JOURNAL OF HORTICULTURE AND POSTHARVEST RESEARCH
2019, VOL. 2 (SPECIAL ISSUE: POSTHARVEST LOSSES OF HORTICULTURAL CROPS), 49-60

Journal of Horticulture and Postharvest Research

Journal homepage: www.jhpr.birjand.ac.ir

University of Birjand

Assessment of grain protection through the incorporation of *Eucalyptus citriodora* leaves in grain/insecticide admixtures in Zimbabwe

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ARTICLE INFO

Article history:
Received 1 November 2018
Revised 2 February 2019
Accepted 10 March 2019
Available online 6 April 2019

Keywords:
Eucalyptus citriodora
Prostephanus truncates
Repellency
Sitophilus zeamais
Susceptibility

DOI: 10.22077/jhpr.2019.1998.1037
P-ISSN: 2588-4883
E-ISSN: 2588-6169

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ABSTRACT

Purpose: The control of stored-grain insect pests is predominantly done through the use of synthetic insecticides. However, the extensive and constant (mis)use of these chemicals has brought complications that include faster evolution of resistant forms of pests, hence a global call for alternative control measures to reduce chemical applications. The aim of this research was to evaluate the repellent and toxic effects of *E. citriodora* leaf powder on adult *P. truncatus* and *Sitophilus zeamais*. **Research Method:** A completely randomized design was adopted in all the experiments. A choice test arena was set up to evaluate repellent effects of *E. citriodora* leaf powder on *P. truncatus* and *S. zeamais*. The toxic effect of *E. citriodora* was also evaluated, with untreated grain and conventional insecticides used as negative and positive controls, respectively. **Findings:** Results showed that E. citriodora leaf powder had repellent properties of up to 68.9% against both P. truncatus and S. zeamais populations. Nonetheless, low adult P. truncatus mortalities were recorded when the protective effects of the E. citriodora leaf powder (at the rate of 10% w/w) were tested against the beetle. Additionally, the efficacy of the synthetic insecticides was relatively higher when applied singly than when in combination with *E. citriodora* leaf powder. **Research limitations:** Time was the major limiting factor to consider other parts of *E. citriodora* plant (e.g. roots) on their usefulness in stored-product insect pest management. **Originality/Value:** Small plantations of *E. citriodora* may be established to offer a temporary grain protection against primary insect pests.

INTRODUCTION

Maize is one of the most important cereal crops in Zimbabwe and is subjected to both quantitative and qualitative losses due to infestation by a number of insect pests in the field as well as in storage. In Zimbabwe, maize is widely grown by smallholder farmers who contribute about 50% to the national output (Rukuni et al., 2006). Losses due to insect infestation are the most serious problems in grain storage in Africa (Adeyemi and Osipitan, 2014), mainly owing to poor sanitation and use of inappropriate storage facilities that permit insect attack. Hence, prevention of food loss with the concept of "a grain saved is a grain produced" as Chomchalow (2003) puts it should be seriously taken into consideration as this is necessary to ensure a continuous supply at stable prices.

The control of stored-grain insect pests is primarily achieved through the use of synthetic insecticides (Sagheer et al., 2014; Adeyemi and Osipitan, 2014). However, the widespread and constant (mis)use of these synthetic insecticides have promoted faster evolution of resistant forms of pests, destroyed natural enemies, turned formerly innocuous species into pests, harmed other non-target species and contaminated food (Zettler and Cuperus, 1990; Ribeiro et al., 2003; Fosu-Mensah et al., 2016). There is therefore need to synergize control strategies available in an effort to reduce chemical applications in the context of developing an Integrated Pest Management (IPM) strategy.

The manipulation of natural product chemicals, such as insect attractants, repellents, stimulants, antifeedants and arrestants which are normally encountered by insects may fulfil the required criteria (Talukder, 2006). Haouel et al. (2010) investigated the chemical composition and assessed the fumigant toxicity of essential oils of *E. camaldulensis* and *E. rudis* against the date moth *Ectomyelois ceratoniae* in storage as alternatives to methyl bromide. Results suggested that *E. rudis* and *E. camaldulensis* essential oils could be used as an alternative to the synthetic fumigant in postharvest treatment programme for the control of *E. ceratoniae.*

Many plant volatile essential oils and their constituents have been shown to possess potential as alternatives for the management of stored product insect pests and these are ecologically safe and biodegradable (Cosmi et al., 2009). For the past three decades, many plant allelochemicals including nicotine, pyrethrins, azadirachtin and rotenoids have been isolated, characterised and developed as commercial insecticides (Talukder, 2006). Mishra et al. (2012) reported that essential oils from *E. globulus* and *Ocimum basilicum* have repellent properties against *Tribolium castaneum* and *Sitophilus oryzae*. In a study to evaluate the efficacy of garlic powder and propolis extracts at controlling *S. zeamais* infestation in stored maize grain, Adeyemi and Osipitan (2014) observed that the two botanicals could be used to overcome drawbacks associated with the use of synthetic insecticides. In an investigation to ascertain the bio-efficacy of *Zanthoxylum xanthoxyloides* and *Securidaca longependuncata* against *P. truncatus* and *T. castaneum*, Eziah et al. (2013) realized that grains treated with plant extracts significantly reduce damage caused by *P. truncatus* and *T. castaneum* compared with untreated grain.

In Zimbabwe, a number of plant-based protectants are readily available for use as grain protectants to reduce weevil damage. These include leaves of *Colophospermum mopane* (Murdock & Kitch, 1997) and *Tagetes minuta* (Parwada et al., 2012). These provide sustainable and degradable pesticides to resource-poor farmers. Stoll (2000) reported the use of wood ash from fires as grain protectant in other parts of Africa. *Eucalyptus*, which is one of the most cultivated genera in the world, has been shown to have various biological properties attributed to it, among them insecticidal activity against beetles (Brito et al., 2006), repellent action against *P. papatasi* (Yaghoobi-Ershadi et al., 2006) and larvicidal activity on culicids (Cheng et al., 2009).

The primary objective of this study was to assess the repellent and protective effects of *Eucalyptus citriodora* leaf powder in grain-insecticide admixtures. *Eucalyptus citriodora* was chosen owing to the strong smell from its leaves in its natural state. This would be particularly important in an Integrated Pest Management (IPM) approach, particularly at the smallholder level where under-dosing of synthetic insecticides is common. This emerged after the effectiveness of several locally registered organophosphorus-pyrethroid insecticides has become questionable as farmers from several provinces of the country have reported major losses due to *P. truncatus* in insecticide-treated stored maize. Preliminary studies made so far strongly support this loss of effectiveness of some of the grain protectants in controlling the beetle.

MATERIALS AND METHODS

Location

The experiments were conducted in the laboratory of Department of Biological Sciences, Faculty of Science, University of Zimbabwe

Source and physical characteristics of maize grains

Clean, healthy dry grains of 30G19 PHB PIONEER HI-BRED maize variety bought from a farmer in Bindura were used for both rearing of insects and the studies. The maize grains were checked visually for damage and then deep-frozen for two weeks to kill hidden infestations. The maize grains were then kept at an ambient temperature of 27±2 °C and 65±5% relative humidity in the laboratory for moisture equilibration for three weeks before use in the experiments.

Test insects

The initial stock cultures of *P. truncatus* were originally obtained from naturally-infested maize sampled from farm granaries in Bindura, Murehwa, and Headlands. Starter cultures for *S. zeamais* were from insects sampled from infested maize in Murehwa, Headlands, Zvimba and Masvingo. The laboratory cultures for both *P. truncatus* and *S. zeamais* were provided courtesy of Biological Sciences Department, University of Zimbabwe. The laboratory strains have been maintained for more than five years on whole maize grain and were used as the standard/susceptible populations in the experiments. Insects from these laboratory strains had not been subjected to any insecticide selection pressure during this period of rearing.

All insect cultures were reared in a constant temperature (27±2°C) and humidity (65±5%) (CTH) room. Culture jars were cleared labelled with date of culture, insect species, and area of origin of the insect species/strain.

Insecticides and grain treatments

The insecticides used for the study were bought from a hardware shop in Harare. The application rates were as per manufacturers' recommendations (Table 1).

Experimental design and data analysis

A Completely Randomised Design (CRD) was adopted in all the experiments. All data were subjected to analysis of variance (ANOVA) in STATA 11. Where significant differences were detected (i.e. $P < 0.05$), treatment means were separated using least significant difference (LSD).

Table 1. Trade names, active ingredients and recommended application rates of the commercial dilute dust insecticides that were used in the study

Product Trade name	Active ingredients	Application rate (g/50 kg of grain)
Shumba Super Dust® (SSD)	fenitrothion (1%) + deltamethrin (0.13%)	25
Ngwena Yedura® (ND)	pirimiphos-methyl (2.5%) + deltamethrin (0.2%)	20
Actellic Super Chirindamatura Dust® (ASCD)	pirimiphos-methyl (1.6%) + permethrin (0.3%)	25
Actellic Gold Chirindamatura Dust® (AGCD)	pirimiphos-methyl (1.6%) + thiamethoxam (0.36%)	25
Hurudza Grain Dust® (HGD)	fenitrothion (1.7%) + deltamethrin (0.05%)	25
Chikwapuro Grain Protectant® (CGP)	pirimiphos-methyl (2.5%) + deltamethrin (0.1%)	20

Repellency studies

Leaves of *E. citriodora* were obtained from Forestry Commission of Zimbabwe. These were air-dried at room conditions for a week and then stored in khaki bags. The dry leaves were then milled into powder using a Christy & Norris Junior laboratory mill and passed through a sieve of 1x1 mm pore size.

A choice test arena consisting of two 250 ml plastic jars tightly fitted at their rims to the base of a 21 cm × 32 cm rectangular flat-bottomed basin (Fig. 1a) was set up to evaluate repellent effects of powdered *E. citriodora* on laboratory cultures of *P. truncatus* and *S. zeamais*. The mouth of each jar was therefore flush with the flat base of the basin. These plastic jars were placed equidistant from the centre of the basin.

Fig. 1. Setup of choice test of repellency of Eucalyptus citriodora.

One hundred grams of maize grain were weighed out and admixed with powdered *E. citriodora* leaf powder (10% w/w), or synthetic insecticide, or a combination of insecticide and powdered *E. citriodora* leaves. Literature review paper by Soujanya et al. (2016) clearly showed that most botanicals applied against post-harvest pests did well when applied at 10% w/w. Some grain was also left untreated, i.e. the negative controls in the experiments. Various paired combinations of treated/untreated grain were then placed in the jars in the arena (Fig. 1b). The treatment combinations were as follows:

1. Untreated grain (control) ***versus*** *E. citriodora* leaf powder
2. Untreated (control) ***versus*** HGD
3. HGD (control) versus HGD + *E. citriodora* leaf powder
4. AGCD (control) ***versus*** AGCD + E. *citriodora* leaf powder

The major reason for having an "Untreated control vs HGD combination in the treatment list is that HGD is assumed to have *Eucalyptus* oil extract incorporated in the formulation. Fifty *P. truncatus* or *S. zeamais* adults previously deprived of food for 48 hours were separately released at the centre of the basin and left to wander to grain of their choice. A nylon mesh was placed over the top part of the basin to prevent the insects from escaping, but allowing free movement of air at the same time. The number of insects that settled in the 'control' (N_c) and treated (N_t) jars were recorded 24 hours' post-exposure. Also recorded was the number of undecided insects (i.e. those found neither on treated nor untreated grain). Each repellency arena was replicated four times. Percent repellency (PR) values were computed using the formula (1) below:

$$PR = \frac{N_c - N_t}{N_c + N_t} \times 100 \tag{1}$$

where:
PR = Percent Repellency
N_c = insect numbers present in control jar
N_t = insect numbers present in treated jar

Index of repellency (IR) was also calculated by following formula (2):

$$IR = \frac{2N_t}{N_c + N_t} \tag{2}$$

The repellency index was classified as: values < 1, repellency; 1, neutral; and > 1, attractant (Padin et al., 2013). Percent repellency data were analyzed by ANOVA after arcsine transformation. Negative PR values were treated as zeros.

Efficacy of E. citriodora leaf powder in grain protectants admixtures

This study was founded on preliminary research work carried out to determine the reproductive performance and associated grain damage of *P. truncatus* and *S. zeamais* in grain treated with half the recommended rate of ASCD. Although the *S. zeamais* could not successfully establish in the under-dosed grain, *P. truncatus* proliferated in the same conditions, causing percentage grain damage of 49.4-83.8%.

Two hundred grammes of grain were weighed out and admixed with each of six commercially available dilute dust insecticides (applied at the manufacturers' recommended rates). Air-dried *E. citriodora* leaf powder (at a rate of 10% w/w) was mixed with some of the insecticide-treated grain. However, some insecticide treatments were applied with no addition of the botanicals. The full list of treatments was as follows:

i. *E. citriodora* leaf powder alone
ii. ASCD
iii. AGCD
iv. HGD
v. CGP
vi. NY
vii. SSD
viii. ASCD + *E. citriodora* leaf powder
ix. AGCD + *E. citriodora* leaf powder
x. HGD + *E. citriodora* leaf powder
xi. CGP + *E. citriodora* leaf powder
xii. NY + *E. citriodora* leaf powder
xiii. SSD + *E. citriodora* leaf powder

Once all jars had been set up with the various treatments, 30 unsexed *P. truncatus* adults were introduced into each. These insects were obtained from a colony that had been deliberately cultured for 12 weeks on grain treated with a suboptimal dosage of ASCD (12.5 g/50 kg instead of 25 g/50 kg). The use of insect survivors from an ASCD treatment (now considered to be resistant) was to see if such insects would be killed by subsequent re-exposure to the same or different chemical treatment alone or applied in combination with *E. citriodora* leaves. This practice simulates the re-treatments which farmers conduct when they find their grain infested with *P. truncatus* despite having initially treated it at the time of storage. Due to a repellent effect, the inclusion of *Eucalyptus* leaves in the admixture would probably enhance effectiveness of such retreatment through making the insects restless and therefore pick up more insecticide deposits during their wandering.

The design of the experiment was a completely randomized factorial of 13 treatments and four factors (LGB populations). For each treatment and LGB population, there were four replications. Replicated control treatments consisting of untreated grain infested with insects from each population were also set up so as to be able to correct for mortalities in the 13 treatments. At seven days post-infestation, the contents of each jar were sieved and the number of dead insects were counted and recorded. Insects were considered dead if they did not respond to gentle probing by a blunt needle. Percentage mortality data were corrected for untreated control mortalities using Abbott's (1925) formula (3):

$$Corrected\ treatment\ \ mortality = \frac{(\%\ mortality\ in\ treatment - \%\ mortality\ in\ control)}{(100 - \%\ mortality\ in\ control)} \times 100 \qquad (3)$$

Prior to analysis, corrected mortality data were transformed by arcsine, and then subjected to ANOVA in STATA 11.

RESULTS AND DISCUSSION

Repellency studies

There were no significant differences in repellency of P. truncatus adults ($F3,15 = 1.24$; $P > 0.05$) (see Table 2) among the different treatment combinations; however, significant differences were observed on S. zeamais ($F3,15 = 4.05$; $P < 0.05$) (see Table 3). Significant differences were also noted between treatments of each combination, e.g. insects preferred to infest untreated controls than treatments which contained Eucalyptus leaf powder. When the LGB adults were put in the test arena, they remained motionless for quite some hours before a few started moving around.

All the treatments containing *Eucalyptus* leaf powder had a repellent effect on both *P. truncatus* adults and *S. zeamais* (Tables 2 and 3). After 24 hours, *E. citriodora* leaf powder produced the highest repellency against *P. truncatus* and *S. zeamais* (IR = 0.3 and 0.6, respectively). HGD was repellent to both species (IR = 0.8 for both species). However, the incorporation of *E. citriodora* leaf powder slightly lowered its repellency.

Incorporation of eucalyptus leaves enhances effectiveness of grain protectants

There were significant population ($F_{3,\ 156} = 4.14$, $P < 0.05$), treatment ($F_{12,\ 156} = 52.10$, $P < 0.05$) and population × treatment interaction ($F_{36,\ 156} = 2.08$, $P < 0.05$) effects. From Table 4 it can be deduced that *E. citriodora* produced the least mortalities across all the geographic populations. AGCD achieved the highest mortalities ranging from 92.8-100%. Further analysis revealed that *E. citriodora* leaf powder had significant variances with all other treatments except with ASCD + *E. citriodora*, NY + *E. citriodora* and SSD + *E. citriodora* where no significant variation was shown. This trend was also portrayed across all the geographic strains. It was also noted that most of the synthetic insecticides' efficacies against the bostrichids decreased when used in combination with the *E. citriodora* leaves.

Table 2. Effect of Eucalyptus citriodora leaf powder and its combination with HGD and AGCD on repellency of Prostephanus truncatus adults.

Treatment	Percentage Repellency	Index of Repellency
Untreated vs E. citriodora leaf powder	33.1±11.	0.6
Untreated vs HGD	23.6±9.4	0.8
HGD vs HGD + E. citriodora leaf powder	52.0±16.0	0.6
AGCD vs AGCD + E. citriodora leaf powder	38.8±16.1	0.6

Table 3. Effect of Eucalyptus citriodora leaf powder and its combination with HGD and AGCD on repellency of Sitophilus zeamais adults.

Treatment	Percentage Repellency	Index of Repellency
Untreated **vs** E. citriodora leaf powder	68.9±3.8a	0.3
Untreated **vs** HGD	31.0±15.7bc	0.8
HGD **vs** HGD + E. citriodora leaf powder	39.4±4.2abc	0.6
AGCD **vs** AGCD + E. citriodora leaf powder	67.4±3.4abcd	0.3

†*Values followed by the same letter in a column do not differ significantly (P < 0.05).
‡ IR: <1 repellency; 1 neutral; >1 attractant.

Table 4. Effects of Eucalyptus citriodora, six commercially registered insecticides and their combinations on % mortality of Prostephanus truncatus from different geographic areas

Treatments	Bindura	Headlands	Laboratory	Murehwa
E. citriodora leaf powder	10.7±0.12a	5.9±0.16a	0.0±0.00a	4.0±0.13a
ASCD	32.1±0.11a	17.8±0.27a	1.2±0.09a	19.3±0.06a
AGCD	100±0.0b	100.0±0.0b	95.2±0.14b	92.8±0.16b
HGD	70.2±0.42bc	75.0±0.34bcg	90.5±0.19bc	71.1±0.26bc
CGD	64.3±0.16bc	83.3±0.30bcd	94.0±0.16bcd	86.7±0.27bdc
NY	70.2±0.18bdc	86.9±0.33be	91.7±0.18bcde	89.2±0.22bcde
SSD	30.9±0.26abd	53.6±0.30b	72.6±0.34bcdef	73.5±0.34bcdef
ASCD + *E. citriodora* leaves	16.6±0.27abd	10.7±0.34a	11.9±0.23a	25.3±0.15a
AGCD + *E. citriodora* leaves	58.3±0.17abde	82.1±0.20bf	67.8±0.09bcdefg	78.3±0.29bcdefg
HGD+ *E. citriodora* leaves	20.2±0.36abde	21.4±0.21a	55.9±0.09bfh	22.9±0.02abfh
CGP + *E. citriodora* leaves	19.0±0.44abd	17.8±0.35ab	46.4±0.13cfhi	30.1±0.09cfhi
NY + *E. citriodora* leaves	25.0±0.22abcde	9.5±0.26ab	14.3±0.07agd	18.1±0.10agd
SSD + *E. citriodora* leaves	15.4±0.17abde	9.5±0.10ab	8.3±0.18age	42.2±0.16age

Means within a column followed by the same letter are not significantly different ($P \leq 0.05$).

Inyang and Emosairue (2005) observed that different insects respond differently to active materials in their environments. However, in some instances, different insect species respond similarly to a common stimulus. Repellents are desirable chemicals which offer grain protection by driving away insect pests from the treated materials through stimulating olfactory or other receptors (Talukder, 2006). When organisms are repelled from feeding materials, they are less likely to feed on them (Inyang & Emosairue, 2005).

Eucalyptus citriodora produces a strikingly pungent odour even without being squashed, and because of this characteristic, maize grain treated with the leaf powder significantly repelled *P. truncatus* and *S. zeamais* under laboratory conditions. Results suggest that if the *S. zeamais/P. truncatus* adults had choice, they would avoid materials treated with the *E. citriodora* leaf powder. Generally, percentage repellency values were higher on insecticides combined with *E. citriodora* leaf powder or *E. citriodora* alone. This result are supported by the studies carried out by Yaghoobi-Ershadi et al. (2006), who reported repellent properties of *Eucalyptus* against insect pests like *Phlebotomus papatasi*.

According to Tuncer and Aliniazee (1998), starved insects would naturally feed on the only food source available. Contrary to this, most of the adult *P. truncatus* remained stationary for nearly 5 minutes after being released at the centre of the arena, instead of moving toward a food source. However, *S. zeamais* became very mobile the very minute the insects were released.

According to Eziah et al. (2013), the overall repellent action of a leaf powder against insects is an indication of the presence of chemicals in the plants that stimulate or cause the insects to make oriented movement away from the source stimulus. The significant repellent activity against *S. zeamais* and *P. truncatus* observed in this exercise therefore suggests that there exist good potential for the use of *E. citriodora* as a traditional grain protectant against storage insect pests. Indeed, fresh gum tree leaves are used in some traditional grain stores in some parts of Zimbabwe (personal communication). Since the treatments with repellent properties reduce grain damage caused by the insects in the stored grains (Udo, 2011; Eziah et al., 2013), it is expected that the use of botanicals will boost food security in areas where investment in synthetic pest control is uneconomic.

Since the study to determine the incorporation of *E. citriodora* leaf powder to enhance the effectiveness of grain protectants was founded on pest insect that survived pre-exposure to grain treated with half-recommended rate of ASCD, the study end up focusing only on the bostrichid because the weevil could not successfully establish itself in the under-dosed grain. The efficacy of the *E. citriodora* leaf powder against LGB was comparable to that of the ASCD (applied using the recommended rate), and to treatment combinations of NY and SSD with *Eucalyptus* leaf powder. AGCD achieved 100% mortality against LGB across all the geographic populations. However, its efficacy against LGB significantly decreased when the same concentration of the treatment was used in combination with *E. citriodora* leaf powder. This scenario was common across most of conventional insecticides when administered in combination with *E. citriodora* leaf powder. The apparent reduced mortality was to be expected as the botanical repelled the insects away from the treated grain.

When a preliminary experiment was conducted using intact *E. citriodora* leaves, most of the LGB adults were found hiding i.e. they were not free to move, but forced to shelter at the bottom of the jars, away from the layer of *E. citriodora* leaves at the top and vice-versa if the leaves were at the bottom. These insect pests were usually found motionless though not dead, hence reducing the chances of picking up the contact insecticides when moving around. This is mainly because the botanical under study has significant repellent effects.

From this study, it can be seen that if farmers are to re-treat grain due to detected presence of live insects in the commodity, there may need to change the chemical product in order to prevent or delay insecticide resistance development in the target pests. Re-treating the grain with ASCD proved ineffective as evidenced by very low mortalities it caused. On the other hand, other synthetic insecticides with different active ingredients produced relatively high mortality rates with AGCD achieving 100% mortality against Bindura and Headlands populations.

Two insecticides can be used sequentially, as mixtures, in rotation or as mosaics (some areas treated with the first insecticide and other areas with the second insecticide) in a bid to manage resistance. Applying insecticides in rotation is generally the preferred method because susceptible pest genotypes generally have a reproductive advantage over resistant ones in the absence of an insecticide. The frequency of susceptible genotypes may increase during the periods when an insecticide is not used.

Other methods of managing resistance include use of insecticides only under good hygiene conditions; ensuring that dosage and application method are correct. Avoiding using insecticides on a calendar basis but only when it is necessary can also discourage development of resistance. Practitioners must also avoid increasing the amount of insecticide (i.e. increasing concentration) as it promotes further resistance. This approach is also uneconomical and not permitted because of stipulations of maximum residue limits in food products. It has been suggested that the risk of resistance be incorporated into pesticide registration requirements and that resistance management be used as justification for the registration of insecticide mixtures (Obeng-Ofori, 2010).

It can be concluded that that *E. citriodora* leaf powder significantly repels both *P. truncatus* and *S. zeamais*, however, its incorporation as a powder in insecticide/grain admixtures is unlikely to increase the insecticidal properties of the conventional insecticides in postharvest pests, especially with regards to LGB. The most practical use of *E. citriodora* leaf powder by smallholder farmers is as a repellent to deter insect infestations thus reducing potential grain damage.

CONCLUSION

There is need for further local studies with as many plant species as possible so as to determine their usefulness in stored-product primary insect pest management, to help the smallholder farmers who are unable to meet the cost of insecticides. Small plantations of *E. citriodora* must be established by smallholder farmers so as to offer a ready source of leaf powder which may be used for enhanced grain protection against primary insect pests by driving them away from the grain stores. However, further studies with *E. citriodora* is encouraged. These studies may be conducted by applying the leaf powder at a higher rate or conducting the studies using leaf extracts.

CONFLICT OF INTEREST

The authors have no conflict of interest to report.

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ارزیابی حفاظت از دانه از طریق تلفیق برگ‌های اکالیپتوس ***citriodora*** در مواد ترکیبی دانه/حشره‌کش در زیمبابوه

جیمز ماچینگورا

چکیده:

کنترل آفات حشرات انبار دانه عمدتا از طریق استفاده از حشره کش‌های مصنوعی انجام می‌شود. با این حال استفاده گسترده و پایدار از این مواد شیمیایی موجب عوارضی شده است که عبارتند از تسریع سریع تر فرم‌های مقاوم در برابر آفات، از این رو، فراخوان جهانی برای اقدامات کنترل جایگزینی برای کاهش کاربردهای شیمیایی وجود دارد. هدف از این تحقیق ارزیابی اثرات ضدعفونی و سمی پودر برگ *E. citiodora* در گونه *P. truncatus* و *Sitophilus zeamus* در دفع آفات بود. یک طرح کاملا تصادفی در تمام آزمایشات استفاده شد. برای ارزیابی اثرات ضدعفونی پودر برگ *E.citriodora* بر روی *P. truncatus* و *S. zeamus* ، یک تست انتخاب شد. اثر سمی *E. citriodora* نیز مورد بررسی قرار گرفت. به ترتیب با غلات و حشره کش‌های معمولی که به عنوان کنترل منفی و مثبت مورد استفاده قرار می گرفت، مورد بررسی قرار گرفتند. نتایج نشان داد که پودر برگ *E. citiodora* در هر دو گونه *P. truncatus* و *S. zeamus* دارای خواص ضدعفونی تا ۶۸/۹ درصد بود. با این وجود، مرگ و میر *P. truncatus* بالغ هنگامی ثبت شد که اثر محافظتی پودر برگ *E. citriodora* (میزان ۱۰٪ وزنی/وزنی) مورد آزمایش قرار گرفت. علاوه بر این، اثربخشی حشره کش‌های مصنوعی به طور جداگانه نسبت به زمانی که در ترکیب با پودر برگ *E. citriodora* استفاده شد، نسبتا بالاتر بود. مقادیر کوچکی از *E. citriodora* ممکن است به منظور حفاظت موقت دانه در برابر آفات اولیه حشرات ایجاد شود.

کلمات کلیدی: *Eucalyptus citriodora*، *Prostephanus truncates*، دفع آفات، *Sitophilus zeamais*، حساسیت