

BIOEFFICACY OF SOME PLANTS ETHANOLIC EXTRACTS AGAINST MAIZE WEEVIL (*Sitophilus zeamais*) INFESTATION OF STORED MAIZE GRAINS

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ABSTRACT

The experiment was conducted to determine the efficacy of three plants ethanolic extracts against maize weevil (*Sitophilus zeamais*) on stored maize grains (*Zea mays*). Five different ethanolic concentrations (0.5 mg/L, 1.0 mg/L, 2.0 mg/L, 4.0 mg/L and 8.0 mg/L) were made from the leaves of *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* with 0.0 mg/L as the control (ethanol) and applied onto the maize grains by dipping. The experiment consists of six treatments (including control) and was laid in completely randomized design (CRD) with three replications. Data were collected for adult mortality, number of eggs, larval development and percentage grain damage. The data were subjected to analysis of variance (ANOVA) at 5% probability level with Duncan's Multiple Range Test (DMRT) used to separate the means that were significant. The result obtained revealed significant difference ($P \leq 0.05$) between the concentrations over the control in terms of toxicity, oviposition, induced adult mortality and progeny suppression. However, the extracts from *Tephrosia vogelii* are the most toxic and produced the best effect with LC_{50} of 4.85 mg/L at 24 hours of exposure and 1.94 mg/L at 48 hours of exposure. Similar result was found in terms of adult mortality and oviposition suppression. The effect of the extracts is concentration-dependent increase with increase in concentration. The percentage decrease in weight due to the weevil's infestation was found to be reduced with increase in concentrations. Thus, 8.0 mg/L of the ethanolic extracts of *Tephrosia vogelii* is recommended for biological control of *Sitophilus zeamais* against stored maize grains.

Key Words: Concentrations, Ethanolic Extracts, Maize, Weevil.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important staple food crops in Nigeria and the highest yielding crop in the world (Whitt *et al.*, 2002). It is the second most common cereal food crop after rice. Maize is a very important food crop for human beings and for livestock. It provides energy, vitamins and negligible amount of protein. Output of maize has continued to increase in Nigeria. About 1336 metric tons of maize was produced in Nigeria in 1986; while in 2003 about 7019 metric tons was produced (CBN, 2003). The livestock industry consumes more than half of the total annual maize production (Babatunde and Oyatoye, 2006). However, despite all the high yielding potential of maize and its significance to the diet of poor man and the Nigerian economy, an estimated 50% grain lost due to improper storage and attack of insects' pests in tropical countries including Nigeria have been reported (Ahmad and Ahmad, 2002). Insects' pests therefore, were the major cause of economic losses in stored maize grains.

The maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) is a serious pest of stored maize grains in Nigeria. The weevil caused loss in grain weight ranging between 20–30% on average (Rees, 2004) which may increase to a total of up to 80% loss for untreated maize grain in traditional facilities depending on the storage period (Boxall, 2002; Tapondju *et al.*, 2002). The need to control maize weevil using synthetic chemicals imparts negative consequences on to the environment and other non-target population including man, besides conferring resistance and other clinical symptoms in man and other animals. These problems led to a search for more effective method of controlling maize weevil that is safer and eco-friendly. One alternative control method is the use of plant extracts (Viegas, 2003; Trevisan *et al.*, 2006), which favors natural enemies, necessary for the biological balance (Gallo *et al.*, 2002).

Hyptis suaveolens, *Alstonia boonei* and *Tephrosia vogelii* were selected for this study due to their relative

abundance within the vicinity of the local communities in Nigeria and were among the plant species reported to have insecticidal properties against insect pests of stored products such as *Aphis gossypii*, *Aulacophora foveicollis*, *Bactrocera curcubitae*, *Callosobruchus maculatus*, *Diabrotica undecimpunctata*, *Phyllotreta conifera*, *Podagrica spp.*, *Sesamia calamistis* and *Zonocerus variegatus* (Adda *et al.*, 2011; Olaniran and Adebayo, 2013; Ileke and Emmanuel, 2018; Emeasor and Ndumele, 2019). This study therefore aimed at testing the bio-efficacy of some plants extracts in the control of *S. zeamais* infestation of stored maize grains.

MATERIALS AND METHODS

Test Plants

Fresh leaves of *Hyptis suaveolens* (Lamiaceae), *Alstonia boonei* (Apocynaceae) and *Tephrosia vogelii* (Fabaceae) were procured from vendors at Oyingbo market in Lagos and identified in the Herbarium of the Department of Botany, University of Lagos, Nigeria.

Source of Insects

The larvae and adults of *S. zeamais* were derived from a laboratory mass rearing facility. Insects were supplied with fresh maize seeds and were reared in wood cages according to the technique described by Dabire *et al.* (2005). Toxicity tests were carried out on 1st, 3rd and 5th instars larvae and adults of *S. zeamais*.

Preparation of Plants Ethanolic Extracts

The fresh leaves of the three test plants: *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* were air dried at room temperature, pounded to fine powder with pestle and mortar according to the protocols described by Dabire *et al.* (2008). The ethanolic extracts were prepared by soaking 100 g of each powder in 150 ml of 95% ethanol and shaken in orbital shaker at 120 rpm. The preparations were left to stand for another 24 hours and then filtered through a 1 mm² mesh and then Whatman No 1 filter paper. The filtrates were concentrated to dryness at 40 °C under reduced pressure on a rotary evaporator and were stored in a refrigerator at -4 °C until usage for the experiment. Different concentrations of 0.5, 1.00, 2.00, 4.00 and 8.00 mg/L were prepared from each of the plant extracts.

Disinfestation of Test Maize Seeds

Maize grains (*Zea mays* var. TZESR-20) were obtained from Bariga market, Lagos. They were identified at the International Institute of Tropical Agriculture (IITA), Ibadan. All damaged seeds and debris were sorted out from the grains after which disinfestation was carried out in an oven at 50 °C for six hours to kill all life stages of insects within the grains. The grains were then left for 24 hours to stabilize at ambient conditions.

Culture of Test Insects

Sitophilus zeamais (Motsch) were maintained on disinfested maize grains. Fifty unsexed 7-14 day old adults of *S. zeamais* were introduced into 500 g of disinfested maize grains (var-TZESR-20) in 1L kilner jars in five replicates in the laboratory. All adult insects were left for seven days to allow for oviposition, after which they were removed. They were then left undisturbed until adults were observed to emerge. At each peak of emergence, the adults were removed and used to set up new cultures. Series of fresh cultures were made from these to ensure regular supply of adult insects of known ages for use in subsequent experiments.

Storage of Maize Grains Treated with Test Plants Ethanolic Extracts

Five kilograms (5 kg) of disinfested maize grains were measured into plastic containers. Concentrations of 0.5, 1.00, 2.00, 4.00 and 8.00 mg/kg of the ethanolic extracts of *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* were applied on the grains and manually agitated and left to air dry. The maize grains were afterwards placed into jute bags and replicated three times. The seeds in the control were treated with ethanol. Thirty unsexed insects were released into each bag as well as that of the control. The bags were kept inside drums in the laboratory. Monthly readings were taken for six months in which 100 g of the treated and untreated maize were taken from each bag and assessed for insect damage according to Odeyemi and Daramola (2000). The mortality of the insects was determined and used to compute mean lethal concentration (LC₅₀) values by probit analysis.

Insect Damage in Grains

Monthly insect damage in each treatment and control was determined from 100 g batches of grains in each jute bag as described by Odeyemi

and Daramola (2000):

$$\text{Percentage weight loss} = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u (N_d + N_u)} \times 100$$

Where:

- W_u = Weight of undamaged grains
- N_u = Number of undamaged grains
- W_d = Weight of damaged grains
- N_d = Number of damaged grains

Data Analyses

The data obtained was analyzed using Analysis of Variance (ANOVA) with SPSS (11.0 versions).

Least Significant Difference was used to separate the means that were significant. Probit analysis was used to determine the LC₅₀ values.

RESULTS

The result of the relative toxicity of the three plant extracts to *S. zeamais* is presented in table 1. The result showed that the extracts obtained from *Tephrosia vogelii* are the most toxic and produced the best effect with LC₅₀ of 4.85 mg/L at 24 hours of exposure and 1.94 mg/L at 48 hours of exposure. However, the extracts obtained from *Alstonia boonei* had the least LC₅₀ value 7.79 mg/L at 24 hours after exposure.

Table 1: Relative Toxicity of Various Test Plants Ethanolic Extracts on *S. zeamais*

Ethanolic Extracts	24hr LC ₅₀ (mg/L)	95% CL	TF	48hr LC ₅₀	95% CL	TF
<i>Tephrosia vogelii</i>	4.85	-	1.32	1.94	-	1.09
<i>Hyptis suaveolens</i>	5.27	3.37-9.61	1.43	4.26	2.64-9.60	2.39
<i>Alstonia boonei</i>	7.79	4.88-34.44	2.11	3.63	1.78-9.49	2.03

Key:

CL = Confidence Limit

Test of significance = LC₅₀ values with no overlap in 95% confidence limits are significantly different

Toxicity Factor (TF) = $\frac{48hr LC_{50} \text{ value of the least toxic compound}}{48hr LC_{50} \text{ value of the more toxic compound}}$

The percentage mortality of *S. zeamais* due to exposure to different extracts from the three test plants is shown in table 2. The result indicated that, 8.0 mg/L of the ethanolic extracts obtained

from *T. vogelii*, *H. suaveolens* and *A. boonei* induced highest percentage mortality of 83.21%, 64.89% and 60.52% respectively. The percentage mortality increases with increase in concentration.

Table 2: Mortality of *S. zeamais* Adults during Exposure to Grains Treated with Ethanolic Extracts of Plants

Ethanolic extract	0.0mg/L	0.5mg/L	1.0mg/L	2.0mg/L	4.0mg/L	8.0mg/L
<i>Tephrosia vogelii</i>	0.00 ^a	42.50 ^a	62.00 ^a	69.82 ^a	75.15 ^a	83.21 ^a
<i>Hyptis suaveolens</i>	0.00 ^a	25.00 ^b	52.00 ^b	55.71 ^b	59.74 ^b	64.89 ^b
<i>Alstonia boonei</i>	0.00 ^a	21.50 ^c	46.50 ^c	51.33 ^c	54.25 ^c	60.52 ^c

N.B: Mean value(s) bearing the same letter(s) down a column are not significantly different (P = 0.05)

Percentage inhibition of oviposition and suppression of progenies development induced by various concentrations of the test plants extracts is presented in table 3. The result showed that grains treated with different concentrations of the ethanolic extracts contained different number of laid eggs. The number of laid eggs decreases with increase in concentrations. The least number of eggs was laid at 8.0 mg/L concentration of *T. vogelii*-treated grains (30 eggs).

There was also varying number of emerged insects among maize grains treated with ethanolic extracts of the test plants at different concentrations. The lowest mean number of progenies that emerged was 6.65 under 8.0 mg/L concentration of *T. vogelii*. This value represents 22.09% of the progenies that emerged as adults. Similar result was found among the remaining extracts from the test plants. The least number of eggs laid and the percentage adult emergence were

found to be under 8.0 mg/L of the remaining test plants extracts. The number of eggs laid and the percentage of adult emergence decrease with increase in concentrations.

Table 3: Oviposition and Progeny Development of *S. zeamais* on Maize Grains

Plant Extract	Concentration (mg/L)	Mean number of eggs laid (\pm SE)	Mean adult emergence (\pm SE)	Mean percent adult emergence (%)
<i>Tephrosia vogelii</i>	0.00	90.31 \pm 1.64 ^{a*}	79.00 \pm 6.21 ^b	87.49
	1.0	57.02 \pm 1.36 ^b	22.31 \pm 2.24 ^c	39.13
	2.0	50.21 \pm 3.06 ^c	17.00 \pm 1.85 ^f	33.86
	4.0	45.02 \pm 1.39 ^d	12.92 \pm 1.12 ^g	28.69
	8.0	30.11 \pm 1.27 ^e	6.65 \pm 1.40 ⁱ	22.09
<i>Hyptis suaveolens</i>	0.00	92.52 \pm 1.84 ^a	78.12 \pm 6.59 ^b	84.44
	1.0	58.28 \pm 3.01 ^b	40.33 \pm 5.59 ^c	69.20
	2.0	50.12 \pm 3.97 ^c	30.98 \pm 3.59 ^d	61.81
	4.0	43.29 \pm 4.21 ^d	20.15 \pm 2.02 ^e	46.55
	8.0	28.11 \pm 1.12 ^e	7.73 \pm 0.14 ⁱ	27.49
<i>Alstonia boonei</i>	0.00	95.06 \pm 0.78 ^a	84.15 \pm 4.18 ^a	88.52
	1.0	68.11 \pm 2.26 ^{ab}	31.35 \pm 1.23 ^d	46.03
	2.0	57.82 \pm 2.03 ^b	20.24 \pm 1.79 ^e	35.01
	4.0	41.96 \pm 2.32 ^d	13.25 \pm 1.23 ^g	31.58
	8.0	32.33 \pm 2.50 ^e	9.13 \pm 1.29 ^h	28.24

Key: *¹ Means bearing the same superscripts down a column are not significantly different (P = 0.05)

The result of protection of maize grains from *S. zeamais* infestation by various concentrations of the leaf ethanolic extracts obtained from *T. vogelii* is presented in figure 1. The result indicated significant difference (P \leq 0.05) in the efficacy of the concentrations in protecting the grains against infestation. The result showed that, all the five concentrations of the test plant gave protection

for a maximum of two months except 8.0 mg/L which extended up to 3 months with no infestation recorded. Similarly, the percentage decrease in weight after six months is low among the treated grains. The least value of reduced damage inferred by the pest on to the grains was found among 8.0 mg/L treated grains. The effect decreases with increase in concentration.

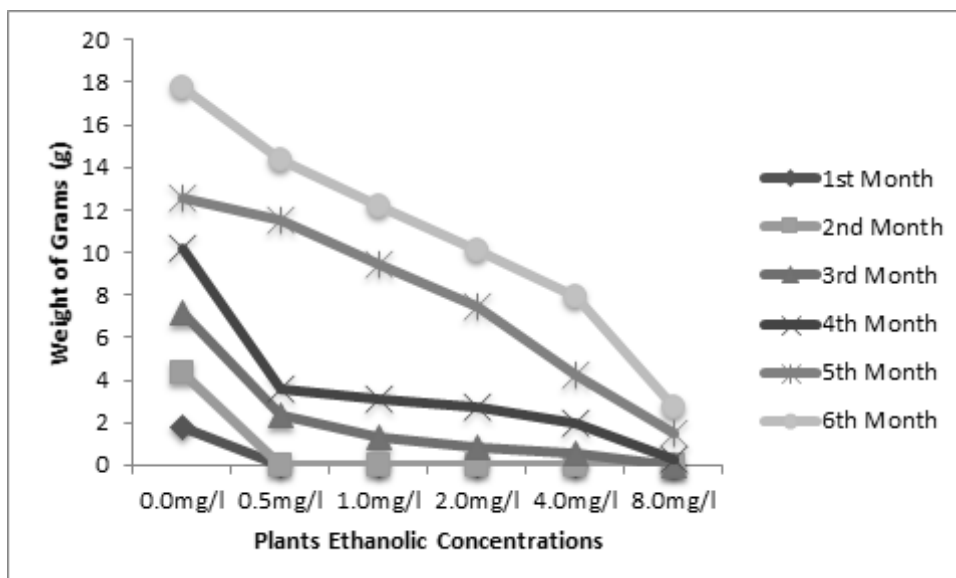


Figure 1: Efficacy of Different Concentrations of *T. vogelii* in Protecting Stored Maize Grains against *S. zeamais*

The potency of leaf ethanolic extracts from *H. suaveolens* in protecting maize grains against *S. zeamais* infestation is shown in figure 2. There was no infestation in the first and second months of treatment except in the control. However, the infestation started at three months and is more

severe (except when compared to the control) in 0.5 mg/L treated seeds in the third and fourth month. Minimum damage was recorded in 8.0 mg/L treated seeds within four months. The effect is concentration dependent, decrease with increase in concentration.

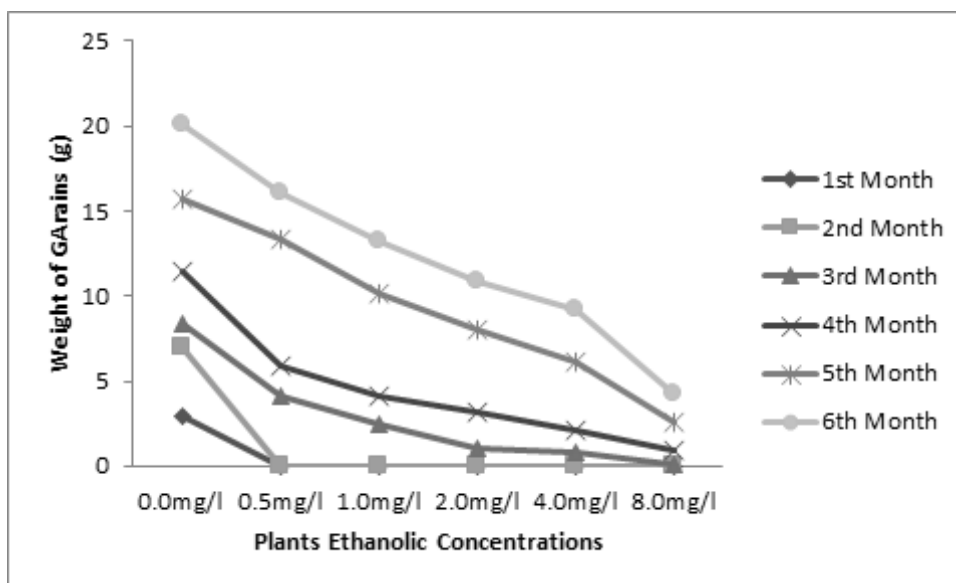


Figure 2: Efficacy of *H. suaveolens* Concentrations in Protecting Stored Maize Grains against *S. zeamais*

The result of the grain protection potency of *A. boonei* leaf ethanolic extracts of maize grains against *S. zeamais* infestation is shown in figure 3. There was significant difference ($P \leq 0.05$) in the

protection potency of various concentrations of the extracts. Minimum grain damage of 6.21 g was recorded in maize grains treated with 8.0 mg/L of *A. boonei* extract.

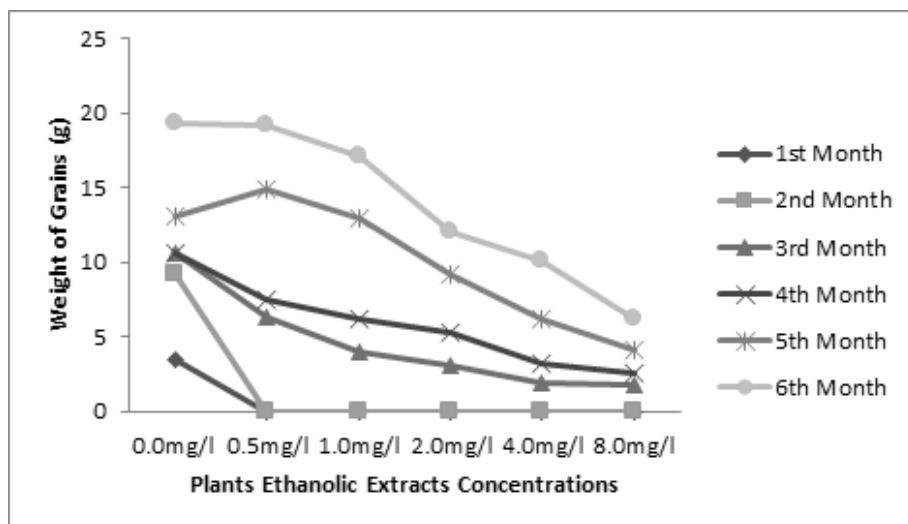


Figure 3: Efficacy of *A. boonei* Concentrations in Protecting Stored Maize Grains against *S. zeamais*

DISCUSSION

The high mortality rate of adult *S. zeamais* due to contact with maize grains treated with the three plants extracts: *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* indicated the relative toxicity of the test plants extracts on the weevil. This finding agrees with that of Belmain *et al.* (2001) who reported that plant extracts have potentials against insect pests' infestation of stored products. Ogendo *et al.* (2004) reported insecticidal efficacy of *T. vogelii* on *S. oryzae* inducing 85-93.7% insect mortality. Also, Mulungu *et al.* (2007) reported the efficacy of ethanol extracts of eucalyptus, lantana and neem leaves against *S. oryzae* and *S. zeamais*. The result for the insecticidal efficacy of *A. boonei* on *S. zeamais* presented in this study is in agreement with the findings of Ileke and Emmanuel (2018) who reported high bioefficacy of *A. boonei* leaf extract against cowpea beetle (*Callosobruchus maculatus*) infesting stored cowpea seeds in storage. Similarly, Emeasor and Ndumele (2019) reported the insecticidal potency of aqueous extract of *T. vogelii* in the control of insect pests of cucumber (*Cucumis sativus* L.), the bioefficacy of *Hyptis suaveolens* on *Anopheles gambiae* was reported by Oumarou *et al.* (2017). However, the finding from this study contradicts that of Ileke (2014) who reported a complete inhibition

of adult emergence of *S. zeamais* when exposed to aqueous extracts of *A. boonei*.

The inhibition of adult emergence of the weevils in grains treated with ethanolic leaf extracts of the test plants at different concentrations reported by this study is in agreement with the work of Suleiman *et al.* (2019) who reported high adult mortalities of maize weevils in the sorghum grains treated with some plants extracts. This induced mortality can probably be attributed to the alteration of physiological processes of the eggs deposited and as such led to inhibition in adult emergence of the weevils in the treated grains. This is in line with the finding of Chudasama *et al.* (2015) who reported that poisonous substances present in the extracts may enter into the egg through chorion and suppressed further embryonic development. This may probably be attributed to the different active constituents present in these plants as stressed by Kilonzo (1991) and Gerard and Ruf (1995) that plant extracts have a high toxic effect on feeding and survival of different pest species. Similar finding was reported by Onu and Baba (2003), Maina and Lale (2004), Kabeh and Lale (2004) and Mbailao *et al.* (2006) who individually reported toxicity of plant extracts on *Callosobruchus maculatus*.

The effect of the three test plants extracts in suppressing progeny development and oviposition of *S. zeamais* can probably be attributed to the ability of the extracts to interfere with the growth and physiological process of developing eggs by reducing food intake thereby reducing assimilation and hence deter growth. This finding is in conformity with that of Osawe *et al.* (2007) who reported that the aqueous extracts of *A. boonei* leaves adversely affected the survival and growth of *Sesamia calamistis*. Similarly, Mukanga *et al.* (2010) reported suppression of progeny development of larger grain borer (*Prostephanus truncatus*) by *T. vogelli* extracts. The growth inhibition may result from toxicity or feeding deterrent properties of the plant as reported by Akhtar and Isman (2004) and Erturk (2006). Iwu and Igboko (1982) established the chemical constituent of *Garcinia kola* seed as biflavonoids xanthone and benzophenones. *A. boonei* at high concentration also reduced adult emergence of *S. zeamais*. Suleiman *et al.* (2018) reported insecticidal efficacy of some plant extracts in suppressing progeny development of *S. zeamais*. The variation in the magnitude of insecticidal efficacy of the three test plants can be due to variations in the nature of active ingredients present in each plant extracts and its effective concentrations. As such, such plants extracts can serve as suitable alternatives for the control of maize weevils.

The protection of the maize grains by the extracts of the three test plants agrees with the work of Appiah *et al.* (2018) who reported similar finding for the extracts from *Hyptis suaveolens* and *Hyptis spicigera* against cowpea weevils. Ileke and Oni (2011) reported *A. boonei* extracts to be highly effective as protectants against *S. zeamais* infestation of stored wheat grains.

CONCLUSION

It was concluded that, ethanolic extracts from the leaves of *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* have high insecticidal activity against *S. zeamais* and can protect stored maize grains from its infestation for as long as three months. The effect of the extracts is concentration-dependent, increase with increase in concentration. Thus, 8.0 mg/L of the ethanolic extracts of *Tephrosia vogelii* is highly recommended

for biological control of *Sitophilus zeamais* in stored maize grains.

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