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Efficacy determination of different essential oils against storage pest *Callosobruchus maculatus* (Coleoptera: Bruchidae)

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Abstract
The present study was carried out at laboratory of Entomology [SEAMEO BIOTROP] Bogor, Indonesia from June-August 2017, to estimate the insecticidal effects of different essential oils of Lemon (*Citrus limon*), Citronella (*Cymbopogon nardus*), Ginger (*Zingiber Officinale*), Cardamom (*Elettaria cardamomum*) and Cinnamom (*Cinnamomum zeylanicum*) against *Callosobruchus maculatus* under laboratory conditions. The results revealed that among the tested essential oils *C. nardus* was the most toxic to the adults of *Callosobruchus maculatus* with all concentrations after different time intervals followed by *Z. officinale. E. cardamomum* showed minimum population reduction percentage at all the given concentrations after different time intervals. *Citrus limon* and *C. zeylanicum* at given concentrations after different time intervals showed moderate population reduction of *C. maculatus*. Present findings concluded that all the tested essential oils showed better results against storage pest *C. maculatus* so all above mentioned essential oils can be used against storage pest as a better control measure.

Keywords: Essential oils, mortality, *Callosobruchus maculatus*, storage pest

1. Introduction

Over the years, damage to stored grains and cereal products caused by insects has been of great concern; quantitative and qualitative, pre- and post–harvest losses caused by insect pests of cereal and legume grains in storage houses can range from 10-50% of total production [1]. Qualitative loss occurs due to loss of nutritional value while quantitative damage in form of grain weight loss caused by insect attack and feeding. These losses has been caused by and the main factor in these losses is the infestation of stored grain pests [2]. Among insects that attack and cause qualitative as well as quantitative loss and infest grains in the field or in big storage houses are the pulse beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and number of other stored pests [3].

The pulse beetle *C. maculatus*, causes maximal losses to the stored grains and their products in the storage around the world [4]. The initial infestation occurs in the field itself. It causes decreased germination potential, weight loss and reduction in commercial value of the seeds [5]. The cowpea weevil, *C. maculatus* Fab. (Coleoptera: Chrysomelidae), is a major and notorious pest of economically important leguminous grains, such as cowpeas, green gram, lentils and black gram [6, 7]. It is a holometabolic insect where the egg and adult stage are present on the grain while the larval and pupal stages living and feed inside the grain. The larvae bore into the pulse grains and eat up the endosperms which become unsuitable for human consumption with reduction in viability for the production of sprouts and for replantation. *C. maculatus* is an important pests of pulse crops in Asia and Africa under storage conditions [7, 8]. The pest causes maximum damage during the month of February until August because of presence of all of its developmental stages which are existing simultaneously [6, 9].

Use of Synthetic insecticides in the control of insect pests proved effective in stored grain protection and has immense benefits for mankind [10]. However, the indiscriminate and unscheduled use has been caused the resistance development in pests [4], resurgence and outbreak of new pests, also caused toxicity to non-target and beneficial organisms [11]. Environmental and health problems concerns associated with indiscriminate use of synthetic insecticides have led to intensive studies to find novel, cheaper, safe, effective alternatives and eco-friendly.

It has been reported that identifications of natural extracts showed detrimental effects on insect physiology and behavior exhibit a potential alternative tactic for development of critical control measures that could replace synthetic insecticides [12]. Botanical extracts by different higher terrestrial plant species has a rich source of bioactive chemicals which can be used for the control of different pests successfully [13]. Botanicals are known to have secondary plant compounds such as terpenes (monoterpenes, sesquiterpenes and triterpenes), steroids, alkaloids, phenolics and glycosides [14], which determine insecticidal effects for a wide range of insect pests. They can affect insects in several ways; e.g. toxic to adult insects [15], can cause disruption of major metabolic pathways and cause rapid death, work as repellents, antifeedants or deterrents [16]. Furthermore, at the same time plant extracts suppress oviposition, longevity of adult insects and progeny production, affecting both egg hatching and hatch rate, emergence of adults and mating behavior [17,18]. Main objective of this research was to estimate the contact toxicity and also to evaluate the insecticidal effects of under-investigation different essential oils based on percent mortality caused by different essential oils.

2. Materials and Methods

2.1 Rearing of population

Callosobruchus maculatus population was collected from grain market Bogor, Indonesia and was brought to Laboratory of Entomology Southeast Regional Centre on Tropical Biology (SEAMEO BIOTROP) Bogor, Indonesia. Adults were placed in the jars having green gram as a source for egg laying and as a food for newly emerged larvae. The green grams having eggs on it were moved to new jars and this procedure was repeated two time to get homogeneous population. Population was maintained at prevailing environmental conditions of 30± 2 ºC and 65 ± 5% RH.

2.2 Estimation of contact mortality caused by different essential oils against adults of *C.maculatus*

The experiment was conducted using different concentrations of Lemon (*Citrus limon*), Citronella (*Cymbopogon nardus*), Ginger (*Zingiber Officinale*), Cardamom (*Elettaria cardamomum*), Cinnamom (*Cinnamomum zeylanicum*) essential oils (5, 10, 20 and 30 µl oil/100µl of acetone (V/V)). Different essential oils were applied with micro injector by spray method to counted quantity of mung beans uniquely. Samples of 50g of treated commodity for each dose rate was taken into five separate sterilized plastic jars in order to make replications with control jar treated with the acetone only. All jars were tightly closed with plastic cover to avoid the escape of *C. maculatus* adults.

2.3 Statistical Analysis

Mortality data was calculated after 24, 48, 72 and 96 hours and was analyzed by Minitab 17 and comparison between different essential oils and their concentrations was determined by the use of Duncan multiple range (DMR) test.

3. Results and Discussion

In vitro application of different aromatic plants extract showed that all the tested essential oils caused reasonable mortality for *C. maculatus* (Table 1). Among the tested essential oils *Cymbopogon nardus* was most toxic to the tested pest *C. maculatus* and have caused maximum mortality of *C. maculatus* (Table 1). Present findings are strongly supported by [19-24], where they have used *Cymbopogon nardus* alone as well as with different other botanicals and aromatic pants extracts and reported that among the different tested essential oils *C. nardus* showed the maximum results with highest mortality. Maximum mortality and repellency was recorded in *C. nardus* treatments on *C. maculatus* [9]. There is increase in mortality with increase in concentration among all the tested essential oils [25].

Table 1: Percent mortality of *Callososbruchus maculatus* caused by different essential oils

Treatments	Concentrations (µl)	Hours			
		24	48	72	96
*C. nardus**	5	$35.64^{A}\pm2.23$	$48.91^{B}\pm3.54$	$65.05^{C}\pm1.80$	$78.12^{D}\pm4.45$
	10	$43.62^{C}\pm2.23$	$57.06^{D}\pm2.28$	$70.96^{D}\pm2.25$	$86.16^{EF}\pm1.88$
	20	$51.06^{E}\pm3.03$	$60.33^{F}\pm2.43$	$78.45^{G}\pm3.30$	$86.70^{G}\pm2.25$
	30	$58.51^{H}\pm1.45$	$68.53^{H}\pm3.20$	$64.20^{H}\pm2.25$	$93.08^{I}\pm4.03$
*Z. officinale**	5	$32.65^{A}\pm2.90$	$48.45^{A}\pm4.07$	$60.93^{B}\pm4.87$	$77.12^{C}\pm3.95$
	10	$36.22^{B}\pm4.77$	$52.57^{C}\pm1.41$	$66.14^{C}\pm4.87$	$85.41^{DE}\pm3.49$
	20	$42.85^{CD}\pm4.63$	$56.18^{E}\pm3.15$	$77.08^{F}\pm3.39$	$83.85^{FG}\pm2.85$
	30	$53.06^{F}\pm4.97$	$63.85^{H}\pm5.66$	$80.21^{G}\pm2.97$	$87.50^{H}\pm3.86$
*C. limon**	5	$34.00^{A}\pm3.35$	$47.50^{A}\pm3.95$	$58.00^{B}\pm3.70$	$72.50^{CD}\pm3.95$
	10	$36.50^{C}\pm2.85$	$53.50^{C}\pm2.85$	$63.00^{C}\pm4.10$	$80.00^{F}\pm2.85$
	20	$47.50^{EF}\pm4.67$	$56.50^{F}\pm3.35$	$73.00^{G}\pm2.09$	$81.00^{H}\pm3.95$
	30	$54.00^{HI}\pm3.79$	$62.50^{H}\pm4.67$	$76.50^{HI}\pm1.36$	$86.00^{I}\pm3.79$
*C. zeylanicum**	5	$28.57^{A}\pm3.12$	$42.78^{B}\pm4.61$	$59.37^{C}\pm3.49$	$70.83^{D}\pm3.86$
	10	$34.69^{C}\pm3.86$	$53.60\pm^{D}4.07$	$64.06^{E}\pm4.65$	$78.12^{E}\pm3.39$
	20	$43.37^{E}\pm3.32$	$59.27^{E}\pm2.15$	$70.31^{F}\pm2.96$	$78.64^{F}\pm4.87$
	30	$53.06^{F}\pm2.90$	$62.81^{G}\pm2.83$	$72.39^{G}\pm2.97$	$79.16^{G}\pm3.95$
*E. cardamomum**	5	$27.55^{A}\pm2.28$	$41.91^{A}\pm6.91$	$57.21^{B}\pm3.90$	$66.14^{D}\pm6.37$
	10	$30.10^{C}\pm2.90$	$49.99^{D}\pm3.74$	$60.31^{E}\pm3.45$	$75.00^{EF}\pm2.97$
	20	$36.73^{E}\pm4.90$	$55.55^{EF}\pm2.25$	$64.43^{FG}\pm4.23$	$76.04^{H}\pm3.86$
	30	$47.96^{G}\pm2.90$	$60.95^{I}\pm2.83$	$68.55^{H}\pm3.82$	$76.24^{I}\pm4.65$

Values are mean of five independent replications. Different letters in superscript following values indicate statistical significance (at $P \leq 0.05$) among treatments within a column.

performed an experiment with topical application and by contact with filter paper and concluded that *Cymbopogon nardus* effects were maximum and reasonable against four stored food products beetles. *C. nardus* contains compound biocide which kill and cause maximum mortality of all the insect pest that were under investigation of various tests [26, 27]. [28] performed an experiment to evaluate the toxicidal and repellent effect of different aromatic plant extracts and noted that all the tested essential oils showed maximum mortality and repellency as which is in favor of present results.

The findings of present research explained that minimum mortality was carried out by the treatments of *Elettaria cardamomum* among the tested essential oils (Table 1). *E. cardamomum* results are in resemblance with the findings of [29], where an experiment was performed to estimate the toxicity of five different essential oils eucalyptus, clove, neem, cardamom and cinnamon against *C. maculates* (Fab.) adults. Overall results explained that *eucalyptus* showed maximum toxicity followed by neem, clove, Cinnamon and cardamom. The findings of [30] are in accordance with the findings of present study where an experiment was conducted to evaluate the impact of naturally derived compounds like essential oils to calculate the toxicity of different essential oils and reported that essential oils caused the maximum mortality of *C. maculatus.*

4. Conclusion

From the present study, it can concluded that *C. maculatus* is a notorious pest of storage cereals and their products. In present study five different essential oils has been tested against *C. maculatus* and noted that all the tested essential oils showed good results and among tested essential oils *Cymbopogon nardus* caused maximum mortality of *C. maculatus* and can be used as an alternative for the control of storage cereals and products.

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