Control of *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) with local plant materials in the western highlands of Cameroon

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ABSTRACT

Sitophilus zeamais Motschulsky is the main insect damaging stored maize in the western highlands of Cameroon. High cost, unreliable supply and environmental hazards of chemical insecticides necessitate search for cheaper, safe and easily available local alternatives. This study identifies and evaluates some local plant materials for control of *S. zeamais*. Field survey and laboratory studies were conducted and four plant materials consisting of leaves and/or roots; *Cupressus arizonica, Eucalyptus grandis, Ocimum gratissimum* and *Vetiveria zizanioides* identified were powdered and investigated. The experimental design used was randomized complete block. Data collected were analysed using F-test and significant means were separated using Least Significant Difference.

The powdered plant materials showed no significant toxicity against F1 progeny but *V. zizanioides* significantly ($P \leq 0.01$) repelled S. zeamais, giving ≥50% at the lowest dosage of 0.1g/25g grains. *V. zizanioides* root powder had potential for control of *S. zeamais* as repellent. This could form part of an integrated pest management package for the Western highlands of Cameroon.

Keywords: Survey, *Vetiveria zizanioides, Sitophilus zeamais*, control, maize, Cameroon

RESUME

Sitophilus zeamais Motschulsky est l'insecte principaux detruiante le maïs pendant le stockage dans les hauts plateaux de l'Ouest du Cameoun. Les coûts éléves, l'offre inconsistente et l'hazard environmental des insecticides chemique necessite la cherche des mésures corollaries locaux, sans danger, facilement trouvé et moins cher. Cette étude identifie et evalue quelques matèriels végétaux locaux pour le traitement de *S. zeamais*. Les études du terrain et du laboratoire sont conduit et quatre matèriels végétaux consistent les feulles et/ou racines; *Cupressus arizonica, Eucalyptus grandis, Ocimum gratissimum* et *Vetiveria zizanioides* identifié était poudrer et examiner. Le modèle experimental utilisé était le block complètement randomizé. Les données collectées ont été analysées en utilisant le test de Fischer et les moyens significatifs étaient séparés en utilisant les plus petites differences moins signifiatives. Les matèriels poudrées n' ont pas donnaient une toxicitée significatifs mais une repellence significatifs ($P \leq 0.01$) contre *S. zeamais* avec *V. zizanioides* donnant plus de 50% au dosage le plus base de 0.1g/25g graines. Les racines de *V. zizanioides* poudre avaient le potentielle pour controller *S. zeamais* comme repellent. Ça peut formé partie d'un strategie de lutte integré pour *S. zeamais* dans les hauts plateaux de l'Ouest du Cameroun.

Mots clés : Enquête, *Vetiveria zizanioides, Sitophilus zeamais*, lutte, maïs, Cameroun.

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1. INTRODUCTION

Maize, *Zea mays* (L) is one of the most important cereal crops in the world today with industrial and household uses. It is consumed as food by humans in various forms, feed for animals and used as raw material for the manufacture of bio-fuels, among many other industrial products. Insect pests are among the most serious factors limiting maize production in various maize growing areas of the world (Bosque-Pérez, 1995). The maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) is a major post-harvest insect pest of stored maize in the tropics. In the western highlands of Cameroon (WHC), it is the main insect pest that damages maize in storage (Ngoko, 1999; Akob and Ewete, 2007). In 1990-91 McHugh (1994) reported that quantitative losses in Ndop due mainly to *Sitophilus zeamais* was up to 33% while qualitative losses attained 52%.

The high cost of synthetic chemical insecticides, risk of contamination of users and their unreliable supply necessitate the search for safer, cheaper and easily available local alternatives such as natural materials of plant origin. The use of plant materials in pest control could be come an important supplement to imported synthetic pesticides because they have an important potential for integrated pest management programmes in developing countries, since they are cheap and readily available Bekele et al., (1996). The use of locally available plant materials to protect stored products against pest damage is common practice in traditional farm storage systems in most developing countries (Poswal and Akpa, 1991; Bekele et al., 1996; Achiano et al., 1999; Boeke et al., 2004). They are biodegradable and so do not persist in the environment or accumulate in the food chain (Jood et al., 1993; Onu and Aliyu, 1995; Ewete et al., 2000).

The objective of this study was to identify and evaluate some local plant materials for control of *S. zeamais* in the western highlands of Cameroon, where the use of botanicals for post-harvest protection of grains is prevalent.

MATERIALS AND METHODS

Source of maize grains

Clean, healthy, uninfested grains of KASAI maize variety collected from the Institute of Agricultural Research for Development (IRAD) Bambui, Cameroon were used for the study. The maize grains were stored in a deep-freezer for a month to kill any insects resulting from field infestation. They were removed from the freezer at -5 to -20^{0}C and allowed to remain under ambient temperature of 13.8 - 26.8^{0}C and 41-82% relative humidity, for moisture equilibration for 3 weeks before use.

Insect culture

Sitophilus zeamais culture was established using adults collected from the maize barn of the Regional College of Agriculture (RCA) Bambili, Cameroon. One hundred weevils were introduced into 250g maize grains in each of 5 kilner jars with mesh lids. These were kept in the crop protection laboratory of RCA Bambili under ambient temperature of 13.8-26.8^{0}C and 41-82% relative humidity to start the insect culture. After 3 weeks of mating and oviposition, the adult weevils were removed. The kilner jars were observed daily and teneral adult weevils removed from the cultures and sexed using the method of Halstead (1963). This insect culture was maintained and used as source of *S. zeamais.*

Identification and preparation of plant materials

A survey was conducted in geographically representative locations in each of the seven divisions of the Northwest Region, western highlands of Cameroon to identify plant species being used locally by farmers to control the maize weevil, *S. zeamais*.

A random sample of 50 farmers from each of the seven divisions of the province (i.e. 350 farmers for the whole province) was interviewed to get information on plant materials being used as maize grain protectant as well as some other basic information on *S. zeamais* and its control in the region (Table 1). A questionnaire was used in the survey so as to allow for an orderly collection of information as well as to facilitate analysis of the information so collected. Personal observations on the field and available literature were also used to properly identify plant species. Those that could not be identified immediately were carefully preserved and later identified with assistance of plant taxonomist in the Department of Forestry, University of Ibadan.

All identified plant materials to be investigated were collected and air-dried under shade for 7 days in the screen house of the Institute of Agricultural Research for Development (IRAD) Bambui. This was to ensure that volatile active principles were retained in the dried samples. Each of the dried plant materials was ground to powder in a milling machine and then sieved through a 0.5mm mesh and 250g of each, packaged in plythene bag, labeled and kept in the refrigerator for the bioassay.

Table 1: Survey on the control of *Sitophilus zeamais* and products used in the Northwest* region, western highlands of Cameroon

Parameters investigated	Distribution of respondents in the seven divisions							Total number out of 350 respondents	Percentage respondents
	Boyo	Bui	Donga/ Mantung	Menchum	Mezam	Momo	Ngoketunjia		
Maize storage for future use	50	50	50	50	50	49	50	349	99.7
S. zeamais, most serious insect pest	50	50	50	50	50	49	50	349	99.7
Products used for *S. zeamais* control:									
Insecticides	19	18	20	10	24	21	22	134	38.3
Local plant materials	23	22	20	22	21	24	19	151	43.1
No treatment	8	10	10	18	5	5	9	65	18.6
Availability of insecticides**	6	11	5	9	10	16	10	67	19.1
Affordability of insecticides**	12	9	8	5	20	14	10	78	22.3
Awareness of hazards of insecticides**	19	15	12	20	25	19	27	137	39.1

*Northwest region has seven administrative divisions and random samples of 50 farmers per division were interviewed (total of 350 respondents)
**Factors related to insecticide use

Bioassay with powdered plant materials

The 250g milled samples of each of the four plant species kept in the refrigerator were used for the bioassay. They were used as direct admixtures to the maize grains at rates calculated on a weight of powdered material per weight of grain (wt/wt) basis, for the toxicity on F1 progeny as well as repellency evaluation against *S. zeamais.*

Toxicity of powdered materials on F1 progeny

The effects of treated maize grains on F1 progeny of *S. zeamais* were investigated using powdered samples from the four test plant species; *C. arizonica, E. grandis, O. gratissimum* and *V. zizanioides* at five rates of 0, 0.1, 0.25, 0.5 and 1.0g/25g of maize grain, determined by preliminary tests and as has been used in previous similar studies.

Twenty-five grammes of maize grains were placed in five separate kilner jars for each of the four powdered plant material and treated with the five different rates of powdered plant materials. Each kilner jar containing maize grains and powdered materials was shaken for even coverage of grains. Ten 1-2 day-old adult maize weevils of mixed sexes (1male: 1female) were introduced into each kilner jar and covered with a lid having mesh. The experiment was laid out as a 4x5 factorial, in four replications and with the treatments arranged in a RCB design. After 7 days, all adult weevils were removed and the kilner jars with grains left undisturbed for about 30 days. This was followed by daily observations and recording of F1 progeny emergence. The data collected on emerged F1 progeny were analyzed using ANOVA and treatment means that showed significant difference ($P \leq 0.05$) were separated using LSD.

Repellent activity of powdered plant materials

The repellent action of the four powdered plant materials; *C. arizonica, E. grandis, O. gratissimum* and *V. zizanioides*, each applied at five different rates (0, 0.1, 0.25, 0.5 and 1.0g/25g of maize grains) were evaluated in a choice experiment (in which, *S. zeamais* had to select either treated or untreated maize grains). The treated and untreated grains were placed opposite each other with a space of 24cm in between them in a round plastic tray of 30cm diameter, under-lain with rough paper to facilitate crawling by the insects. The tray was covered using a nylon mesh with a hole cut in the middle for introduction of the test insects and held in position with a rubber band fastened over the mesh around the tray. Five lots of 25g maize grains were each treated with one of the five rates of powdered plant materials, and each placed near the circumference inside a circular plastic tray. Another 25g of untreated grain were also placed near the circumference inside the circular plastic

tray but at the diameter position or directly opposite the treated grains of each tray and covered. Ten 1-2 day-old adult *S. zeamais* were introduced into each tray through the hole in the middle of the mesh cover, with a small funnel. A randomized complete block (RCB) design was used with the five rates of powdered plant material as treatment in four replications. The number of weevils present on the control and treated maize grains were recorded after one hour and the Percent Repellency (PR) computed as:

$PR = [(Nc - Nt)/(Nc + Nt)] \times 100$

Where (Nc) = number of weevils present on the untreated (control) maize grains and

(Nt) = number of weevils present on treated maize grains.

A negative PR value was treated as zero and the data analyzed using ANOVA after transforming them into arcsine values (Little and Hills, 1978).

RESULTS

Identification of plant materials for control of S. zeamais

Survey of locally available plant species used by farmers in Cameroon as grain protectants against infestation revealed that 99.7% of the farmers (respondents) recognized *S. zeamais* as the most serious insect pest of stored maize.

For the control of the weevil, 43% used local plant materials, 38.3% used synthetic insecticides while some farmers (18.6 %) did not treat their maize before storage (Table 1). In addition, 19.1% of the respondents indicated that insecticides were available when needed while 22.3% indicated that they were affordable.

Figure 1 shows plant materials being used for control of *S. zeamais* in the Northwest region, western highlands of Cameroon while Table 2 shows the botanical identity of the plants and plant parts being used. The most frequently used four plants were short-listed for the bioassay included cypress leaves (*Cupressus arizonica* Greene), Eucalyptus leaves (*Eucalyptus grandis* Hill ex Maiden), Ocimum leaves (*Ocimum gratissimum* Linn.) and vetiver roots (*Vetiveria zizanioides* (Linn.) Nash).

Bioassay with powdered plant materials

Powdered plant materials applied to maize grains at varying doses of 0.1 - 1.0 g/25g of grains showed no significant toxicity to F1 progeny of *S. zeamais* infesting maize (Table 3).

Powdered plant materials at different doses of 0.1 - 1.0 g/25g of grains had significant ($P \leq 0.01$) repellent action against *S. zeamais* (Table 4). Repellency was dosage-dependent across all powdered plant materials, increasing from the lowest to the highest dosage. Percentage repellency was highest (> 60%) in grains treated with *V. zizanioides* over all dosages and lowest (< 40%) in grains treated with *O. gratissimum* across all dosages.

DISCUSSION

The survey revealed that 99.7 of the farmers (respondents) recognized S. zeamais as the most serious insect pest of stored maize. This is in conformity with Ngoko (1999) that *S. zeamais* is the main damaging insect in storage reported by all farmers interviewed in three agro-ecological zones including the western highlands of Cameroon. Thus, *S. zeamais* infestation is an important constraint that needs to be tackled.

Table 2: Botanical identity of plant materials being used against *Sitophilus zeamais* in the Northwest region, Cameroon.

Botanical name	Family	Common name	Part used
Vetiveria zizanioides	Gramineae	Vetiver	root
Cupressus arizonica	Cupressaceae	Cypress	leaf
Eucalyptus grandis	Myrtaceae	Eucalyptus	leaf
Ocimum gratissimum	Labiatae	Ocimum	leaf
Nicotiana tabacum	Solanaceae	Tobacco	leaf
Capsicum frutescens	Solanaceae	Chilli pepper	fruit
Aframomum melegueta	Zingiberaceae	Alligator pepper	fruit
Cola acuminata	Sterculiaceae	Kola nut	fruit shell
Afrostyrax lepidophyllus	Styracaceae	Country onion	seed

Table 3: Effect of powdered plant materials on F1 progeny of *Sitophilus zeamais* infesting maize.

Plant powdered dosage (g/25g of grains)	Mean no. (± S.D.) of emerged F_1 progeny			
	Cupressus arizonica	*Eucalyptus grandis*	*Ocimum gratissimum*	*Vetiveria zizanioides*
0	14.5 ± 3.0	13.8 ± 4.5	17.5 ± 2.2	15.0 ± 4.3
0.10	14.3 ± 2.9	13.3 ± 4.9	16.5 ± 2.7	15.0 ± 4.0
0.25	12.0 ± 2.6	12.8 ± 2.5	19.0 ± 1.6	15.8 ± 3.6
0.50	12.5 ± 2.3	17.3 ± 2.7	19.0 ± 1.7	18.3 ± 2.2
1.00	13.5 ± 2.7	15.8 ± 2.6	17.0 ± 1.8	17.3 ± 2.7
$LSD_{(0.05)}$	NS	_	_	_
C.V. %	22.5	_	_	_

NS = Not Significant

Therefore appropriate and affordable control measures of this pest are required in order to enable farmers preserve their maize longer and obtain higher market prices. Akob and Ewete (2007) observed that little *S. zeamais* infestation occurs on the field unless harvest is delayed, suggesting that most of the infestation occurs in storage.

The finding that up to 43.1 % of respondents (farmers) in the Northwest region of Cameroon use various local plant materials against *S. zeamais* is in agreement with Jilani (1984), that plants have been known to possess insecticidal properties and grain protectants in particular and that physiochemicals were used as pesticides before the advent of synthetic insecticides (Jacobson 1989). The wide disparity between percent users of *Cupressus*

Table 4: Percentage repellency of powdered plant materials against *Sitophilus zeamais*

Plant Powder dosage (g/25g of grains)	Percentage repellency (± S.D.) of powdered plant materials			
	Cupressus arizonica	*Eucalyptus grandis*	*Ocimum gratissimum*	*Vetiveria zizanioides*
0	0.0	0.0	0.0	0.0
0.10	35.3 ± 9.1	23.1 ± 4.7	16.3 ± 12.9	60.4 ± 7.7
0.25	56.4 ± 9.0	43.6 ± 9.0	27.5 ± 6.2	76.3 ± 5.0
0.50	60.4 ± 7.7	52.4 ± 9.6	35.7 ± 5.0	83.7 ± 12.9
1.00	68.4 ± 6.2	60.4 ± 7.7	39.6 ± 7.7	86.8 ± 10.6
$LSD_{(0.05)}$	10.6	11.1	11.2	12.6
C.V. %	21.0	25.1	32.3	19.3

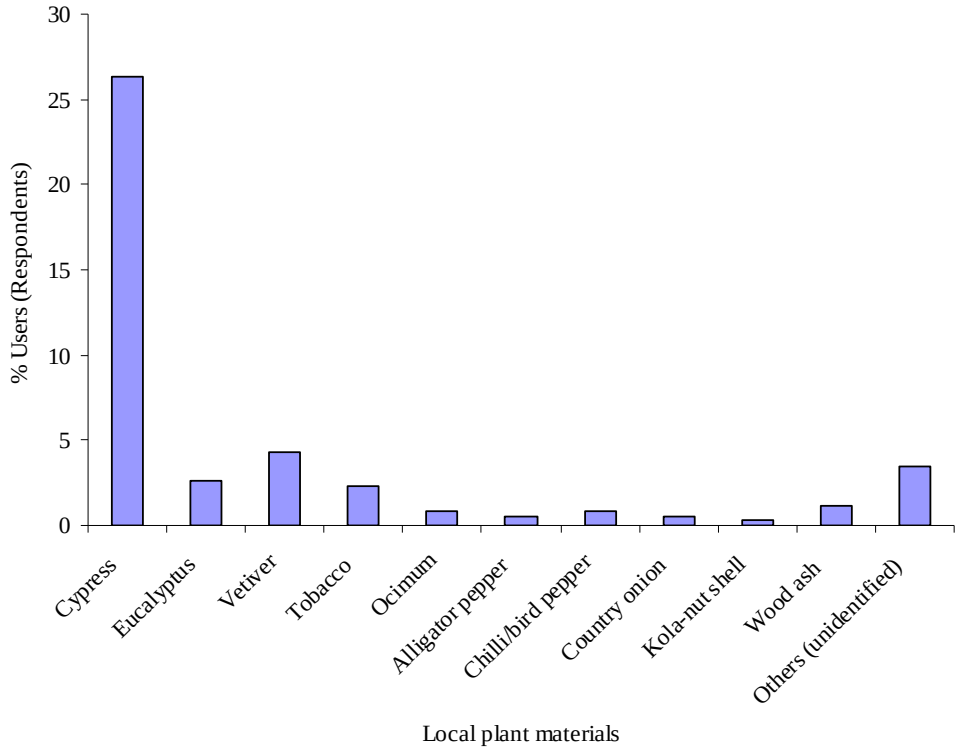

Fig. 1: Local plant materials being used for control of *Sitophilus zeamais* in the seven divisions of the Northwest region, western highlands of Cameroon

arizonica and *Vetiveria zizanioides* from results of survey and those obtained from bioassay is probably because the introduction of *V. zizanioides* and its use as a grain protectant in the area is recent and needs widespread application and acceptability like *C. arizonica*.

V. zizanioides root powder at the rate of 0.1-1.0g per 25g of maize grains showed the highest percentage repellency (64.0-86.8) compared to all other plant materials studied. This is in conformity with Glasby (1991) and National Research Council, (1993), that vetiver contains mainly bicyclic and tricyclic sesquiterpenes-hydrocarbons, alcohols and carboxylic acids as well as minor constituents including α-vetivone, β-vetivone, khusimone and khusitone that are insect repellent.

Though powdered plant materials showed no significant toxicity to F1 progeny of *S. zeamais* infesting maize in the present study, Bekele et al., (1996) found that the ground leaves (powder) of Ocimum suave, a very close relative of *O. gratissimum* provided protection to maize and sorghum grains against attack by *S. zeamais*. Similarly, Dike and Mshelia (1997) using cowpea treated with eucalyptus leaf powder also reported that the powder significantly (P = 0.05) inhibited oviposition and progeny development of *Callosobruchus maculatus* at 10 and 20g/100g cowpea seed. The differences in toxicity observed in these studies could be attributed to the differences in the genera and species of the powdered materials and grain types used.

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