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Original Research Article

Fumigant Toxicity of Essential Oils against *Callosobruchus chinensis* for Protection of Gram

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A B S T R A C T

In India, only aluminum phosphide and methyl bromide are available for fumigation of stored commodities. The use of aluminum phosphide is restricted by law while methyl bromide needs special infrastructures for its use. Due to injudicious use, aluminum phosphide is poisoning our environment, causing many fatal diseases in exposed persons in addition to facilitating many to end the life. Its improper use is also developing resistance in the *Callosobruchus chinensis* in stored pulses and in many parts of world including India it has become useless for fumigation. Essential oil from more than seventy five plant species belonging to different families, such as Anacardiaceae, Apiaceae (Umbeliferae), Araceae, Asteraceae (Compositae), Brassicaceae (Cruciferae) Chenopodiaceae, Cupressaceae, Graminaceae, Lamiaceae (Labiatae), Lauraceae, Liliaceae, Myrtaceae, Pinaceae, Rutaceae and Zingiberaceae have been studied for fumigant toxicity against insect pests of stored commodities by several scientist in different part of the world. The laboratory experiments carried out to find the fumigant toxicity of seventeen essential oils from locally available herbs, weeds and waste materials against *Callosobruchus Chinensis* in gram. The essential oils from *Allium sativum*, *Artemisia annua*, *Callistemon citrinus*, *Chenopodium botrys*, *Cinnamomum zylanicum*, *Citrus reticulata*, *Cuminum cyminum*, *Foeniculum vulgare*, *Murraya koenigii*, *Pinus roxburghii*, and *Piper nigram* were found highly effective against test insects at 0.2 and 0.4 percent. The essential oil of *Lantana camera, Cinnamomum tamala* and *Curcuma longa* were also found highly effective against *C. chinensis* at 0.4 percent concentration. All tested essential oils don't affect the germination quality of gram.

Introduction

Stored products of agriculture and animal origin are attacked by more than 600 species of beetles, 70 species of moths and about 355 species of mites causing quantitative and qualitative losses and insect contamination in food commodities is an important quality control problem of concern at different storage level and for food industries. According to estimates about 70-75 percent of food grain is handled at farmer's level in India where we do not have adequate scientific storage facilities and grain protection technologies, rest 25-30 percent of food grain is procured and stored by Food Corporation of India, Central Warehousing Corporation and State Warehousing Corporation who have scientific storage facility (Commodity Online, 2007). Stored-product insects can cause serious post-harvest loss, estimated from up to 10 percent in developing countries but they also contribute to contamination of food products through the presence of live insects, insect products such as chemical excretions or silk, dead insects and insect body fragments, general infestation of buildings and other storage structures, and accumulation of chemical insecticide residues in food, as well as human exposure to dangerous chemicals as a result of pest control efforts against them. Essential oil from more than seventy five plant species belonging to different families, such as Anacardiaceae, Apiaceae (Umbeliferae), Araceae, Asteraceae (Compositae), Brassicaceae (Cruciferae) Chenopodiaceae, Cupressaceae, Graminaceae, Lamiaceae (Labiatae), Lauraceae, Liliaceae, Myrtaceae, Pinaceae, Rutaceae and Zingiberaceae have been studied for fumigant toxicity against insect pests of storage grain (Rajendran *et al.* 2008). Fumigant toxicity of some essential oils has also been studied by some investigators (Tunc *et al.* 2000, Tripathi *et al.* 2002, Lee *et al.* 2002, 2004, Ngamo *et al*, 2007, Kumar 2016, Kumar et. al. 2017).

Callosobruchus chinensis are important pests of pulses in India but also found in tropic and sub tropics. *Callosobruchus chinensis* prefer cowpea but it has been reported to feed on gram, pea, pigeon pea, lentil, ming, urd, soybean, and other whole pulses. In the present experiment, attempt has been made to study the fumigant toxicity of some essential oils against *Callosobruchus chinensis* in gram under Indian condition.

Materials and Methods

Culture of insects

Pure culture of test insects were developed in the BOD incubator maintained at 27$^{°C}$±1 temperature and 70±5% relative humidity. Plastic jars of about 1.0 kg capacity were used for rearing purpose. At the center of the lid a hole of 1.8 cm diameter was made and covered with 30 mesh copper wire net to facilitate aeration in the jar. The adults of *C. chinensis* reared on whole gram. Before use, grain was disinfested in the oven at 60° C for 12 hrs. After disinfestation the moisture content of the grain was measured and raised to 13.5 per cent by mixing water in the grain. The quantity of water required to raise the moisture content was calculated by using following formula as described by Pixton (1967).

Procurement of oils

Oils selected for the study were extracted from the locally available plants by steam distillation at Medicinal and Aromatic Plants Research and Development Centre, Pantnagar, and by Clevenger Apparatus in Post Harvest Entomology Laboratory Pantnagar.

Preparation of grain

The fumigation experiments on *C. chinensis*, were conducted on untreated seed grade gram. Before use, the grain was disinfested in the oven at 60^{0C} for 12 hrs. After disinfestations the moisture content of grain was measured and raised to 13.5 per cent by adding water in the required quantity to the grain as described in section 3.1. To ensure the even distribution of water, the grain was spread on a platform and water was sprayed on it by hand sprayer. The grain was then mixed thoroughly and closed in polythene bag for a week for equilibration of moisture content of grain. The 50 g grain was then filled in 100 ml capacity plastic vials.

Fumigant toxicity of essential oils against *C. chinensis*

The experiment was conducted on *C. chinensis* to confirm the efficacy of essential oils. The experiment was conducted under controlled conditions at 27 ± 1^0C temperature and $70\pm$ 5 percent relative humidity. Fifty gram gram (moisture content 13.5 percent) was filled in each plastic vial. Each treatment was replicated three times. Untreated gram was used as control. Twenty adults of *C. chinensis* (0-7 days old) were released in each vial. After 24 hrs of releasing the insects measured quantity of oil was poured on the absorbing mat to perform experiment than sealed for progeny development.

Results and Discussion

Fumigant toxicity of essential oils against *C. chinensis*

The fumigant toxicity of different essential oils against *C. chinensis* is presented in Table 1 which indicates that all oils except *J. curcas* oil were highly effective against *C. chinensis* at 0.2 and 0.4 percent concentration as not any adults emerged from treated grain in both preliminary and confirmatory study. The oil of *J. curcas* was least effective against *C. chinensis* at 0.2 percent concentration as only 49.22 and 26.47 percent inhibition was observed in preliminary and confirmatory test, respectively. (Pathak *et al.,* 1997) investigated toxicity and repellent activity of *Murraya koenigii* against *C. chinensis* in stored green gram, chickpea at 340 ppm they found oil are highly effective. (Dwivedi *et al.* 2000) reported that oil formulation of Citrus clean inhibited 100 percent oviposition and 89.5 percent mortality of larvae and its efficacy against *C. chinensis* in cowpea. Rahman et al., (2001) reported the fumigation action of camphor against pulse beetle, *C. chinensis*. Miah (2007) reported that camphor @ 2 gm/kg seeds performed the best results in respect of percent reduction (100%) of larvae and pupae, grain infestation and grain content loss over control for both *C. chinensis*. The chemical name phostoxin is aluminium phosphide (Onu and Aliyu, 1995),which is used as a rodenticide, insecticide, and fumigant for stored cereal grains (Mahadi and Hamoudi, 2010). Naphthalene is a household fumigant also, which build up vapors that are toxic to both the adult and larval forms of many insects that attack textiles (Bryn, 2002) and other stored products. In considering hazards free management of C. chinensis using fumigants in storage aiming to assess the extent of damage of stored mungbean grains infested by C. chinensis as well as determining the efficacy of some fumigants against this insect pest.

Results conclude that the essential oils of *A. sativum, A. annua, C. citrinus, C. botrys, C. zylanicum, C. reticulata, C. cyminum, F. vulgare, M. koenigii, P. roxburghii,* and *P. nigram*, were found highly effective against *C. chinensis* at 0.2 and 0.4 percent as these oils completely suppressed the feeding and breeding of *C. chinensis* and cause 100 percent inhibition. The essential oil of *L. camera, C. tamala* and *C. longa* were found highly effective against *C. chinensis* at 0.4 percent concentration as compare to untreated control.

Table.1 Number of adults of C. chinensis emerged and percent inhibition in grain treated with different essential oils in preliminary and confirmatory tests

Essential oils	Conc.% (V/w)	Preliminary test		Confirmatory test	
		No. of adults emerged	Percent Inhibition	No. of adults emerged	Percent Inhibition
Allium sativum	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Allium sativum	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Artemisia annua	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Artemisia annua	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Callistemon citrinus	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Callistemon citrinus	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Chenopodium botrys	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Chenopodium botrys	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Cinnamomum tamala	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Cinnamomum tamala	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Cinnamomum zeylanicum	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Cinnamomum zeylanicum	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Citrus reticulata	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Citrus reticulata	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Cuminum cyminum	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Cuminum cyminum	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Curcuma longa	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Curcuma longa	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Foeniculum vulgare	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Foeniculum vulgare	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Jatropha curcas	0.2	21.7 (3.1)	49.22	23.3 (3.5)	48.47
Jatropha curcas	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Lantana camara	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Lantana camara	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Murraya koenigii	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Murraya koenigii	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Myristica fragrans	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Myristica fragrans	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Pinus roxburghii	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Pinus roxburghii	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Pipper nigram	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Pipper nigram	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Syzygium aromaticum	0.2	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Syzygium aromaticum	0.4	0.0 (0.0)	100.00	0.0 (0.0)	100.00
Untreated control		42.7 (3.6)	0.0	45.3 (3.8)	0.0
S. Em ±		(0.57)		(0.24)	
CD at 5%		(0.16)		(0.70)	

Data in parenthesis indicate log (X+1) transformed values

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