially the red rust flour beetle, *Tribolium castaneum*.

However, effort must be intensified to control the damage caused by *T. castaneum* to stored cereals, this could be achieved by the use of plant extracts which are cheap, low risk control techniques and are readily available to the farmers which prompted this study. Therefore, thorough testing, screening and biochemical studies of plant extracts should be promoted for identification and synthetic production of active ingredient present in potent plant extracts at commercial scale. Further work would be required to estimate the duration of efficacy and concentration levels of the plant extracts for effective management of insect pests of stored cereals. Finally, the information obtained in this study to the use of these plant extracts will act as guide for planning economical management techniques against *T. castaneum* and other stored cereals pests.

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