ADAN J. Agric. 2022, 3: 107-113 DOI:10.36108/adanja/2202.30.0121

ISSN 2736-0385

Natural weapons unleashed: Harnessing *Hyptis suaveolens*, charcoal dust, and wood ash extracts for controlling insect pests of Maize (*Zea mays*)

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Abstract
Insect pests pose a significant threat to maize (Zea mays) crops worldwide, leading to substantial yield losses and reduced agricultural productivity. Traditional control methods relying on synthetic pesticides have raised concerns regarding their environmental impact and potential health risks. Therefore, the search for eco-friendly and sustainable alternatives is essential. This study investigates the efficacy of natural extracts derived from Hyptis suaveolens (commonly known as wild mint), charcoal, and wood ash in the control of insect pests infesting maize crops. Research was conducted at an experimental unit at University of Ilorin in 2022 using a pot trial. The experiment employed a randomized complete block design, with treatments including ethanol extracts of Hyptis suaveolens, charcoal dust, and wood ash, as well as a control group with no treatment. A kilogram of wood ash, Hyptis suaveolens and charcoal each was soaked in 5liters of ethanol for 48hours. Each mixture was sieved, extracted and applied at 30g/L to maize plants at various growth stages to assess their insecticidal properties against common pests such as aphids, armyworms, and maize weevils while the control (Cypermethrin) was applied at 2.25ml per liter. The results of the study demonstrated that the application of Hyptis suaveolens extracts significantly reduced the population of insect pests compared to the control group. The extracts exhibited strong insecticidal properties, effectively repelling or eliminating a wide range of insect pests.

***Key words**: Treatment, Insect Pest, Zea mays, Hyptis suaveolens*

Introduction

As important as maize can be, over 300 million farmer's family solely depends on maize for their daily survival in Sub-Saharan Africa (Cock et al., 2017; Kumela et al., 2018). More than 200 species of insects have been reported to affect maize worldwide. Although, some of the stem borer that are associated with maize in Nigeria includes maize stalk borer, Busseola fusca Fuller (Noctuidae), the pink stalk borer, *Sesamia calamistis* Hampson (Noctuidae), the millet stem borer, *Acigona ignefusalis* Hampson (Pyralidae) and the Africa sugarcane borer, Eldana Saccharina Walker (Pyralidae) (Okweche et al., 2010) but Fall army worm still remain the most damaging insect affecting maize.

Fall armyworm (*Spodoptera frugiperda*) is currently the most damaging crop pest affecting maize in South Saharan Africa (SSA), where it has spread very widely (Matova et al., 2020) The severity and nature of stem borer damage depends upon the number of larvae feeding on the plant and the plant's reaction to borer attack (Okweche et al., 2010). This research was conducted to investigate the effect of ethanol extracts of *Hyptis suaveolens*, wood ash, charcoal as control methods against insect pests of maize using a pot trial.

Materials and Methods

The trial was conducted at pavilion of Faculty of Agriculture, University of Ilorin, Ilorin. Kwara State, arranged in a Randomized Complete Block Design (RCBD). Two varieties (Extra early and Oba super 6) of drought resistant maize were planted using a pot system, thirty buckets filled with sterilized soil were used in planting, these buckets were divided equally for planting between the two varieties (fifteen buckets per variety).

Collection and Preparation of Plant Materials

The leaves of *Hyptis suaveolens* were collected and identified at the herbarium unit of the Department of Plant Science, University of Ilorin, Ilorin. The leaves were air-dried for 7 days. The air-dried leaves were finely grinded using an electric blender. Wood ash was sieved to remove all dirt's and charcoal was grinded into tiny fine particles. A kilogram of each material in grounded particles was soaked in 5 litres ethanol for 48hours, it was filtered then taken to the laboratory for evaporation, extraction, and condensation.

Application of Extracts and Data Collection

The application of the extracts was done on a weekly basis at the rate of 30g/l while the chemical control was applied as 2.25ml/L. Data collected were plant height, number of leaves, pest population, number of perforations, yield weight and infected yield. Data collections were on weekly basis starting from the application day. The data collected was subjected to Analysis of Variance (ANOVA) and means were separated using Tukey HSD test at 5% probability level.

Results

Effect of wood ash, charcoal, and *Hyptis suaveolens* extract and cypermethrin on maize plant height for two varieties

The effect of the treatment extracts was observed on the maize plant height and were reported in Tables 1 and 2 for each maize variety respectively. Table 1 revealed that all the extracts showed no significant effect on Extra early maize variety plant height from 1-9 WAT, although there was significant ($P>0.05$) effect observed at 10WAT. At 10WAT, maize plant treated with *Hyptis suaveolens* and cypermethrin had significantly higher height when compared to other treatments. The maize plant treated with charcoal and untreated maize plant showed the least effect on the plant height. The effect of the treatments on the maize variety (Oba super 6) plant height was reported in Table 2. It was observed that all the treatments showed no significant effect on Oba super variety plant height throughout the WAT. The application of cypermethrin on both varieties had the highest plant height which can be attributed to the active ingredient present. As reported, active chemical ingredients are combined with water, solvents, and non-chemical ingredients to repel, kill and control pests in the garden or landscape (Pimentel, 2005).

The pest population was observed after the application of extracts of wood ash, charcoal, *Hyptis suaveolens* and cypermethrin and was reported in Tables 3 and 4 for each variety of maize respectively. For extra early maize variety, at 1 and 2 WAT, there was no significant effect observed on the pest population. At 3-10 WAT, it was observed that the control had highest number of pest when compared with other treatments which was significantly higher than other treatments. This implies that the extract showed a great effect on the pest population with cypermethrin having highest effect with the least pest population. *Hyptis suaveolens* extract were also observed to have high significant effect on the pest population at 9 and 10WAT which might be attributed to the chemical composition of the plant which was not present in the other treatment extracts.

Table 1: Effect of wood ash, charcoal, and *Hyptis suaveolens* extract and cypermethrin on the plant height of Extra early maize plant.

	Weeks after treatment (WAT)									
Treatment	1	2	3	4	5	6	7	8	9	10
Wood ash	13.87^{a}± 1.46	18.13^{a}± 1.03	25.53^{a}± 2.34	34.50^{a}± 4.53	45.40^{a}± 7.61	54.30^{a}± 7.25	88.3^{a}± 2.44	102.3^{a}± 10.03	133.7^{a}± 10.25	170.7^{ab}± 7.01
Charcoal	15.23^{a} ± 1.37	19.00^{a}± 0.87	22.17^{a}± 0.850	28.37^{a}± 1.00	39.57^{a}± 2.23	48.87^{a}± 3.56	84.23^{a}± 5.20	100.40^{a}± 3.08	122.37^{a}± 5.85	145.27^{b}± 2.47
Hyptis suaveolens	16.13^{a}± 3.06	20.93^{a}± 5.18	27.567^{a}± 5.335	35.63^{a}± 5.10	47.10^{a}± 8.62	58.43^{a}± 12.64	94.00^{a}± 9.64	115.10^{a}± 8.03	155.63^{a}± 20.81	184.00^{a}± 11.17
Cypermethrin	14.20^{a}± 1.587	17.33^{a}± 2.41	23.07^{a}± 2.47	31.50^{a}± 1.73	40.07^{a}± 2.11	49.67^{a}± 1.53	90.70^{a}± 2.46	116.57^{a}± 6.69	157.03^{a}± 14.87	186.17^{a}± 14.87
Control	14.77^{a}± 0.68	17.90^{a}± 0.85	22.90^{a}± 1.21	30.53^{a}± 3.05	42.53^{a}± 6.22	51.30^{a}± 5.48	84.73^{a}± 4.61	99.60^{a}± 7.15	125.60^{a}± 6.86	153.87^{b}± 13.13

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at $p = 0.05$

Table 2: Effect of wood ash, charcoal, and *Hyptis suaveolens* extract and cypermethrin on the plant height of Oba super 6 maize plant.

	Weeks after treatment (WAT)									
Treatment	1	2	3	4	5	6	7	8	9	10
Wood ash	13.57^{a}± 0.51	17.10^{a}± 0.90	20.30^{a}± 0.87	26.63^{ab}± 0.645	34.77^{a}± 3.36	43.87^{a}± 3.10	81.40^{a}± 3.55	89.77^{a}± 2.82	119.03^{a}± 4.45	153.77^{a}± 5.93
Charcoal	13.50^{a}± 0.87	16.80^{a}± 0.72	20.77^{a}± 0.97	24.67^{ab}± 2.08	35.90^{a}± 2.71	44.67^{a}± 4.73	78.57^{a}± 7.31	88.03^{a}± 6.96	113.03^{a}± 12.14	143.60^{a}± 20.49
Hyptis suaveolens	14.40^{a}± 1.97	17.50^{a}± 2.21	22.00^{a}± 2.60	27.77^{ab}± 3.42	36.73^{a}± 6.7	47.53^{a}± 8.2	81.47^{a}± 14.73	93.97^{a}± 14.28	120.43^{a}± 26.33	156.7^{a}± 37.06
Cypermethrin	13.80^{a}± 1.44	17.53^{a}± 1.75	21.40^{a}± 1.82	30.67^{a}± 3.79	40.93^{a}± 4.17	52.43^{a}± 5.50	86.13^{a}± 6.41	96.13^{a}± 8.85	122.07^{a}± 12.43	158.00^{a}± 20.52
Control	13.50^{a}± 1.64	15.90^{a}± 1.97	19.90^{a}± 1.83	23.40^{b}± 0.871	31.40^{a}± 2.37	39.43^{a}± 2.95	78.07^{a}± 1.51	86.30^{a}± 4.25	109.67^{a}± 13.35	141.13^{a}± 12.99

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at $p = 0.05$

Table 4 revealed that the pest population observed on the Oba super 6 maize variety was higher than extra early maize. This might be attributed to the susceptibility on the varieties to insect pest. It was further observed that *Hyptis suaveolens* showed significantly highest effect on the pest population which might be attributed to the chemical composition on the plant. The medicinal plant H. *suaveolens* contains high percentage yield of crude alkaloids and flavonoids ranging from 10.44% to 14.32% and 9.28% to 12.54% respectively (Edeoga et al., 2006). Adda et al. (2011) reported that *Hyptis suaveolens* was compared favorably with furadan.

The effect of the pest population was to disrupt the physiological and ability of plants to fully photosynthesize which includes perforation of the leaves. The mean number of perforated leaves for each variety was analyzed and reported in Tables 5 and 6 respectively. The number of perforated leaves was significantly different when considering all treatment extracts and the control. The leaves of extra early maize variety reported in Table 5 revealed that control had significantly highest number of perforated leaves due to highest number of pests earlier reported in this research for both verities. As also reported in Table 3, cypermethrin showed a high significant effect on the pest population, it implies that it had least leaf perforation. Table 4 also reported that *Hyptis suaveolens* had the highest effect on the pest population, it is imperative for it to have the least number of perforated leaves as reported in Table 6. This might as well verify the research of Isman (2006) who reported that botanical insecticides are used as chemo-sterilant. Talukder (2006) also reported that botanical pesticides showed deleterious effects on the growth and development of insects, reducing the weight of larva, pupa and adult stages and lengthening the development stages (Talukder, 2006). Plant derivatives also reduce the survival rates of larvae and pupae as well as adult emergence. Many botanical pesticides have been reported to have a pronounced effect on the developmental period, growth, and adult emergence (Shaalan et al., 2005).

Table 3: Mean pest population of extra early maize variety treated with wood ash, charcoal, *Hyptis suaveolens.* extracts…

Treatment	Weeks after treatment (WAT)									
	1	2	3	4	5	6	7	8	9	10
Wood ash	0.00^{a} ± 0.00	0.00^{a} ± 0.00	1.00^{b} ± 0.56	1.00^{b} ± 0.56	2.00^{b} ± 1.00	2.00^{b} ± 1.00	2.00^{b} ± 1.00	2.33^{b} ± 1.16	1.67^{bc} ± 0.58	2.00^{b} ± 0.00
Charcoal	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{b} ± 0.00	1.00^{b} ± 0.58	1.67^{b} ± 1.16	2.00^{b} ± 1.00	2.00^{b} ± 1.00	2.33^{b} ± 0.58	2.33^{b} ± 0.58	2.33^{b} ± 0.58
Hyptis suaveolens	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{b} ± 0.00	0.00^{b} ± 0.00	2.00^{b} ± 1.00	1.00^{b} ± 0.58	0.67^{b} ± 0.58	1.00^{b} ± 0.58	1.00^{bc} ± 0.00	1.00^{bc} ± 0.00
Cypermethrin	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{b} ± 0.00	0.00^{b} ± 0.00	1.00^{b} ± 0.58	1.00^{b} ± 0.58	1.00^{b} ± 0.58	0.67^{b} ± 0.58	0.33^{c} ± 0.58	0.33^{c} ± 0.58
Control	0.00^{a} ± 0.00	0.00^{a} ± 0.00	4.00^{a} ± 2.00	4.33^{a} ± 2.08	4.67^{a} ± 1.53	5.67^{a} ± 1.16	5.00^{a} ± 1.00	5.00^{a} ± 1.00	5.33^{a} ± 1.16	5.33^{a} ± 1.16

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at $p = 0.05$

Table 4: Mean pest population of Oba super 6 maize variety exposed to wood ash, charcoal, *Hyptis suaveolens.*

	Weeks after treatment (WAT)									
Treatment	1	2	3	4	5	6	7	8	9	10
Wood ash	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{a} ± 0.00	1.33^{a} ± 0.58	1.33^{ab} ± 0.58	1.67^{ab} ± 0.58	2.33^{a} ± 0.58	2.67^{ab} ± 0.58	3.33^{a} ± 0.58	3.33^{ab} ± 0.58
Charcoal	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.67^{a} ± 1.16	1.00^{a} ± 1.00	1.33^{ab} ± 0.58	2.00^{ab} ± 0.00	2.33^{a} ± 0.58	2.67^{ab} ± 1.16	2.67^{ab} ± 1.16	2.67^{ab} ± 1.16
Hyptis suaveolens	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.00^{b} ± 0.00	0.00^{c} ± 0.00	0.00^{b} ± 0.00	0.33^{c} ± 0.58	0.67^{b} ± 1.16	1.00^{b} ± 1.00
Cypermethrin	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.67^{a} ± 0.58	1.00^{a} ± 1.00	1.00^{ab} ± 1.00	1.00^{bc} ± 1.00	0.67^{b} ± 0.58	1.33^{bc} ± 0.58	1.67^{ab} ± 1.16	2.00^{ab} ± 1.00
Control	0.00^{a} ± 0.00	0.00^{a} ± 0.00	0.67^{a} ± 0.58	1.00^{a} ± 1.00	2.33^{a} ± 0.58	2.67^{a} ± 0.58	3.00^{a} ± 1.00	3.33^{a} ± 0.58	3.67^{a} ± 0.58	4.00^{a} ± 1.00

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at $p = 0.05$

Table 5: Mean number of perforations in Extra early maize variety exposed to wood ash, charcoal, *Hyptis suaveolens.*

	Weeks after treatment (WAT)									
Treatment	1	2	3	4	5	6	7	8	9	10
Wood ash	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.33^{b} \pm 0.58$	$1.00^{a} \pm 1.00$	$3.00^{b} \pm 2.00$	$4.67^{b} \pm 2.08$	$5.67^{b} \pm 1.16$	$7.67^{b} \pm 1.16$	$6.67^{b} \pm 2.52$	$5.33^{bc} \pm 3.22$
Charcoal	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.67^{b} \pm 1.16$	$1.67^{b} \pm 1.53$	$3.00^{b} \pm 2.00$	$4.67^{b} \pm 1.53$	$5.67^{b} \pm 2.31$	$7.00^{b} \pm 2.00$	$7.00^{b} \pm 2.00$	$7.00^{b} \pm 2.00$
Hyptis suaveolens	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{b} \pm 0.00$	$1.33^{b} \pm 1.53$	$1.33^{b} \pm 1.53$	$2.00^{b} \pm 1.73$	$2.33^{b} \pm 2.08$	$2.33^{bc} \pm 2.08$	$3.33^{bc} \pm 0.58$	$3.67^{bc} \pm 0.58$
Cypermethrin	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{b} \pm 0.00$	$0.00^{b} \pm 0.00$	$0.33^{b} \pm 0.58$	$0.67^{b} \pm 0.58$	$1.00^{b} \pm 1.00$	$1.33^{c} \pm 1.53$	$0.33^{c} \pm 0.58$	$0.33^{c} \pm 0.58$
Control	$0.00^{a} \pm 0.00$	$1.67^{a} \pm 2.89$	$8.67^{a} \pm 5.51$	$10.67^{b} \pm 5.69$	$12.33^{a} \pm 6.11$	$14.67^{a} \pm 7.23$	$14.33^{a} \pm 3.51$	$14.33^{a} \pm 3.51$	$17.67^{a} \pm 3.22$	$17.67^{a} \pm 3.22$

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at p = 0.05

Table 6: Mean number of perforations in Oba Super 6 maize variety exposed to wood ash, charcoal and *Hyptis suaveolens.*

	Weeks after treatment (WAT)									
Treatment	1	2	3	4	5	6	7	8	9	10
Wood ash	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$2.00^{a} \pm 1.00$	$2.00^{a} \pm 1.00$	$3.67^{a} \pm 1.16$	$7.67a^{b} \pm 2.51$	$8.33^{ab} \pm 1.53$	$9.67^{a} \pm 0.58$	$10.67^{a} \pm 2.08$
Charcoal	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.67^{a} \pm 1.16$	$1.33^{a} \pm 1.53$	$2.00^{a} \pm 1.00$	$5.33^{a} \pm 0.58$	$8.67^{a} \pm 2.52$	$10.00^{a} \pm 3.61$	$10.0^{a}0 \pm 3.61$	$10.00^{a} \pm 3.61$
Hyptis suaveolens	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{c} \pm 0.00$	$0.33^{c} \pm 0.58$	$1.33^{b} \pm 2.31$	$2.33^{b} \pm 2.08$
Cypermethrin	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$2.00^{a} \pm 2.00$	$3.33^{a} \pm 3.51$	$3.67^{a} \pm 4.04$	$4.33^{a} \pm 5.13$	$2.33^{bc} \pm 2.08$	$3.33^{bc} \pm 0.58$	$3.67^{ab} \pm 0.58$	$4.00^{ab} \pm 1.00$
Control	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$1.33^{a} \pm 1.53$	$1.67^{a} \pm 1.53$	$3.33^{a} \pm 0.58$	$4.67^{a} \pm 0.58$	$7.67^{b} \pm 3.06$	$8.00^{ab} \pm 2.65$	$9.67^{a} \pm 3.51$	$10.33^{a} \pm 3.79$

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at p = 0.05

The yield weight was observed after the application of treatment ethanolic extract and was reported in Table 7. There was a significant difference observed in all the treatment. Although it has been reported by Barre and Jenber, (2022) that maize has extremely high yielding potentials. The effect of the pesticides contributed to the yielding capacity of various varieties. Cypermethrin application as an inorganic chemical had the highest yield weight of 241.72g and 230.9g for Oba super 6 and Extra early respectively. This was significantly higher than any of the organic treatment (*Hyptis suaveolens*, wood ash and charcoal). Although there was no significant difference observed in the yield weight with respect to application of *Hyptis suaveolens*, wood ash and charcoal for Oba super 6 while the control treatment showed the significantly least yield weight of 90.67g and 110.43g for Oba super 6 and Extra early respectively. This might be attributed to the chemical composition and active ingredient present in all the treatment. Also, Naz et al. (2003) reported similar conclusion that treated maize plant had higher yield weight as compared to untreated maize plants. Considering the yield weight of the two verities, extra early verities had a higher yield weight with respect to each treatment. This might be attributed to the genetical makeup of the verities or the effect of the insect pest perforating the maize thereby affecting the photosynthesis ability. The yield infected was further analyzed and was observed that there was no significant difference observed in the yield infested when all the treatment was applied even the control. Although the yield infested was high in the control pot where no application was made while application of cypermethrin showed no infested yield. This implies that both varieties might be resistance to the insect pest. Sharma and Ortiz, (2002) reported about resistance to insect pest being a criterion to release varieties and hybrid for cultivation by the farmers.

Table 7: Mean yield of maize (extra early and Oba super 6) exposed to wood ash, charcoal, *Hyptis suaveolens* and cypermethrin.

Treatment	Yield weight (g)		Yield infested	
	Oba Super 6	Extra Early	Extra Early	Oba super 6
Wood ash	140.01^{b}±9.94	135.82^{bc}±5.54	19.67^{a}±17.21	21.33^{a}±36.95
Charcoal	116.24^{b}±30.77	145.48^{b}±40.49	12.67^{a}±21.94	8.67^{a}±7.17
Hyptis suaveolens	155.59^{b}±16.86	163.96^{ba}±17.34	29.00^{a}±28.05	14.67^{a}±25.40
Cypermethrin	241.72^{a}±44.83	230.90^{a}±56.69	0.00^{a}±0.00	0.00^{a}±0.00
Control	90.67^{c}±39.87	110.43^{c}±37.77	33.67^{a}±14.19	37.33^{a}±27.54

Mean values in the same column with the same alphabets are not significantly different from each other according to Tukey HSD at p = 0.05

Conclusion and Recommendations

Hyptis suaveolens showed significant control against the pest in both varieties considered. The application of ethanolic extracts of *Hyptis suaveolens* showed a higher control effect on the pest which contributed immensely to the yield weight, although the chemical application had the highest yield weight followed by the *Hyptis suaveolens* extracts. From eco-friendly approach *Hyptis suaveolens* ethanolic extract will be more advised against maize pest infestation.

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