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Effectiveness of Soybean Oil and Powder from Leaves of *Lantana camara* Linn. (Verbenaceae) as Protectants of Stored Maize Against Infestation by *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae)

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Abstract: Soybean oil and powder from leaves of *Lantana camara* were tested at the farm level for efficacy in protecting maize grains from damage and for insecticidal activity against the maize weevil *Sitophilus zeamais*. Grains were stored in jute bags for seven months during which they were treated every two or three months with either of the two natural products. The two treatments showed significantly lower percent grain damage (0.2-13% damage) than the untreated control (> 50% damage) ($p<0.05$). The efficacy of soybean oil when applied every two months was comparable ($p>0.05$) to that of the chemical control (Poudrox©, malathion 5%). The number of dead weevils in maize treated with soybean oil was similar ($p>0.05$) to that in maize treated with powder from leaves of *Lantana camara*. Contrast analysis showed that grain damage of maize treated every two months was not significantly different ($p=0.083$) from the damage of maize treated every three months. This suggests that after an initial treatment of grains at the beginning of a 7-month storage period, two additional treatments renewed every three months can be as efficient in protecting maize against damage by *S. zeamais* as three treatments applied every two months.

Key words: Soybean oil, *Lantana camara*, storage, *Sitophilus zeamais*, jute bag, repeated treatment

INTRODUCTION

In spite of the availability of synthetic insecticides, insect pests continue to reap a heavy toll in stored maize at the farmer level in Cameroon, with losses estimated at about 30% in the West Province[1]. This suggests that farmers either use little or no chemical at all for grain protection, probably because of their high cost and/or toxicity. This has prompted research efforts in recent times to focus on investigations on the bioactivity of locally available natural products considered by farmers as less hazardous.

The natural substances most investigated include vegetative oils such as palm and groundnut oils, powders from leaves of such plants as tobacco (*Nicotiana tabacum* L.), *Lantana camara* L., *Chromolaena odorata* L. and *Chenopodium ambrosiodes*, or essential oils extracted from these plants[2-7]. Some of these substances act as repellents owing to their persistent odors and they have basically been tested in the laboratory in airtight containers which, unlike jute bags commonly used by farmers for grain storage, can conceal odors and thus maximize substance efficacy[8].

In the present study carried out in different regions of the Western Province in Cameroon, maize was stored for seven months in jute bags at the farmer level and treated repeatedly with soybean oil and powder from leaves of *Lantana camara* to evaluate their insecticidal activity and also test their efficacy in protecting grains against damage by *Sitophilus zeamais* Motsch., the most prominent and damaging weevil on maize in Africa[9]. Damage is manifested by characteristic circular exit holes chewed out of the grain kernel by emerging adults, a cycle which starts with female weevils laying eggs singly in small holes chewed into the maize kernel and larvae feeding within by boring a thin tunnel from the surface towards the inside of the grain.

MATERIALS AND METHODS

This study was conducted in three agricultural extension regions of the Western Province in Cameroon, namely Monts-Bapit (900-1000 m altitude), Centre-Ouest (1200-1400 m altitude) and Menoua (> 1400 m altitude). Two natural products were used: soybean oil and *Lantana camara*, a straggling aromatic shrub native of tropical America which grows in Cameroon as an

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ornamental plant. Maize (variety Kasai) was supplied by farmers in respective experimental regions and was not treated. It had been planted in the first season in late March 2001 and harvested early August 2001. The study started in November 2001 when an initial natural infestation of the maize (egg laying in grains) had already occurred. Grains moisture content was measured to insure that RH was 9-10%. The storage period was seven months.

Preparation of the powder from *L. camara*: Fresh leaves of *L. camara* were collected at the IRAD experimental plot in Dschang and their identification confirmed at the Cameroon National Herbarium, Yaoundé, where a voucher specimen is kept. This plant is characterized chemically by a high percentage of triterpenoids which are hepatotoxic and flavonoids which exert antibacterial and antifungal activities[10-12]. Leaves were dried in an oven (Model Heraeus, type 5060) at 40°C for 2 days, milled with a blender to a fine powder, then stored in a plastic container for use as maize treatment at the dose of 2% (w/w). Lower doses using plant powders had been reported to have no insecticidal activity[5].

Treatment of maize: Soybean oil (at the rate of 5 mL kg^{-1} of grain) and powder from leaves of *L. camara* (2%, w/w) were added separately to 2.5 kg of sorted maize grains (grains without apparent bruchid-bore holes) in jute bags and the bags shaken thoroughly to ensure even mixing. Bags were then divided into two sets: one with grains being treated every 2 months (making a total of four treatments for the seven months of storage, including the initial treatment at the start of experiment) and the other where treatment was applied every three months (making a total of three treatments). Untreated bags and those treated with the insecticide Poudrox© (malathion 5%) were added as controls. There were twelve replicates of each treatment in each experimental region. All bags were tied randomly to the roof inside farmers' houses with a string to prevent attack by rodents. Data were collected every month on the number of damaged grains, as well as the number of live and dead insects per bag. Only dead insects were discarded after the count. Grains were considered damaged if they had one or more holes. Grains were separated into three categories, namely: A, number of grains with no hole; B, number of grains with one hole; and C, number of grains with more than one hole. Total grain damage was calculated as B+C. In order to assess the severity of the damage, a grain Damage Index (DI)[13] was computed to give weight to these different damage categories such that: DI = (0.5 X%B) +%C.

Data analysis: Data for each treatment were pooled and evaluated with general linear model procedures using SAS Statistical Software Package[14], after appropriate transformations were carried out on percentage of grain damage and number of live and dead insects to stabilize variances[15]. Mean separation was performed using the SNK test.

RESULTS

Treatment effect on grain damage: The percentage grain damage of treated maize (either with soybean oil, powder from leaves of *Lantana camara*, or the chemical

Table 1: Grain damage (%) by *S. zeamais* in maize stored for 7-months and treated periodically with two natural products and a chemical insecticide

	Monts-Bapit$^{\Psi}$		Menoua		Centre-Ouest	
Treatments	Treatment every 2 months*	Treatment every 3 months	Treatment every 2 months	Treatment every 3 months	Treatment every 2 months	Treatment every 3 months
Soybean oil	0.2±0.1b	1.1±0.3a	0.9±0.2b	7.4±8.5a	2.6±0.6a	3.3±0.7a
Lantana camara	1.7±0.4a	1.6±0.1a	9.8±4.9a	12.8±6.8a	2.6±0.1a	3.2±1.5a
Poudrox©$^{\blacktriangledown}$	0.3±0.1b	0.2±0.1b	1.5±0.2b	1.5±0.8b	1.1±0.4b	1.4±0.5b
Mean	0.8±0.2	1.0±0.1	4.1±1.2	7.2±4.0	2.1±0.3	2.6±0.5

$^{\Psi}$Region, $^{\blacktriangledown}$Chemical control, *Means (±S.E) in each column followed by the same letter are not significantly different at 5% level (SNK test)
Means separation based on arcsine-transformed data

Table 2: Number of live *S. zeamais* in maize stored for 7-months and treated periodically with two natural products and a chemical insecticide

	Monts-Bapit$^{\Psi}$		Menoua		Centre-Ouest	
Treatments	Treatment every 2 months*	Treatment every 3 months	Treatment every 2 months	Treatment every 3 months	Treatment every 2 months	Treatment every 3 months
Soybean oil	3.5±1.4a	4.2±1.2a	19.3±13.5a	43.7±19.1a	23.0±2.2a	25.4±2.8a
Lantana camara	4.7±0.9a	6.4±1.9a	27.7±11.7a	57.5±25.0a	23.7±3.8a	27.3±7.6a
Poudrox©$^{\blacktriangledown}$	0.0±0.0b	0.0±0.0b	0.7±0.3b	0.2±0.1b	0.3±0.2b	0.0±0.0b
Mean	2.7±0.6	3.5±0.9	16.1±4.1	33.8±14.1	15.7±2.1	17.6±3.3

$^{\Psi}$Region, $^{\blacktriangledown}$Chemical control, *Means (± S.E) in each column followed by the same letter are not significantly different at 5% level (SNK test)
Means separation based on log-transformed data

Table 3: Number of dead *S. zeamais* in maize stored for 7-months and treated periodically with two natural products and a chemical insecticide

	Monts-Bapit[ψ]		Menoua		Centre-Ouest	
Treatments	Treatment every 2 months*	Treatment every 3 months	Treatment every 2 months	Treatment every 3 months	Treatment every 2 months	Treatment every 3 months
Soybean oil	2.8±1.2a	3.8±1.3a	14.7±3.7a	46.5±28.0a	25.4±2.8a	30.6±9.2a
Lantana camara	2.4±0.6a	1.2±0.6a	12.5±4.4a	18.2±10.7a	23.7±3.8a	25.3±2.6a
Poudrox©[♥]	0.3±0.2b	0.5±0.2a	4.0±1.2b	8.0± 2.8a	3.0±0.6b	6.1±1.9b
Mean	1.8±0.3	1.8±0.4	10.4±2.9	24.2±13.4	17.4±2.1	20.7±4.1

[ψ]Region, [♥] Chemical control, * Means (± S.E) in each column followed by the same letter are not significantly different at 5% level (SNK test). Means separation based on log-transformed data

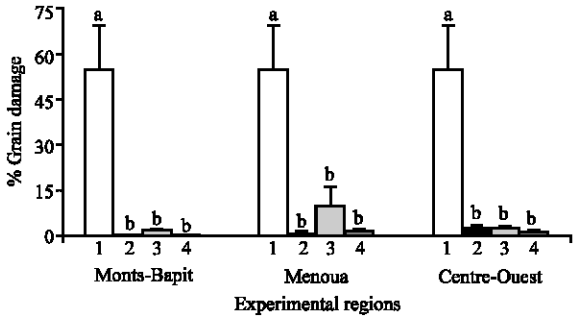

Fig. 1: Damage by *S. zeamais* in 1-untreated maize, or maize treated with 2-soybean oil, 3-*Lantana camara*, and 4-Poudrox (chemical control) after 7-months of storage in jute bags (Bars with the same letter are not different at the 5% level of significance using the SNK test)

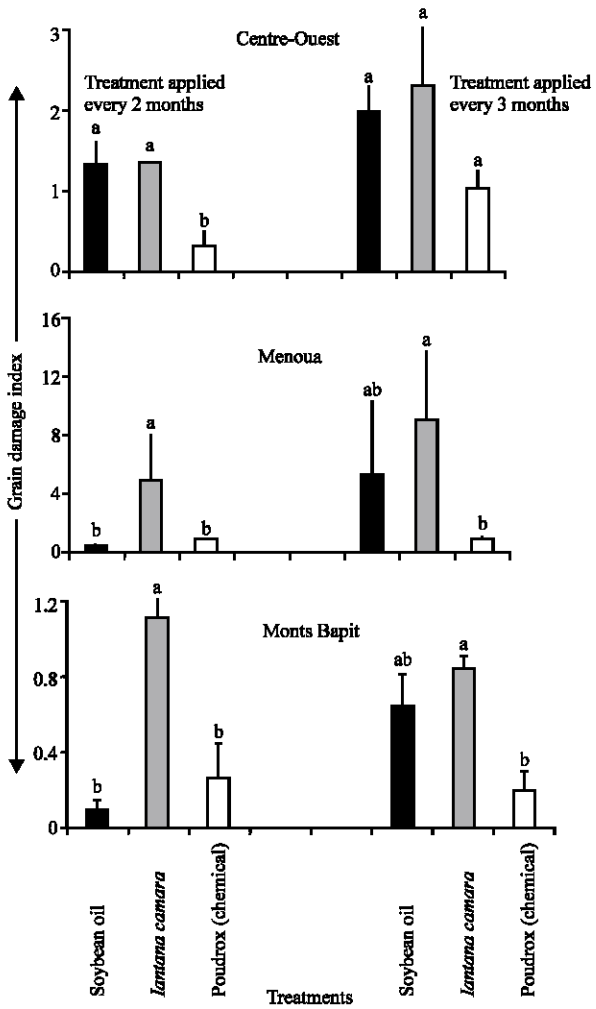

Fig. 2: Severity of the damage by *S zeamais* to maize treated every 2 or 3 months with two natural products and a chemical insecticide in three experimental regions after 7-months of storage (Bars with the same letter(s) for each treatment frequency are not different at the 5% level of significance, SNK test)

insecticide Poudrox©) was significantly lower ($p<0.05$) than the damage of untreated maize in all three experimental regions at the end of the 7-month storage period (Fig. 1). When application was repeated every two months, soybean oil and Poudrox© treated grains had similar ($p>0.05$) percentage damage in two (Monts-Bapit and Menoua) out of the three experimental regions; this percentage damage was significantly lower than the damage recorded for the *L. camara* treatment (Table 1). When treatment was applied every three months, the two natural-products (soybean oil and powder from leaves of *Lantana camara*) recorded similar ($p>0.05$) percentage grain damage; this damage was significantly higher ($p<0.05$) than the damage recorded for the chemical treatment (Table 1). Mean percentage grain damage across treatments generally increased from grains treated every two months to those treated every three months. Damage index values had trends similar to those of total percentage grain damage (Fig. 2). Contrast analysis performed between maize treated every two and that treated every three months showed no significant grain damage difference ($p = 0.083$).

Treatment effect on insects: The two natural-product treatments showed comparable ($p>0.05$) numbers of live (Table 2) and dead (Table 3) insects at the end of the 7-month storage period. The chemical treatment recorded the lowest number of live and dead insects. There was a significant correlation ($r=0.91$, $p<0.001$) between percentage grain damage and number of live insects.

DISCUSSION

The drastic damage difference observed in all experimental regions after seven months of storage between untreated maize on the one hand and maize treated with either soybean oil, powder from leaves of *L. camara*, or Poudrox© on the other hand, provides clear evidence of a treatment effect. Soybean oil seemed to be more effective than *L. camara* when treatment was applied every two months, as indicated by the low damage index values recorded for this treatment which compared well with those for the chemical control. A low damage index value gives an indication of a less severe damage level, which in the present study would mean that fewer adult weevils emerged from grains treated with soybean oil. This may be due to the reported toxic effect of various vegetative oils on egg embryos, as a result of oxygen deprivation[16-19]. This oil toxicity is likely to reduce with time of exposure due to auto-oxidation[20], an hypothesis supported by a faster decline in the efficacy of soybean oil in comparison to *L. camara*, since both natural product treatments showed similar grain damage levels when time between two treatment applications was longer (three months), as opposed to application every two months.

The comparable number of live insects between soybean oil and *L. camara* treatments seems incompatible with observations of higher grain damage for maize treated with *L. camara*, given the significant correlation between number of live insects and total grain damage. This observation lends further credence to the hypothesis of a faster biodegradability of soybean oil. It may also be surprising to note comparable numbers of dead insects between these two natural product treatments. Insect mortality by *L. camara* can be ascribed to its reported high flavonoid content, as this compound is one of the most associated with deterrence against insects[21]. Such deterrence could be attributed to the diffusing of persistent odors capable of suffocating weevils in bags, as observed for other plant powders[3,5,6,22]. These powders can reduce insect movement and also cause death through desiccation of insects or through occlusion of their spiracles, thereby preventing respiration via the tracheal system[23]. For soybean oil, the observed high weevil mortality could be attributed to the toxic effect on egg embryos mentioned earlier leading to weakened and non-viable emerging adults.

In conclusion, the efficacy of soybean oil and powder from leaves of *L. camara* in protecting maize stored at the farmer level in jute bags against damage by the maize weevil *S. zeamais* was clearly established in the present study. It is suggested that after an initial treatment of grains at the beginning of a 7-month storage period, two additional treatments applied every three months can be as efficient as three treatments applied every two months.

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