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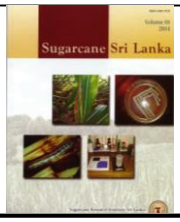

RESEARCH

Evaluating the plant extracts effective as repellents for Sugarcane Internode Borer *Chilo sacchariphagus*; (Lepidoptera: Pyralidae)

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ABSTRACT

Sugarcane internode borer (INB) (*Chilo sacchariphagus*) is a major pest causing severe losses to the crop. Efficacy of six plant-derived extracts, lantana (*Lantana camara*), marigold (*Tagetes spp.*), wild sunflower (*Helianthus annuus*), cloves (*Syzygium aromaticum*), lemon grass (*Cymbopogon citratus*), and black pepper (*Piper nigrum*), were selected for their potential bioactivity. Extracts were prepared using ethanolic extraction (lantana, marigold, wild sunflower), steam distillation (lemon grass, cloves), and hydro distillation (black pepper). Field experiments were conducted using prepared Gel vaporizers. The total number of moths attracted to the sugarcane plants while repellent gel vaporizers were established were recorded. Phytotoxic effect on leaves, retention of odour and keeping quality and yeast and mold count of each was studied. Lemmon grass and lantana were effective repellent to the sugarcane moth borer i.e., Lemmon grass (p>0005), lantana (p>0.0007). Wild sunflower (p>0.0078) and clove (p>0.0007) showed attractant to the sugarcane moth borer. Marigold (p>0.0964), pepper (p>0.0539) not showed repellence and attractant to the sugarcane moth borer. Highest effective distance was recorded for lemon grass and lantana, 9m from the gel vaporizer. Odor retention of the all four selected gel vaporizers were in good quality for 2 weeks period and after 2weeks it was in a diminishing trend in open environment. Under both cold and dry conditions keeping quality was observed to be in good state. According to the results lemon grass and lantana gel vaporizers were effective in repelling sugarcane moth borer in different extent and having good potential in repelling sugarcane moth borer from the plants.

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INTRODUCTION

Sugar is an important sub-sector of the economy of Sri Lanka. Thus, the sugar sector of Sri Lanka makes a significant contribution to the national balance of payments in addition to its contributions to income and employment generation. Sugarcane pests in Sri Lanka cause significant crop and sugar losses. It is affected by several pests i.e. borers, sap feeders, termites. Among them Sugarcane moth borers pink borer, internode borer [1], Sugarcane woolly aphids, *Aceria sacchari* [2], *Pyrilla perpusilla* [3], white leaf disease (WLD) vector; *Deltocephalus menoni* [3] are most important and crucial pest at the moment.

Sugarcane moth borers (*Chilo sacchariphagus*, Lepidoptera: Pyralidae and *Sesamia inferans*; Lepidoptera: Noctuidae) considered as a major pest group in sugarcane in Sri Lanka. An increasing trend of borer damage incidences has been found in sugarcane plantations in Sri Lanka since 2016 and it has reached to economic injurious level in 2019 resulting poor quality seed-cane production in seed-cane nurseries and reduction of sugar production due to low juice quality. Currently several management strategies have employed in integrated pest management (IPM) package for sugarcane moth borers including several cultural, physical and biological control measures [5]. Moth borers are being controlled naturally with the indigenous egg, larval and pupae parasitoids for long time and they remain as chronic pests causing severe and localized losses in some regions [1].

Most sugarcane farmers in Sri Lanka conventionally apply insecticides to control the insect pests including moth borers even though using insecticides causes many kinds of side effects. Long-term use of pesticides may result in the development of target insect pests that resistance to the insecticides, chemicals and Chemical treatments. Hence it is very important to adopt an environmentally friendly pest control method. Earlier people used plants with pesticidal qualities. Plant based botanicals are very effective in pests management as they are eco-friendly, less costly, and less harmful to the environment than synthetic pesticides. Botanicals have many properties including insecticidal activity. A repellent can be defined as a behavioral response to a stimulus and the differences between behavioral responses can be subjective.

Therefore the main objective of the study was evaluating the effectiveness of the repellent action of six (06) selected plant extracts on *Chilo sacchariphagus,* Lepidoptera: Pyralidae under natural conditions.

MATERIALS AND METHODS

Study Area

The study will be conducted in the Entomology laboratory and the Research farm of the Sugarcane Research Institute (SRI), Uda-Walawe, Sri Lanka (60 21 N^0; 80 48 E^0; Average temperature: 17-36 ºC; Average rainfall: 1300-1600 mm; Elevation from mean sea level: 76 m).

Selection of Plant materials

Six different plants i.e. pepper, lantana, lemon grass, marigold, wild sunflower and cloves were selected for the experiment (Table 01). These plant materials were selected on the basis of ease of supply, availability and cost effectiveness.

Table 01. Plants with repellent nature to Hemipterance and the parts use to repellents

Scientific name	Common name	Plant part
L. camara	Lantana	Leaves
T. irecta	Marigold	Flowers
P. nigrum	Pepper	Fruit
S. aromaticum	Cloves	Fruit
C. citratus	Lemon grass	Leaves
H. annus	Wild sunflower	Leaves

Preparation of Plant Extract

Considering the available literature on plant repellants for hemipterans, especially leaf hoppers, six plant spp (Marigold, Lemon grass, Lantana, Wild sunflower, Pepper, and Cloves) were selected for the study. Considering the available literature ethanol extraction, steam

and hydro distillation methods were selected for extraction of the repellent compounds for the study. Following procedures were followed in extraction.

Marigold flower extract: Marigold flowers were plucked and dried under shade. Then it was ground into fine powder. Twenty grams (20 g) of dried plant materials were used for extraction at room temperature using 100ml of 96 %ethanol. It was kept in the shaker for about 6 hrs and extracts were filtered through a Whatman No 01-filter paper. Filtered solution was evaporated in a water bath at 65 ° C for about 72hrs and it was kept in an oven at 45 ° C [6] The dried extract was dissolved in distilled water to give final concentrations.

Lemon grass leaf extract: Steam distillation was practiced with 250 ml of distilled water and 150 g of fresh lemongrass sample added to 1l round bottom flask. Lemongrass leaves were steamed to release the essential oil. As steam passes through the condenser, it condensed into liquid. The condensate collects immediately into a 500 ml beaker, and poured through the reparatory funnel. Two layers of water and oil separated using separator. To stop the essential oils from evaporating, the bottle is securely secured.

Wild Sunflower leaf extract: Wild sunflower leaves were collected and air dried and grinded into fine powder by using electrical grinder. The powdered dry leaves filtered with a wire mesh. 20g of dried plant material was used for extraction at room temperature by using 100ml of 96% ethanol. It was kept in the shaker for about 6 hrs and extracts were filtered through a Whatman No 01-filter paper. Filtered solution was evaporated in a water bath at 65 ° C for about 72hrs and it was kept in an oven at 45 ° C. The dried extract was dissolved in distilled water to give final concentrations.

Lantana leaf extract: Lantana leaves were collected, air dried and grinded into fine powder by using electrical grinder. The powdered dry leaves filtered with a wire mesh. 20g of dried plant material was used for extraction at room temperature by using 100ml of 96% ethanol. It was kept in the shaker for about 6 hrs and extracts were filtered through a Whatman No 01-filter paper. Filtered solution was evaporated in a water bath at 65 ° C for about 72hrs and it was kept in an oven at 45 ° C. The dried extract was dissolved in distilled water to give final concentrations.

Pepper extract: Black pepper plant extracts was extracted by using hydro distillation method. Black pepper seeds were picked, dried and grinded by using a grinder. The pepper was cooled at 10 °C in a refrigerator for 2 h before milling. The ground pepper particles were filtered with a wire mesh which was sizes ranging from 20 to 160 meshes. Then sodium chloride dissolved in water was added to the flask containing the material and then the brine/material suspension was gently shaken. After soaking in NaCl solution for required time, 20 g of black pepper was placed into a 1000 ml volume flask, connected directly to the Clevenger apparatus and heated with the Heating Mantle. After the extraction process was completed, the essential oil is recovered and dehydrated with sodium sulfate (Na_2SO_4) and stored in a storage tank at 10 °C.

Cloves extract: The ground clove bud samples (30 g) were weighed and quantitatively transferred into a filter paper extraction thimble and inserted into a 500-ml reflux flask. After that extracted with 250 ml absolute ethanol for about 6 h in a Soxhlet apparatus. Finally, soxhlet extraction, extracts were concentrated using rotary vacuum evaporator at 50 ^{0}C [7].

I. Identification of best plant repellent for moth borer

Study was conducted in two steps viz., preliminary study and field study. Choice tests were conducted to study the repellent nature and toxicity of the extracts to the WLD vector. Two-month-old potted plants in insect proof cages were used for the study. All six treatments were used in both repellent and toxicity study. One milligram of solid repellents extracts (i.e., Marigold, Wild sunflower, Lantana) were concentrated with 1ml of distilled water and treatment was prepared. Liquid repellents (i.e., Lemongrass, Cloves, and Pepper) were used 1ml concentration as the treatment.

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a. Studying the repellent nature of extracts

In here two 2-month-old potted plant were established in an insect proof field cage and one plant was sprayed with 1 ml of prepared plant extract and other plant was not sprayed and taken as a control. Two number of internode borer (*Chilo sacchariphagus*) were released in to the cage. Positions of the insects were obtained after 24 hours.

b. Determining the toxicity effect of the extraction on moth borers

Two-month-old potted plant part was sprayed with 1 ml of prepared plant extracts and established in an insect proof field cage. Two number of internode borer (*Chilo sacchariphagus*) were released in to the cage. Positions and death count of the insects were obtained after 24 hours.

c. Observing phytotoxic effect of selected repellents on sugarcane leaves

Two months old potted sugarcane plants were established in an open area. Four - centimeter area of 3rd leaf was marked. Prepared extracts of Marigold, Lemmon grass, Pepper, Cloves, Wild Sunflowers, and Lantana solutions were sprayed to 3rd leaf of three sugarcane plant and three plants were kept aside without any treatment as control. Condition of the sprayed leaves and non-sprayed leaf were observed up to twelve days and changes were recorded.

II. Field study to determine best plant repellent for moth borers

Preparation of gel vaporizer: Fifteen grams of gelatin was dissolved in 50ml of distilled water at room temperature. Distilled water was boiled and removed from the heat. The gelatin solution was added to the boiling water and mixed until yellow homogeneous solution was obtained. Prepared extracts were added, to 50ml gelatin solution. One percent of the salt was also added in the all samples. After stirring well, the homogeneous mixture was poured into a porous mould / containers and then left in the freezer for 2 hours to fix. After cooling in the freezer, the samples were taken out at the room temperature.

a. Determining the effectiveness of the gel air vaporizer in the field

In here light traps were used to determine the insect population in the areas where treatment established and control. Insect counts were obtained during 7.00pm to 8.00pm.

In the nursery gel air vaporizer was established using stick pole at the canopy height of the sugarcane plants. Standard UV light trap for borer moths was established 3m distance from the treatment and another UV light trap with same standards was established in 30 m distance as a control.

Traps were lit approximately 6.45 pm when the area is dark and kept undisturbed for 1hour period until the insects were landed on the trap. After one hour period number of insects attracted to the trap were collected and counted. Test was done for each six treatments ie Marigold, Lemon grass, Pepper, Cloves, Wild sunflower and Lantana in a same way and test was replicated for 3 times for each selected treatment.

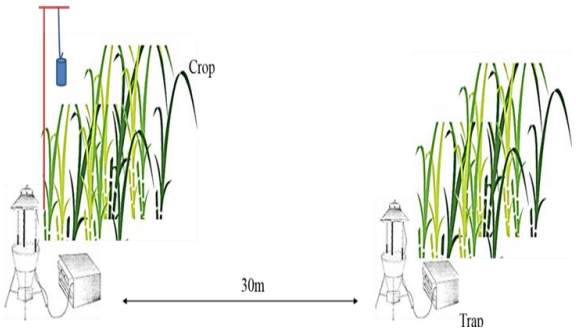

Figure 01. Experimental setup for studying the repellency of sugarcane moth borers for selected repellents under the field condition

b. Determining the effective distance of the gel air freshener

A light trap was established in the field without any treatment to confirm the availability of the moth borer. After the Lemmon grass, Lantana and Marigold gel air freshener were established in the field as illustrated in the figure 02. Those were established orderly distance of 3m, 6m, 9m, and 12m. In each establishment 3m distance

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increased after confirming the absence of the vectors at the particular distance. Here light trap were established, left for ½ hr period undisturbed and attracted vectors were counted and recorded carefully.

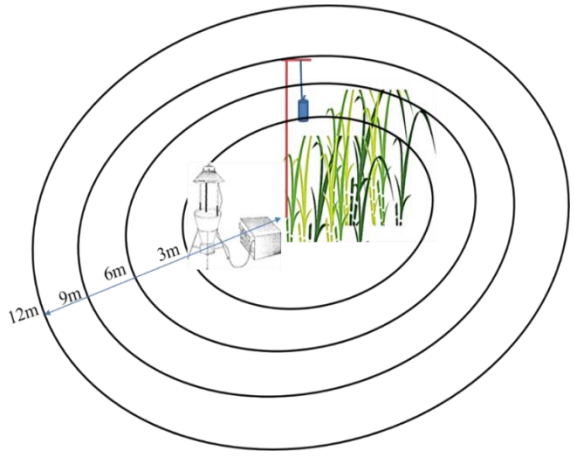

Figure 02. Experimental setup for studying the effective distance of gel vaporizers with repellents for sugarcane moth borers under the field condition

c. *Determining the effective period and keeping quality of the gel vaporizer*

Retention odor in external environment:

Marigold, Lemon grass, Pepper, Cloves, Lantana and Wild sunflower gel air freshener samples were kept in open environment and its odor was observed daily.

Appearance and color in cold and dry environment:

Ten grams of lemmon grass, marigold, Pepper, Cloves, Lantana and Wild sunflower gel vaporizer samples were prepared. Then, 5g of each sample was divided in to two portions and placed them in a sterilized petri dishes separately. Petri dishes were replaced with lid and wrapped with paraffin and labeled. One sample from each sample was placed outdoors in room temperature. The other sample was kept in the refrigerator. The changes of colour, texture and fungi growth of samples were observed within a month.

Plate Count and Yeast and mould count

Yeast mold count: Potato Dextrose Agar (PDA) media was poured into each plate and left plate on the sterile surface until the media had solidified. 1 gram of extracted samples from marigold, lemmon grass, citronella, and mustard were weighted and dissolved in 99 ml distilled water separately. Sterilized test tubes were filled with 9 ml of distilled water. Then, the 1ml from dissolved sample was added to one test tube and mixed thoroughly until they were completely dissolved. Dilution was prepared until 105. After that 2 microliter of diluted sample was inoculated in the particular culture plate. Lid was replaced and wrapped with paraffin and labeled. Plates were inverted and kept in the incubator at 300 °C for 27 hours. All process were conducted inside the lamina flow chamber. All procedures were continuous for all samples separately. After 27 hours and after two days colonies were counted. Value of the Colony forming unit per milliliter was calculated by using following formula.

$$\frac{\text{CFU}}{\text{ml}} = \frac{(\text{Number of colonies} \times \text{Dilution Factor})}{\text{Volume of culture plate}}$$

(CFU/ml – (Number of colonies*dilution factor) / volume of culture plate.)

Total Plate Count (PCA)

Plate Count Agar (PCA) media was poured into each plate and left plate on the sterile surface until the media had solidified. 1 gram of extracted samples from marigold, lemmon grass, citronella, and mustard were weighted and dissolved in 99 ml distilled water separately. Sterilized test tubes were filled with 9ml of distilled water. Then, the 1ml from dissolved sample was added to one test tube and mixed thoroughly until they were completely dissolved. Dilution was prepared until 1010 for lemmon grass and citronella. Dilution was prepared until 1020 for mustard and marigold. After that 2 microliter of diluted sample was inoculated in the particular culture plate. Lid was replaced and wrapped with paraffin and labeled. Plates were inverted and kept in the incubator at 300 °C for 24 hours. All processes were conducted inside the lamina flow chamber. All these procedures were continuous for all samples separately.

After 24 hours and after two days colonies were counted. Value of the Colony forming unit per milliliter was calculated by using following formula.

$$\frac{\text{CFU}}{\text{ml}} = \frac{(\text{Number of colonies} \times \text{Dilution Factor})}{\text{Volume of culture plate}}$$

Percentage of toxicity of each plant extracts on moths were taken after 24 hours, number of moths attracted to light trap while presence of the gel vaporizers were taken to measure the effectiveness of the gel air vaporizer in the field to measure the effective distance, data of Yeast and Mold Count (PDA) and data of the Total Plate Count (PCA) for all plant extracts were taken to measure the keeping quality of the gel vaporizers.

Data Analysis

SAS software version 9.0 was used in data analysis. Effect of selected plant extracts and gel vaporizers were determined by using Wilcoxon Scores (Rank Sums) test. Means of the effective distances were separated by using Duncan's Multiple Range Test (DMRT) at 0.05 probability level. Data on laboratory tests were illustrated using Microsoft excel.

a. Studying the repellent nature and toxicity effect of extracts

According to the laboratory results, death of the insects recorded in the insect cages where lantana treatment was placed on the sugarcane plants. In the marigold treatment the insects were observe in the roof of the insect cage. In the wild sunflower treatment one insect found in the control side and one insect found at the wall of insect cage. After 24 hours taken the results and taken the percentage of the repellent and toxicity nature of each plan extracts.

According to the results, lemon grass has repellent nature. Significant effect was recorded on repellence of the sugarcane moth borer (p> 0.0005) due to the treatment. Lantana also has repellent nature. Significant effect was recorded on repellence of the sugarcane moth borer (p> 0.0007) due to the treatment. Marigold is not a repellent for sugarcane moths. Significant not effect was recorded on repellence of the sugarcane moth borer (p> 0.0964) due to the treatment. Wild sunflower and cloves act as attracted treatments for sugarcane moths. Wild sunflower was significant effect was recorded on repellence of the sugarcane moth borer (p> 0.0078).

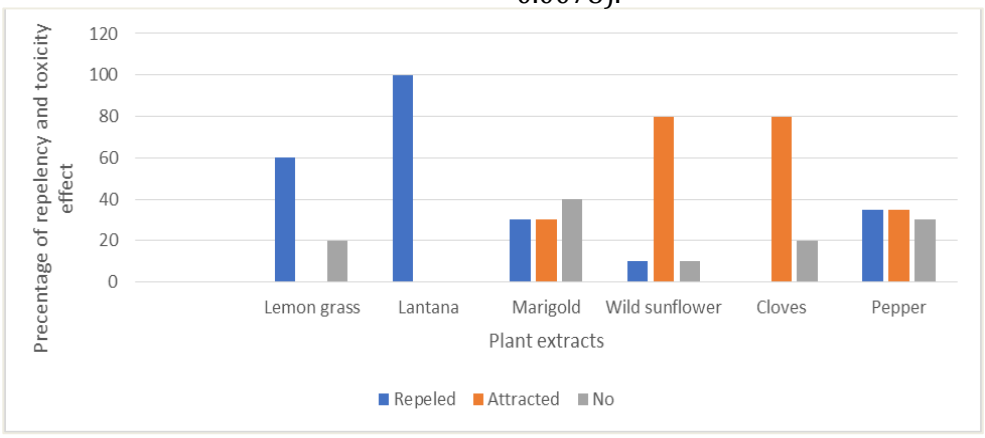

Figure 03. Percentage of repellency and toxicity effect of plant extracts at the laboratory test

RESULTS AND DISCUSSION

I. Determination of best plant repellent for sugarcane moth borer under laboratory condition

Cloves was significant effect was recorded on repellence of the sugarcane moth borer (p> 0.0007). Pepper also not a repellent. Significant not effect was recorded on repellence of the sugarcane moth borer (p> 0.0539) due to the treatment.

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b. Observing phytotoxic effect of selected repellents sugarcane leaves

After spraying the selected repellents phytotoxic effect for sugarcane leaves was observed for 12 days and among them there was no phytotoxic effect was observed on leaves due to spraying of Lemmon grass extracts. Slight yellowing was observed in clove and pepper extract sprayed leaves after day six on leaf lamina. But no any significant burning appearance of leaf death observed. Rough nature was observed in lantana extract sprayed leaves. After day three on leaf lamina. There for spraying clove, pepper, lantana extract would not be effective in controlling pests of sugarcane and thereby it will be effective to use them as repellents.

significantly effective to the sugarcane moth borer ie, wild sunflower ($p>0.0078$) and cloves ($p>0.0007$). Wild sunflower and cloves were act as an attractants to the sugarcane moths bores (adult moths).

b. Determining the effective distance of the gel air freshener

According to the field study data can be observed lantana and lemon grass are more effective than other treatments. Therefore determination of effective distance is done for that treatment. In related to the effective distance of selected repellents lantana and lemon grass were recorded 9 m (9a±0) from the gel vaporizer.

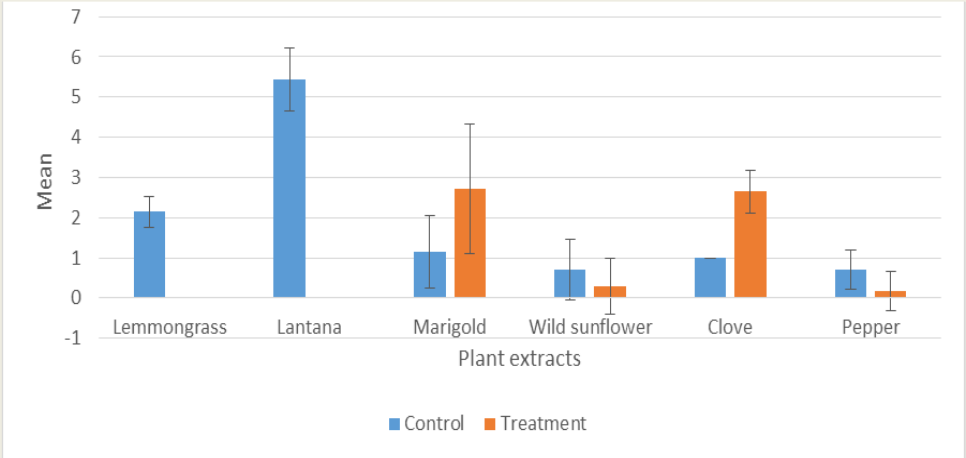

Figure 04. Effectiveness of the gel vaporizer in the field

II. Determination of best plant repellent for sugarcane moth borer under field condition

a. Determining the effectiveness of the gel air vaporizer in the field

During the period of field test sugarcane moths were attracted to the control and the numbers were among 0 to 6. For lemon grass and lantana no sugarcane moths were recorded throughout the study at the distance of 3 m from the gel vaporizer. Lantana and lemon grass treatments showed significant repellence to the sugarcane moth borer ie, lantana ($p>0.0007$) and lemon grass ($p>0.0005$). Marigold and pepper treatments showed significantly not repellence to the sugarcane moth borer ie, marigold ($p>0.0964$), pepper ($p>0.0539$). Wild sunflower and cloves were showed

Accordingly lantana and lemon grass showed highest repellency to the sugarcane moth borers in the menace of repellent character and effective distance.

III. Determining the effective period and keeping the quality of the gel vaporizer

a. Retention odor in external environment

Odor retention of all six selected gel vaporizers was in good quality for 2 - week period and after 2 weeks it was in a diminishing trend in open environment. There for these vaporizers will be able to use for 2 week period after opening for outer environment.

Appearance and color in cold and dry environment: There was no change in

appearance or color recorded in all the gel vaporizer samples in cold environment (Refrigerator condition) at one week period (Figure 05 (a)) and at after 4 week period (Figure 05 (b)) after preparation.

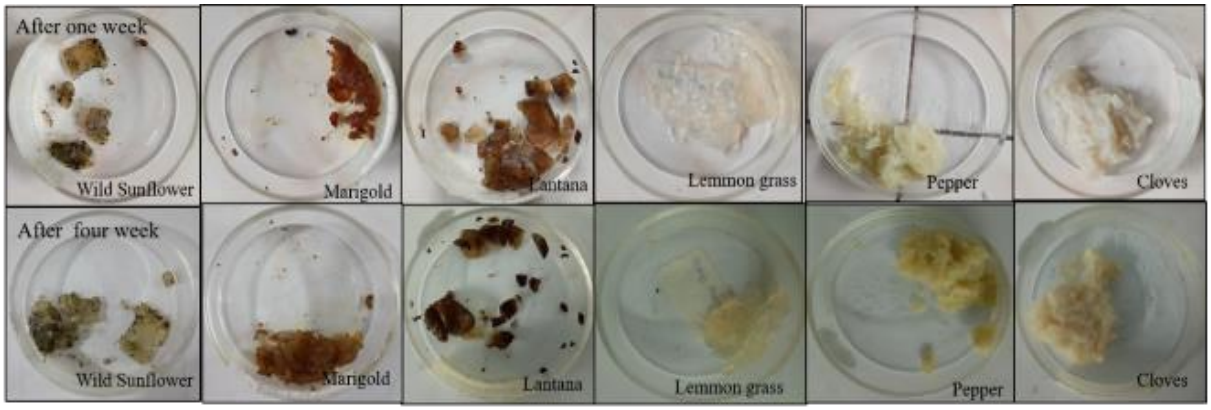

Figure 05. Appearance and color of wild sunflower, marigold, lantana, lemmon grass, pepper, clove gel vaporizer samples in cold environment (Refrigerator condition)
Note: a). at one week period and b). at after 4 week period after preparation

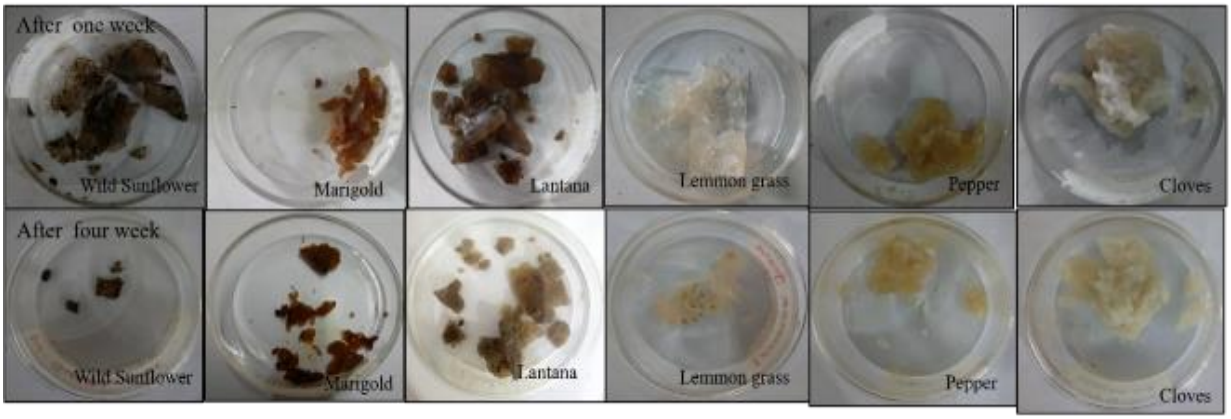

Figure 06. Appearance and color of wild sunflower, marigold, lantana, lemmon grass, pepper, clove gel vaporizer samples in dry (outer) environment
Note: a). at one week period and b). at after 4 - week period after preparation

Also, there was no change in appearance or color recorded in all the gel vaporizer samples in dry (outer) environment at one week period (Figure 06 (a)) and at after 4 week period (Figure 06 (b)) after preparation. Under both cold and dry conditions keeping quality was observed to be in good state by maintaining good hygiene at preparation and storing.

b. Plate Count and Yeast and mould count

Total Plate Count: provides information about the total number of viable bacteria in a sample. A higher TPC indicates a higher microbial load, which can be a concern if it exceeds acceptable limits, depending on product type. TPC is often used as a quality control measure. In many cases, lower TPC values are desirable, as they indicate better product quality and reduced risk of spoilage.

Yeast and mould count; for all the prepared gel vaporizers yeast and mold count was zero at initially. A zero yeast and mold count in a product can be interpreted as a positive quality indicator. It means that, at the time of testing, the product had no detectable levels of yeast and mold. This is typically a desirable result, as yeast and mold can cause spoilage and affect product quality.

Table 02. Plate Count and Yeast and mould count

Extract	PDA		PCA	
	CFU/ML after 24 hrs	CFU/ML after 24 hrs	CFU/ML after 24 hrs	CFU/ML after 24 hrs
Lemon grass	0	$42x10^{8}$	$10.5x10^{13}$	$33.5x10^{13}$
Marigold	0	$0.5x10^{8}$	0	$0.5x10^{13}$
Lantana	0	$7x10^{8}$	$30x10^{13}$	$36.5x10^{13}$
Wild Sunflower	0	0	$81.5x10^{13}$	$10.5x10^{23}$
Cloves	0	$0.5x10^{8}$	$3x10^{23}$	$3.5x10^{23}$
Pepper	0	$3.5x10^{15}$	$23x10^{18}$	$40x10^{18}$

Proper handling, storage, and packaging are essential to maintain this low microbial count throughout the product's shelf life. Regular testing and monitoring are required to ensure continued product quality and safety. An increase in yeast and mold counts is a warning sign of potential spoilage of the product. These microorganisms can degrade the quality, appearance, and safety of the product over time.

Bratovčić [8], have noted that, in a study on the stability of synthetic gel vaporizer at room temperature (about 28 ^{0}C) mold begins to grow after 84 hours at room temperature in the presence of water. It observed that, mold begins to grow after 72 hours at room temperature which is similarly to it. According to the results lemmon grass and lantana gel vaporizers were effective in repelling sugarcane moth borer in different extent.

Wild sunflower and clove were act as attractant to the sugarcane moth borer. In related to the marigold and pepper extracts were not effective in both manners. Several studies have confirmed that these compounds effective in pest management. When considering the lemmon grass which have been found as effective repellent in this study, it has been long known for repellent for many pests. If an emulsion containing oil is sprayed on crops affected by pests, it kills aphids, mites and ticks. Just by rubbing the fresh leaves of the plant onto a surface keeps away flies and mosquitoes. Burning the plant oil also repels insects. A diluted solution of the juice obtained from pressing the roots can be used effectively for pest control. To control nematodes, it is recommended to grow the grass on infested plots. This leads to a rapid decline in nematode populations in the soil. Lemmon grass oil had significantly less effect on larval duration and larval weight which resulted in increased larval mortality [9]. Lemongrass essential oil as an insecticide approach to management of *A. ipsilon.*

Lemon grass oil is used as a pesticide. Lemmon grass oil also used in soaps, as an insect repellent (especially mosquitoes) in insect sprays and candles, and in aromatherapy. Essential oils of natiuve and exotic lemongrass have efficacy for maize weevil mortality. It is confirmed that the increase in the applied dose reflects in a reduction in the insect's exposure time for death to occur. Lemmon grass has the capacity and potential to be used in the management of corn weevil, and can be an alternative for small holder farmers and organic production [10].

In this study found that lantana had repellent effect on sugarcane moth borer. Previous study showed that the insecticidal property of methanol, ethanol, and ethyl acetate extracts of *Lantana camara* leaf oil and powder can be used for controlling maize weevils, *Sitophilus zeamais*. The effect of leaf powder and extracted oil on repellency and mortality for insects is due to the presence of bioactive and phytochemical molecules such as Phytol, Pyrroline, Paromomycin, Pyrrolizin and 1-Eicosano. It was concluded that both *L. camara* leaf powder and extract oil can be used to protect stored maize from *S. zeamais* infestation [11]. *L. camara* at 10% w/w repelled 65.0 and 62.5% of insects [12]. In no-

choice tests, termite feeding activity was significantly reduced and termite mortality was significantly greater in the treatments than in the control.

That is showed that the chloroform leaf extract of *L. camara* has excellent repellent and moderate toxic and anti-feedant activities [13]. *L. camara* contain Hexadecanoic acid phytol, caryophyllene oxide, 9,12,15-octadecatrienoic acid, methyl ester, (Z,Z,Z) caryophyllene, α-caryophyllene, germacrene D, isocaryophillene, γ -muurolene, γ – elemene that effect to target pests [14]. There was a study showed that the potential of essential oil that extracted from *L. camara* in developing new repellents against mosquitoes [15].

Marigold and pepper extracts were not showed any effectiveness as repellent for sugarcane moth borer in this study. But previous studies showed that marigold and pepper had repellent effect for insects. The marigold treatment had the highest cabbage flea beetle (*C. confinis*) prevalence, which could be attributed to its role as a pulling strategy. Marigold is recognized as a valuable plant that maintains a high natural enemy biodiversity. The marigold plant (*T. erecta*) can reduce crop pest infestation [16], [17]. *P. nigrum* extracts can provide reasonable levels of control against lepidopteran and European pine sawfly larvae and also act as a short-term repellent and feeding deterrent.

CONCLUSIONS

Lemmon grass and lantana showed repellence to the sugarcane moth borer. Wild sunflower and cloves showed attractant to sugarcane moth borer. Marigold and pepper are not showed effectiveness in both manner.
In related to the effective distance of selected repellents, highest distance was recorded for lantana and lemon grass. It was 9m from the gel vaporizer.
Odour retention of the all four selected gel vaporizers were in good quality for 2 weeks period and after 2 weeks it was in a diminishing trend in open environment.
Under both cold and dry conditions keeping quality was observed to be in good state, for all the the prepared gel vaporizers yeast and mold count was zero at initially.
Additional trials are needed to study the effective time period of the odour of gel air fresheners in the field.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

[1] Wanasinghe, V.K.A.S.M. and Chanchala, K.M.G.2020. Pests of Sugarcane in Sri Lanka. Sugarcane Research Institute, Uda Walawe.

[2] Wanasinghe, V.K.A.S.M., Chanchala, K.M.G., Navia, D., Nugaliyadde, L. and Aratchige, N.S. 2018. The First Record of *Aceria sacchari* Wang, an Eriophyoid Mite, in Sugarcane Plantations in Sri Lanka. International Journal of Scientific and Research Publications, 8 (9), pp 266-268. [CrossRef]

[3] Wanasinghe, V.K.A.S.M., Chanchala, K.M.G., MKPC Gunawardena and A Wijesuriya . 2019. Control of Sugarcane Leaf Hopper, *Pyrilla perpusilla* by *Fulgoraecia (Epiricania) melanoleuca* Fletcher (Lepidoptera: Epipyropidae) in the seed cane nursery at Kantale, Sri Lanka. Proceeding of International Conference Sugarcon, Pp 119.

[4] Chanchala, K.M.G., Wanasinghe, V.K.A.S.M., Ariyawansa, B.D.S.K. and Hemachandra, K.S. 2014. Relationship between the incidences of Sugarcane White Leaf Disease and the Population Dynamics of Its Vector, Deltocephalus menoni (Homoptera: Cicadellidae), in Sri Lanka. pp 143-149. [CrossRef]

[5] Wanasinghe, V.K.A.S.M., Chanchala, K.M.G., Weragoda, W.G.M.S., and Nugaliyadde, L. (2019). Evaluation of the necessity of insecticides and the potential in establishing the larval parasitoid; *Cotesia flavipes* (Hymenoptera: Braconidae) for management of sugarcane shoot borers in Ampara district, Sri Lanka. Proceedings of the Seventh Symposium on Plantation Crop Research. Pp. 145-152. [CrossRef]

[6] Ahmad, N., Fazal, H., Abbasi, B.H., Farooq, S., Ali, M. and Khan, M.A., 2012. Biological role of *Piper nigrum* L. (Black pepper): A review. Asian Pacific Journal of Tropical Biomedicine, 2(3), pp.S1945-S1953. [CrossRef]

[7] Guan, W., Li, S., Yan, R., Tang, S. and Quan, C., 2007. Comparison of essential oils of clove buds extracted with supercritical carbon dioxide and other three traditional extraction methods. Food Chemistry, 101(4), pp.1558-1564. [CrossRef]

[8] Bratovčić, A., 2019. Synthesis of gel air freshener and its stability. Technologica Acta: Scientific/Professional Journal of Chemistry and Technology, 12(2), pp.15–21. [CrossRef]

[9] Abdel-Hakim, E.A., Ibrahim, S.S. and Salem, N.Y., 2021. Effect of garlic and lemongrass essential oils on some biological and biochemical aspects of corn stem borer *Sesamia cretica* larvae (Lepidoptera: Noctuidae) during diapausing phase. Proceedings of the Zoological Society, 74(1), pp.73–82. [CrossRef]

[10] Radünz, A.L., Radünz, M., Bizollo, A.R., Tramontin, M.A., Radünz, L.L., Mariot, M.P., Tempel-Stumpf, E.R., Calisto, J.F.F., Zaniol, F., Albeny-Simões, D. and Rezende, R.S., 2022. Insecticidal and repellent activity of native and exotic lemongrass on Maize

weevil. Brazilian Journal of Biology, 84, p.e252990. [CrossRef]

[11] Ayalew, A.A., 2020. Insecticidal activity of *Lantana camara* extract oil on controlling maize grain weevils. Toxicology Research and Application, 4, p. [CrossRef]

[12] Ogendo, J.O., Belmain, S.R., Deng, A.L. and Walker, D.J., 2003. Comparison of toxic and repellent effects of *Lantana camara* L. with Tephrosia vogelii Hook and A Synthetic Pesticide against *Sitophilus zeamais* Motschulsky (Coleoptera: Gurculionidae) in Stored Maize Grain. International Journal of tropical insect science, 23, pp.127-135. [CrossRef]

[13] Yuan, Z. and Hu, X.P., 2012. Repellent, antifeedant, and toxic activities of Lantana camara leaf extract against *Reticulitermes flavipes* (Isoptera: Rhinotermitidae). Journal of Economic Entomology, 105(6), pp.2115-2121. [CrossRef]

[14] Sonkar, K.S.Y. and Chouhan, N.K., 2023. Role of botanicals in pest management. Emerg. Trends Entomol., 43, pp.43–62. [CrossRef]

[15] Bhargava, S., Agrawal, D.D. and Agrawal, O.P., 2013. Repellent activity of essential oil and leaf extract of *Lantana camara* L. in laboratory condition. International Journal of Theoretical and Applied Science, 5(1), pp.170-174. DOI: [CrossRef]

[16] Iamba, K. and Yaubi, T., 2021. Incorporating lemon grass (*Cymbopogon citratus* L.) and marigold (*Tagetes erecta* L.) as non-host barrier plants to reduce impact of flea beetle (*Chaetocnema confinis* C.) in cabbage (*Brassica oleracea* var. capitata L.). Acta Entomology and Zoology, 2(1), pp.95-101. [CrossRef]

[17] Mutalib, Abd N., Azis, T.M.F., Mohamad, S., Azizan, N.I., Sidek, H.J., Roziana, M.H. and Razali, Z., 2006. The repellent and lethal effects of black pepper (*Piper nigrum*), chilli pepper (*Capsicum annuum*) and cinnamon (*Cinnamomum zeylanicum*) extracts towards the odorous house ant (*Tapinoma sessile*). [CrossRef]