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Evaluation of the Insecticidal and Deterrence Properties of Pepper Fruit, *Dennetia tripetala* (G. Baker) and Ginger *Zingiber officinale* Roscoe against Maize Weevil *Sitophilus zeamais* (Motsch.)

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Abstract
Laboratory studies were conducted to evaluate the insecticidal and deterrent properties of pepper fruits (*Dennetia tripetala*) and ginger (*Zangiber officinale*) against maize weevil *Sitophilus zeamais*. One hundred grams of maize were weighed into 500ml kilner jar and treated with 0%, 1%, 5% and 10% powders each of *D. tripetala* and *Z. officinale* on weight by weight (w/w) basis. The experiments were laid out in a 4x4 factorial combinations and arranged in a Complete Randomized Design (CRD) and replicated four times. The results showed significant (P<0.05) percentage mean adult mortality of 13.34, 15.34 and 16.33 post treatment with *D. tripetala* and 11.33, 14.33 and 18.7 post treatment with *Z. officinale* at 10% after 24, 48 and 72h respectively over other levels. The percentage adult mortality at 5% was significantly (P<0.05) higher after 72 hours post exposure than at 1% and the control. Significantly (P<0.05) higher percentage adult mortality was also observed in the 10% combinations of the tested plant products of 4, 5.33 and 5.67 after 24, 48 and 72 hours of storage for *D. tripetala* and *Z. officinale* respectively. Also, significantly (P<0.05) higher mean adult emergence of 266.42 and 267.58 were observed on *Z. officinale* and *D. tripetala* treated seeds after 10 weeks storage period. Interaction of the tested powders also showed significantly (P<0.05) lower adult emergence at 10%. Significantly (P<0.05) higher percentage adult deterrence was observed when 10% *D. tripetala* and *Z. officinale* was applied compared to the other levels, however, this was significantly different at 5%. Significant (P<0.05) reduction in the number of adults that emerged was observed when treatment concentrations increased. The interaction at 10% showed significantly (P<0.05) higher than percentage reproductive deterrence than at the other levels. The studies showed that extracts of *Z. officinale* and *D. tripetala* can be used effectively in the management of *S. zeamais* in store.

Keywords: *Dennetia tripetala, Sitophilus zeamais*, mortality, deterrence, protectants

INTRODUCTION:

Maize (*Zea mays* L. Merri) is a major staple food together with rice in the cereal group in Nigeria (Adesuyi, 1979), where it is cultivated mostly for its seeds either as dry grains or green maize with an estimated national production of 5.2 million metric tonnes (Adesuyi, 1979). It is also called 'corn' especially in the United States of America which is referred to as the Corn Belt. It is usually stored to provide food reserve during off season, and also as seed material for planting (Okoruwa, 1996).

Maize is heavily infested in the tropics by various vertebrate and invertebrate pests which include rodents and insects (Adedire *et al*., 2011), the most important being the maize weevil, *Sitophilus zeamais* (Adedire, 2001) which is a field to store pest of maize in several parts of Africa including Nigeria (Akob and Ewete, 2007; Ukeh *et al*., 2009, Isah *et al*., 2012). Almost infestation of the weevil commences in the field, but most of the damage is done during storage (Demissie *et al*., 2008). Losses ranging from 20 to 90% due to *S. zeamais* have been reported (Delima, 1987; Giga *et al*., 1991). Damaged grains have reduced nutritional values, germinability, weight loss and market values (Okiwelu *et al*., 1987; Abebe *et al*., 2009).

The devastating loss of stored products to insect attack has therefore necessitated the use of various measures such as chemical control against maize weevils. However, the use of insecticide for the control of stored product insect pests is of global concern with respect to environmental hazards, development of resistance, chemical residues in food, side effects on non-target organisms and the associated cost (Cherry *et al*., 2005; Abebe *et al*., 2009). The use of plant products against pest damage is a common practice in traditional farm storage systems in most developing countries including Nigeria (Poswal and Akpa, 1991; Boeke *et al*., 2004).

Pepper fruit (*D. tripetala*) and ginger (*Z. officinale*) are spices that are found locally in Southern Nigeria. They are used in spicing soup, meat and mixed with other herbs in traditional African medicine and its insecticidal potential has been reported (Umoetok*, et al*., 2004; Ukeh, *et al*., 2011). The aim of this research work is to evaluate the insecticidal and deterrence properties of pepper fruit (*D. tripetala*) and ginger (*Z. officinale*) against *S. zeamais* in stored maize.

MATERIALS AND METHODS:

Insect culture

The insects used for the experiments were obtained from a stock culture in the Department of Crop Science, University of Calabar, Nigeria. Maize seeds were purchased from local farmers in Obudu, Cross River State, Nigeria and were sterilized in a Gallenkamp oven set at 60°C for 3 hours to eliminate the possibility of any inhibiting insects (Isah *et al*., 2012).

Matured ripe pepper fruits (*D. tripetala*) and ginger (*Z. officinale*), were bought from the local market in Calabar and the identity confirmed in the Department of Crop Science, University of Calabar. The fruits were rinsed and dried under the shade. The dried fruits were later blended using mechanical blender and sieved using 2mm sieve to obtain fine powder. The powder was sealed in a transparent plastic container and kept in the laboratory until needed.

Experimental procedure

One hundred grammes (100g) maize were weighed into 500ml kilner jars which were treated with 0%, 1%, 5% and 10% of *D. tripetala* and *Z. officinale* combinations on w/w basis. Twenty 1-3 days old unsexed synchronized adults were introduced into each kilner jar. The treatments were arranged in a 4x4 factorial combinations laid out in a Complete Randomized Design (CRD) and replicated four times. The kilner jars were covered with a nylon mesh to screen out any unwanted organism from gaining access to the medium and to ensure proper ventilation.

Mortality count was conducted after every 24hr for three days post insects introduction. Dead insects were counted and discarded while live ones were returned to their respective containers. Ten days after introduction both live and dead insects were removed and recorded, and the treated maize kept for F1 progeny emergence. Four weeks later, all emergent adults were sieved out and counted and removed from each container on a daily basis to prevent mating. The experiment was terminated when no new adult emerged from any of the treatments.

Reproductive potential deterrence

The reproductive potential deterrence of treatments was calculated using the formula:

[(Mean no. of emerged adults in control – Mean no. of emerged adults in treated crop)] ÷ (Mean no. of emerged adults in control) x 100

Germination test

Germination test was conducted after 10 weeks post treatment when there was no more adult emergence from any of the treatments. Twenty seeds were randomly selected from each treatment and soaked in distilled water for 20 minutes after which the grains were removed and placed in labelled Petri dishes pre-lined with Fisherbrand QL 100 filter paper. The grains were moistened for four days after which germination percentage was calculated as:

[(No. of sprouted seeds ÷ Total no. of seeds in Petri dish X 100)]

Data Analysis

Data obtained were analysed using Analysis of Variance (ANOVA), using GENSTAT 15v statistical software.

RESULTS

Results from this study showed that there was significantly ($P \leq 0.05$) higher percentage mortality in maize seeds treated with 5% and 10% doses of *D. tripetala* and 10% *Z. officinale* compared to 1% and the control (Table 1). Significantly ($P \leq 0.05$) higher percentage mean adult mortality was also observed when higher doses of 10% *Z. officinale* and *D. tripetala* were combined (Table1). After 48 hours exposure the combination of 10% *D. tripetala* and *Z. officinale* recorded significantly ($P \leq 0.05$) highest mean percentage mortality. Also, significantly higher percentage mean mortality was recorded when 5% and 1% *Z. officinale* was applied from the control. The same trend was observed in the applications of *D. tripetala*.

However, when *D. tripetala* was combined at 10% with 1%, 5% and 10% of *Z. officinale* significantly higher percentage mean mortality was observed from other treatment combinations. The same trend was observed after 72 hours storage period with the higher concentration of *D. tripetala* and *Z. officinale* recording higher significant mean mortality which was observed throughout as the percentage concentration of the two powders increases. Progressive increase in number of adult mortality was recorded with increase in exposure period as higher mortality was recorded between 24 and 48h, and between 48 and 72h

Significant lower ($P < 0.05$) percentage adult emergence (Table 2) was observed in the treated maize seeds than the control after ten weeks of treatments application. Thus, the maize treated with 10% *D. tripetala* and *Z. officinale* respectively recorded significantly lower adult emergence than the other treatments. Adult emergence decreased significantly as the concentration of the powders increased (Table 2). No significant ($P>0.05$) difference was observed when 10% of *D. tripetala* was mixed with either 10% or 5% *Z. officinale* (Table 2).

Significant ($P<0.05$) percentage reproductive potential deterrence was observed when 5% and 10% *D. tripetala* was applied and this was significantly ($P<0.05$) different from seeds treated with 0% and 1% (Table 3). Also, significant difference was observed when 5% and 10% *Z. officinale* was mixed with maize from the control and at 1%. Significant ($P<0.05$) difference was also observed when 10% *Z. officinale* was combined with 5 and 10% *D. tripetala*

Moreover, higher significant ($P< 0.05$) reproductive potential deterrent effect of the treatment on *S. zeamais* was observed in the mean adult emergence. *D. tripetala* applied at 5% and 10% doses 10.31 and 12.52 respectively from control and 1%. The percentage reproductive deterrence observed when *Z. officinale* was applied was significantly ($P< 0.05$) different progressively from the control, with 18.04 observed when 10% *Z. officinale* was applied. Significant difference was observed in the treatment combinations of the treatment applied. Higher significance ($P< 0.05$) (30.47) reproductive deterrence was recorded when *D. tripetala* and *Z. officinale* was applied at 10% from the other treatment combinations.

Significant difference was observed among the mean percentage germination of the seeds treated with different doses of *D. tripetala* and *Z. officinale* post infestation (10 weeks) (Fig. 1). The highest mean percentage germination (88.8%) was observed in seeds treated with 10%, followed by 5% (63.5%) and 1% (15.57%) respectively, while in control 9% of the seeds germinated.

DISCUSSION

The result from this study showed that *D. tripetala* fruits and *Z. officinale* possess insecticidal and deterrence properties and can play a significant role in food preservation and protection against *S. zeamais*. Their extracts significantly ($P<0.05$) increased adult mortality, increased percentage reproductive potential deterrence, reduced F1 progeny emergence and improved germination percentage, and their efficacy was also shown to increase with increased dosage and time of exposure. Ukeh *et al*. (2011) reported that *D. tripetala* could be a source of biologically active plant material, which could be harnessed in stored product protection in small scale level in the developing world. The toxicity and repellence property of *D. tripetala* ethanol extract against larvae and adults of *Dermestes maculatus* on catfish, *Claries gariepinus* Burchell have also been reported (Akinwumi *et al*., 2007) while its seed powder and solvent extracts in stored *D. maculatus* compared favourably with pyrethrum (Egwunyenga *et al*., 1998). Again, Inyang and Emosairue (2005) reported that aqueous extract of *D. tripetala* seed elicited dosage dependent antifeedant and repellent properties against the banana weevil *Cosmopolites sordidus* Germar.

Data from this experiment showed higher mortality of adults, deterrence and lower F1 progeny emergence with increased dosage and time of exposure. Although the mode of action of the powder was not investigated but dehydration due to the adhesion of the powder to the outer layer of the cuticle (Gwinner *et al*., 1996; Saayman, 1997) could also be implicated as a cause for the mortality. The powder may also have blocked the insect's spiracles resulting in suffocation and death (Ramaswamy *et al*., 1995). Timothy and Okeke (2008), reported that toxicity of *D. tripetala* may be imparted by the presence of β – phenyl-nitroethane which is an active ingredient of *D. tripetala*.

Lower progeny emergence could be attributed to the ovicidal properties of the powder, as has been the case with other plant materials investigated (Obeng-Ofori *et al*., 1997; Tapondjou *et al*., 2002). Nelson and Guy (2010) reported the essential oils extracted from the leaves and bark of *L. sempervirens* and *D. winteri* were shown to possess contact and fumigant toxicity as well as repellent activity towards *Tribolium castaneum*. Many plant products, such as essential oils, have been screened for their repellent activity against stored grain pests (Cosimi *et al*., 2009; *Nerio et al*., 2009). In conclusion, plant materials are more preferred to synthetic chemicals in pest management due to their being locally available, safer for use to both animals and environmental health and less likelihood for insects to develop resistance to them. The seeds fruits are also readily available, cheaper and easy to process and apply

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Table 1: Effect of *D. tripetala* and *Z. officinale* powder on adult *S. zeamais* motality at 24, 48 and 72 hours post treatment

Treatments	0%	Cumulative percentage mean mortality of *S. zeamais* 1%	5%	10%	Total (A)
		24 Hours			
0%	1.00	0.67	1.67	4.00	1.83
1%	1.00	0.67	1.67	2.67	1.50
5%	1.00	0.67	1.67	2.67	1.50
10%	2.33	2.00	3.00	4.00	2.83
Mean (*D. tripetala*)	1.33	1.00	2.00	3.34	
LSD (<0.05) = 1.92 (Interaction)					
LSD (<0.05) A = 1.15 (*Z. Officinale*)					
LSD (<0.05) B = 1.67 (*D. tripetala*)					
		48 Hours			
0%	0.00	0.67	1.00	2.67	1.09
1%	0.00	1.67	2.00	3.67	2.09
5%	1.00	1.67	2.00	3.67	2.09
10%	1.00	3.33	3.67	5.33	3.58
Mean (*D. tripetala*)	1.00	1.84	2.17	3.84	
LSD (<0.05) = 1.99 (Interaction)					
LSD (<0.05) A = 1.57 (*Z. Officinale*)					
LSD (<0.05) B = 1.94 (*D. tripetala*)					
		72 Hours			
0%	0.33	1.67	2.00	3.00	1.75
1%	0.67	2.00	2.33	3.33	2.58
5%	1.67	3.00	3.33	4.33	3.08
10%	3.33	4.67	5.00	5.67	4.67
Mean (*D. tripetala*)	1.50	2.84	3.17	4.08	
LSD (<0.05) = 1.65 (Interaction)					
LSD (<0.05) A = 4.72 (*Z. Officinale*)					
LSD (<0.05) B = 5.42 (*D. tripetala*)					

TABLE 2: Effect of *D. tripetala* and Z. officinale powder on mean adult emergence of *S. zeamais* after 10 weeks of storage

	D. tripetala				
Z. officinale	0%	1%	5%	10%	Mean (*Z. officinale*)
0%	425.00	387.67	357.67	325.33	373.92
1%	366.33	329.00	299.00	266.67	315.25
5%	360.00	322.67	292.67	260.33	308.92
10%	317.67	280.33	250.33	218.00	266.42
Mean (*D. tripetala*)	367.25.00	329.92	299.92	267.58	

LSD (<0.05) = 43.83 (Interaction)
LSD (<0.05) A = 12.75 (*Z. Officinale*)
LSD (<0.05) B = 12.77 (*D. tripetala*)

TABLE 3: Effect of *D. tripetala* and *Z. officinale* powder on percentage reproductive potential of *S. zeamais*

Treatments (%)	Reproductive potential deterrence (%)				
	0	1	5	10	Mean (*Z. officinale*)
0	0.00	0.00	0.00	0.00	0.00
1	2.31	4.83	7.01	8.17	5.58
5	4.57	6.21	9.22	11.42	7.86
10	6.49	10.20	25.01	30.47	18.04
Mean (*D. tripetala*)	3.34	5.31	10.31	12.52	

LSD (<0.05) = 3.83 (Interaction)
LSD (<0.05) A = 1.14(*Z. Officinale*)
LSD (<0.05) B = 2.77 (*D. tripetala*)

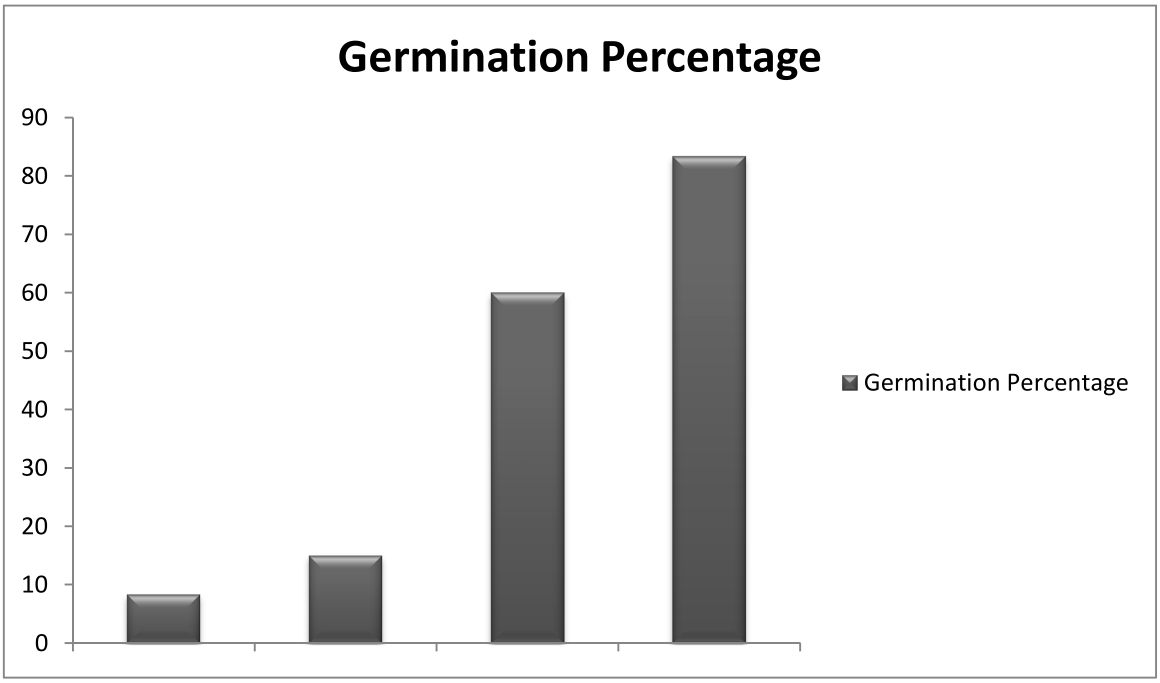

Fig 1: Mean germination percentage of maize seeds treated with *D. tripetala* and *Z. officinale* extract after 10 weeks storage period