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Insecticidal Potential of *Hyptis suaveolens* and *Tithonia. Diversifolia* against *Tribolium castaneum* in Stored Wheat

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ABSTRACT

Tribolium castaneum, commonly known as the red flour beetle, is an important pest of stored grains and agricultural commodities worldwide, causing substantial economic losses. The use of synthetic insecticides for its control poses several challenges, including environmental concerns and development of insecticidal resistance. Consequently, there is a growing need to explore natural alternatives for the effective management of pest. This study investigates the insecticidal efficacy of leaf extract of *Hyptis suaveolens* and *Tithonia diversifolia* against *Tribolium castaneum*. The experiment was a factorial arrangement fitted into a completely randomized design with three replications set up in the Crop Protection laboratory, Faculty of Agriculture, University of Ilorin, Ilorin in 2020. The treatments were botanical pesticides formulated with *Hyptis suaveolens* and *Tithonia diversifolia*, aluminium phosphide and an untreated control. The effect of the extracts on survival of *Tribolium castaneum* was assessed by recording adult mortality rate, larva mortality rate, pupa mortality rate, adult emergence and wheat seed weight loss. All numerical data were subjected to analysis of variance (ANOVA) and means were separated by Tukey's honest significant difference. The findings highlight the potential of *H. suaveolens* and *T. diversifolia* as a natural source of insecticide against *T. castaneum*. Although there were no significant differences between the wheat treated with *Hyptis suaveolens* and *Tithonia. Diversifolia* is significantly more effective than the control with respect to weight loss, reducing *T. castaneum* damage.

Keywords: *Hyptis suaveolens,* Insect pest, Postharvest loss, *Tithonia diversifolia, Tribolium castaneum*

INTRODUCTION

In the field of pest management, the search for effective and sustainable alternatives to synthetic insecticides has gained significant attention. Traditional approaches to pest control, such as the use of synthetic insecticides, have raised concerns due to their detrimental effects on human health and the environment. One promising avenue is the exploration of natural plant-based compounds with insecticidal properties. Among the numerous plant species studied for their potential insecticidal properties, *Hyptis suaveolens* and *Tithonia diversifolia* have emerged as promising candidates (Kumar & Kalita, 2017). These plants have been traditionally used in folk medicine and possess a wide range of biological activities, including insecticidal potential. (Mishra *et al*., 2021).

Wheat *(Triticum aestivum)* is an industrial and food grain crop; it ranks second among the cereals crops in the world, after rice. It is the most important cereal traded on international markets (Giraldo *et al*., 2019). One of the storage insect pests that affect the quality of wheat is *Tribolium castaneum* and red flour beetle was reported to have a broad host range for most grains (Kumar & Kalita, 2017).

Hyptis suaveolens, commonly known as "Lantana" or "Mexican mint," belongs to the Lamiaceae family and is widely distributed in tropical and subtropical regions. It has been traditionally used in folk medicine for its medicinal properties. Several studies have reported the insecticidal activity of *Hyptis suaveolens* extracts against a wide range of insect pests, including mosquitoes, stored product pests, and agricultural pests (Mishra *et al*., 2021; Chung *et al*., 2020). The active compounds responsible for its insecticidal properties include essential oils and secondary metabolites, such as terpenoids and flavonoids (Mishra *et al*., 2021).

Reduction of post-harvest losses of crops is crucial in ensuring food and nutrition security. However, a lack of knowledge on the extent of post-harvest losses and its associated impeding factors are posing major challenges to effectiveness of grain post-harvest loss management strategy (Debebe, 2022). Post-harvest loss accounts for direct physical losses and quality losses, which reduce the economic value of crops, or may make it unsuitable for human consumption. In severe cases, these losses can be up to 80% of the total production. In African countries, these losses have been estimated to range between 20% and 40%, which is highly significant considering the low agricultural productivity in several regions of Africa (Kumar and Kailita, 2017). Consequently, this study aims to investigate the insecticidal potential of *Hyptis suaveolens* and *Tithonia diversifolia* against *Tribolium castaneum* and their efficacy as natural pest control agents on grains.

MATERIALS AND METHODS

Study Location

This study was conducted in the Crop Protection laboratory, Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State. Situated in the heart of Kwara State, Nigeria, Ilorin finds its place on the globe at approximately 8.4855° North Latitude and 4.6636° East Longitude. These coordinates serve as the city's geographical fingerprint, defining its position on the earth's surface. The insect free wheat seeds used were obtained from a local market in Ilorin.

Collection and Preparation of Botanicals.

Hedychium suaveolens and *T. diversifolia* were collected from University of Ilorin Teaching and Research Farm, Ilorin. The leaves were air dried for 7 days at room temperature, grounded using mortar and pestle and sieve to uniform size particle. It was thereafter soaked in organic solvent for 24 hours in ratio of 1:4 that is leaves and organic solvent respectively. The mixture was filtered using muslin cloth and was concentrated to dryness after 24 hours of filtration.

Insect Culture

The initial stock of *Tribolium castaneum* larvae used in the study was obtained from Nigerian Stored Products Research Institute (NSPRI), Ilorin and reared in the Crop Protection laboratory. Four 50 cm^3 plastic containers containing wheat flour and *Tribolium castaneum* larvae were left for three weeks at room temperature 37°C for complete metamorphosis to adult insects. Newly emerged *Tribolium castaneum* adults were used for the experiment.

Experimental Procedure

100 g of untreated wheat seeds were weighed using sensitive weighing scale and placed in 18 plastic containers of 8mm in diameter. The wheat seeds were treated with the botanicals *(H. suaveolens* and *T. diversifolia*), aluminium phosphide and control. Due to the slurry composition of both concentrated botanicals, they were gently tied in a muslin cloth and placed in the wheat containers at the rates of 10 g and 15 g for both botanicals while the Aluminium phosphide and control were applied at 0.375 g and 0 g respectively. The experiment was laid out in a completely randomized design and each treatment was replicated three times. Newly emerged *Tribolium casteneum* adults which were randomly chosen from the culture were introduced at 15 insects per replicate. The containers were covered with muslin cloth held by rubber bands and the effect of the extracts on the survival of *Tribolium castaneum* was assessed by recording adult mortality, emergence of larvae, pupa, adult and weight loss.

Data Collection and Analysis

Data on larval emergence, larvae mortality, pupal emergence, pupal mortality, adult emergence and weight loss were collected on a weekly basis. The data collected were subjected to analysis of variance (ANOVA), using statistical package for social sciences (SPSS) and treatment means, where significant were separated using Tukey's honest significant difference at 5% level of significance.

RESULTS AND DISCUSSION

Effect of Botanicals on the Population and Mortality of *Tribolium castaneum* Larva

The effect of botanicals on the adult mortality of *Tribolium castaneum* Larvae is presented in Table 1 and Table 2. No significant difference was observed in the population of larva that was treated with either botanical (Table 1). There was difference between population and number of *Tribolium castaneum* larvae treated with the botanicals, Aluminum phosphide and control. The control recorded the highest number 17.33 of the larvae from week 5 to week 12 while the seeds treated with aluminum phosphide recorded the least population. Although at week 12, no significant

difference was observed in the population of larvae in botanical extract treated seeds and control. This implies that the aluminium phosphide had effect on the population of *Tribolium castaneum.* The mortality of the larvae treated with botanicals and aluminum phosphide is presented in Table 2. The results show that at 5 and 6 weeks there was no significant difference between larva mortality rate in samples containing botanical treatments and the control experiment while there was a significant difference between botanical treatments and chemical treatment. It was observed that there was no significant difference between all the treatments at week 12 (0.00).

Table 1: Effect of Botanicals on the Adult Mortality of *Tribolium castaneum* Larva

		Weeks After Treatment (WAT)								
Treatment	Conc (g)	4	5	6	7	8	9	10	11	12
Helianthus annuus	10	4.00^{b}	4.67^{a}	8.00^{b}	4.33^{b}	7.67^{ab}	6.00^{ab}	8.00^{a}	8.33^{ab}	10.67^{a}
	15	4.00^{b}	5.67^{a}	12.33^{ab}	8.67^{a}	10.00^{a}	8.67^{a}	8.67^{a}	8.00^{ab}	10.00^{a}
Hyptis suaveolens	10	3.67^{b}	5.33^{a}	14.00^{a}	4.67^{b}	6.00^{ab}	9.00^{a}	6.33^{ab}	7.33^{ab}	12.33^{a}
	15	5.00^{ab}	7.33^{a}	10.67^{ab}	3.33^{b}	4.00^{bc}	5.00^{ab}	3.333^{ab}	4.333^{ab}	11.00^{a}
Aluminium Phosphide	0.375	0.00^{c}	0.00^{b}	0.00^{c}	0.00^{c}	0.00^{c}	0.67^{b}	0.00^{b}	0.00^{b}	0.67^{b}
Control	0	0.00^{a}	6.67^{a}	13.67^{a}	10.00^{c}	9.33^{ab}	8.00^{ab}	6.00^{ab}	10.67^{a}	17.33^{a}

Note: Values with same letter(s) in a given column are not significantly different using Tukey's honest significant difference at 5% level of significance.

Table 2: Effect of Botanicals on Larval Mortality of *Tribolium castaneum*

Treatment	Conc (g)	Weeks After Treatment (WAT)							
		5	6	7	8	9	10	11	12
Helianthus annuus.	10	3.00^{a}	3.33^{a}	5.33^{a}	3.00^{a}	2.33^{a}	0.67^{a}	5.00^{a}	3.67^{a}
	15	1.33^{ab}	2.33^{ab}	4.67^{a}	4.33^{a}	2.33^{a}	2.67^{a}	3.67^{ab}	1.33^{a}
Hyptis suaveolens	10	2.67^{a}	3.67^{a}	5.00^{a}	1.67^{ab}	3.33^{a}	2.33^{a}	3.67^{ab}	3.00^{a}
	15	2.67^{a}	2.67^{a}	6.00^{a}	2.33^{ab}	2.67^{a}	2.67^{a}	2.33^{ab}	2.33^{a}
Aluminium Phosphide	0.375	0.00^{b}	0.00^{b}	0.00^{a}	0.00^{b}	0.00^{a}	0.33^{a}	0.00^{b}	0.00^{a}
Control	0	2.00^{ab}	2.00^{ab}	4.67^{a}	4.00^{a}	1.67^{a}	2.67^{a}	3.67^{ab}	5.67^{a}

Note: Values with same letter(s) in a given column are not significantly different using Tukey's honest significant difference at 5% level of significance.

Table 3: Effect of Botanicals on the Pupa of *Tribolium castaneum*

Treatment	Conc (g)	Weeks After Treatment (WAT)							
		5	6	7	8	9	10	11	12
Helianthus annuus	10	2.33^{b}	2.33^{a}	4.67^{ab}	2.33^{bc}	3.67^{bc}	3.00^{a}	3.33^{ab}	3.67^{ab}
	15	2.67^{b}	4.00^{a}	6.33^{a}	4.00^{ab}	5.33^{ab}	3.67^{a}	5.67^{a}	3.33^{ab}
Hyptis suaveolens	10	1.33^{bc}	2.33^{a}	5.67^{ab}	2.67^{bc}	2.67^{bcd}	5.67^{a}	6.67^{a}	4.00^{ab}
	15	3.00^{ab}	4.67^{a}	2.67^{bc}	0.67^{cd}	1.33^{cd}	1.67^{a}	5.67^{a}	5.33^{a}
Aluminium Phosphide	0.375	0.00^{c}	0.00^{b}	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{a}	0.00^{b}	0.00^{b}
Control	0	4.67^{a}	4.67^{a}	7.00^{a}	5.33^{a}	7.00^{a}	5.33^{a}	8.00^{a}	7.33^{a}

Note: Values with same letter(s) in a given column are not significantly different using Tukey's honest significant difference at 5% level of significance

Table 4: Effect of Botanicals on Pupa Mortality of *Tribolium castaneum*

Treatment	Conc (g)	Weeks After Treatment (WAT)						
		6	7	8	9	10	11	12
Helianthus annuus	10	0.67^{a}	2.33^{ab}	5.33^{a}	5.00^{a}	2.67^{a}	3.33^{a}	5.33^{b}
	15	0.33^{a}	1.33^{ab}	2.00^{bc}	2.00^{abc}	2.33^{a}	5.33^{a}	1.33^{ab}
Hyptis suaveolens	10	0.67^{a}	3.33^{a}	1.67^{bc}	1.00^{bc}	3.00^{a}	3.33^{a}	5.00^{a}
	15	1.33^{a}	2.67^{ab}	3.00^{b}	2.00^{abc}	3.33^{a}	1.33^{a}	1.00^{ab}
Aluminium Phosphide	0.375	0.00^{a}	0.00^{b}	0.00^{c}	0.00^{c}	0.00^{a}	0.00^{a}	0.00^{b}
Control	0	0.67^{a}	3.33^{a}	2.33^{bc}	4.33^{ab}	2.67^{a}	4.67^{a}	4.00^{ab}

Note: Values with same letter(s) in a column are not significantly different using Tukey's honest significant difference at 5% level of significance.

Table 3 and 4 showed the population and mortality rate of pupa that infested the wheat samples treated with botanicals and aluminum phosphide respectively. It was observed that there was no significant difference observed in the pupa mortality rate observed for all treatments, although there was higher population of pupa observed in the control treatment while chemical treatment recorded the least population of pupa. At week 8 and 12, 10 g of *Helianthus annuus*. concentration recorded the highest (5.33) mortality rate.

Results for number of adult *T. castaneum* infestation in wheat were presented in Table 5. The number of adult insect pests observed in the wheat samples treated with chemical was significantly higher or lower from other treatments samples throughout the observation period. There were significant different observed in the adult insect pest population in wheat samples treated with

botanicals and control except at week 8 and 12 where there is no significant difference between botanical treatments and control (0.00).

Table 6 shows the results on mortality rate of adult *Tribolium castaneum* in samples of wheat treated with chemical and botanicals. Chemical treatment had the higher number of adult mortalities at 1week after treatment. Mortality rate for in chemical treated samples were significantly different compared to botanicals without any control experiment at week 1 and 7. At weeks 2 and 3, there was no significant difference between adult *Tribolium castaneum* mortality rate of chemical and botanical treatments while there was significant difference between mortality rate in chemical treatment and control. At week 5 after treatment, there was no significant difference between mortality in all treatments. There was no significant difference in number of adult *Tribolium castaneum* mortality in all treatments at week 11 and 12. However, control had the highest mortality rate at week 12. This implies that the botanicals had highest mortality rate on the adults for the first 3 weeks while the higher mortality rate of the insect pest in the control treatment at week 12 might be attributed to nutrient exhaustion in the in the wheat sample at the later weeks during the trials.

Table 7 shows the result of grain weight loss as a result of *T. castaneum* infestation. From the results, *Helianthus annuus* at 15 g had the highest feed consumption rate of wheat from 1 – 3 weeks after treatment. As from week 4 of the experiment when larva emergence occurs, the feed consumption rate of control was the highest until week 12. However, there was no significant difference between botanical treatments and the control from week 1 – 12 (85.02). While from week 5 – 12 after treatment, there was significant difference between grain weight loss of control and the chemical. And there was significant difference between grain weight loss of chemical and botanicals.

This study showed that the chemical treatment has higher effect on the insect pest but chemical treatment of crops for storage may have undesirable effects that leads to decreased nutritional value or altered sensory properties. It has been well documented that botanical insecticides could be useful for development into products that are fit for integrated pest management because of their pest selectivity, no detrimental effects on non-target organisms, humans and the environment (Rajashekar, 2016; Singh *et al*., 2021). *Hyptis suaveolens* leaf extract insecticidal actions were also reported by Hassan *et al.* (2018). The insecticidal effect of *T. diversifolia* was also reported by Devi *et al*. (2022). This might be attributed to their phytochemical properties.

Table 5: Effects of Botanical on the Population of *Tribolium castaneum*

Treatment	Conc	Weeks After Treatment (WAT)											
	(g)	1	2	3	4	5	6	7	8	9	10	11	12
Helianthus annuus.	10	12.00^{ab}	9.00^{b}	6.33^{b}	4.33^{b}	2.67^{b}	5.67^{b}	4.67^{ab}	4.67^{a}	8.33^{b}	10.00^{ab}	8.00^{a}	12.67^{a}
	15	11.33^{b}	10.00^{b}	7.67^{b}	4.67^{b}	2.33^{b}	4.33^{b}	7.33^{ab}	9.00^{a}	9.33^{a}	14.00^{a}	9.67^{a}	15.00^{a}
Hyptis suaveolens	10	13.33^{ab}	10.33^{b}	8.00^{b}	4.33^{b}	2.67^{b}	4.33^{b}	6.33^{b}	9.00^{a}	7.33^{a}	8.33^{ab}	6.33^{ab}	11.00^{a}
	15	13.33^{ab}	10.00^{b}	7.67^{b}	5.33^{b}	4.00^{b}	4.33^{b}	6.33^{ab}	5.67^{a}	3.00^{ab}	4.67^{bc}	5.67^{ab}	15.00^{a}
Aluminium Phosphide	0.375	8.333^{c}	4.67^{c}	1.33^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}	0.00^{a}	0.00^{c}	0.00^{b}	0.00^{b}
Control	0	14.67^{a}	14.00^{a}	13.33^{a}	10.33^{a}	9.67^{a}	11.00^{a}	8.33^{a}	9.00^{a}	8.33^{a}	10.33^{ab}	11.33	15.33^{a}

Note: Values with same letter(s) in a column are not significantly different using Tukey's honest significant difference at 5% level of significance.

Table 6: Effect of botanicals on adult mortality of *Tribolium castaneum*

Treatment	Conc	Week After Treatment (WAT)											
	(g)	1	2	3	4	5	6	7	8	9	10	11	12
Sunflower	10	3.00^{c}	3.00^{ab}	2.67^{a}	1.67^{b}	1.67^{ab}	2.00^{ab}	3.33^{b}	3.67^{ab}	3.00^{ab}	4.33^{ab}	5.33^{a}	3.00^{a}
	15	3.67^{b}	2.00^{ab}	2.33^{ab}	3.00^{ab}	2.33^{ab}	1.67^{ab}	3.33^{b}	5.00^{ab}	2.33^{ab}	2.00^{bc}	4.00^{ab}	3.67^{a}
Hyptis	10	1.67^{bc}	3.00^{ab}	2.33^{ab}	4.00^{a}	1.67^{ab}	0.67^{b}	2.67^{b}	3.00^{ab}	4.67^{a}	2.33^{b}	6.33^{a}	4.67^{a}
	15	1.67^{bc}	3.33^{a}	2.33^{ab}	2.33^{ab}	1.33^{ab}	1.67^{ab}	3.67^{b}	4.67^{ab}	5.33^{a}	3.00^{b}	2.33^{ab}	1.00^{a}
Aluminium Phosphide	0.375	6.67^{a}	3.67^{a}	3.33^{a}	2.00^{ab}	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{a}
Control	0	0.33^{c}	0.00^{b}	0.67^{b}	3.00^{ab}	0.67^{ab}	3.67^{a}	9.00^{a}	6.67^{a}	5.33^{a}	5.67^{a}	3.67^{ab}	6.33^{a}

Values with same letter(s) in a given segment of a column are not significantly different at probability level using Tukey's honest significant difference at 5% level of significance

Table 7: Effect of Botanicals on weight loss of wheat (*Triticum aestivum) grains*

Treatment	Conc (g)	Weeks After Treatment (WAT)											
		1	2	3	4	5	6	7	8	9	10	11	12
Sunflower	10	97.85^{a}	97.29^{a}	96.55^{a}	95.95^{a}	95.12^{ab}	94.32^{bc}	93.07^{b}	91.78^{b}	90.52^{b}	89.37^{b}	87.86^{b}	86.48^{b}
	15	96.90^{a}	96.78^{a}	95.93^{a}	95.60^{a}	94.75^{ab}	94.04^{bc}	92.84^{b}	91.17^{b}	90.06^{b}	88.87^{b}	87.76^{b}	86.29^{b}
Hyptis	10	98.58^{a}	98.08^{a}	97.13^{a}	96.28^{a}	95.50^{ab}	94.89^{ab}	93.58^{b}	91.79^{b}	90.18^{b}	88.99^{b}	87.53^{b}	86.20^{b}
	15	97.62^{a}	97.26^{a}	96.82^{a}	95.98^{a}	95.26^{ab}	94.72^{ab}	93.78^{b}	92.06^{b}	90.56^{b}	88.77^{b}	87.71^{b}	86.44^{b}
Aluminum Phosphide	0.375	98.09^{a}	97.59^{a}	97.42^{a}	97.15^{a}	96.57^{a}	96.05^{a}	95.68^{a}	94.94^{a}	93.39^{a}	91.75^{a}	90.42^{a}	88.92^{a}
Control	0	97.73^{a}	97.09^{a}	97.42^{a}	95.19^{a}	94.10^{b}	93.24^{c}	92.13^{b}	90.65^{b}	89.25^{b}	87.62^{b}	86.08^{b}	85.02^{b}

Note: Values with same letter(s) in a given segment of a column are not significantly different at probability level using Tukey's honest significant difference at 5% level of significance

CONCLUSION

The results of this study demonstrate the significant insecticidal potential of Hyptis (*Hyptis suaveolens)* and Sunflower (*Tithonia diversifolia)* against the red flour beetles, *Tribolium castaneum*. The ethanolic leaf extracts of both plant species exhibited strong insecticidal activity in contact. The values obtained indicated that ethanolic (leaf) extracts of *Hyptis suaveolens* and *Tithonia diversifolia* were highly toxic to *T. castaneum*. From the result, Aluminium phosphide treatment was the most efficient in control of *T. castaneum* in all stages of growth while 15 g Hyptis is moderately effective after chemical treatment in control of larva of *T. castaneum* and 10 g of sunflower extract is moderately effective in control of pupa stage of *T. cataneum* in wheat. The present study provides scientific support to existing traditional information that has been available amongst locals for centuries and which attests to the use of both plant species as insecticides against insect pests of agricultural importance.

RECOMMENDATIONS

It is recommended that the insecticidal potentials of both botanicals be conducted on more storage pest. Their efficacy would place them in prominent position as insecticides of major importance.

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