Fumigant toxicity of essential oils against pulse beetle, *Callosobrucrhus maculatus* (F.) (Coleoptera: Bruchidae)

C. Sivakumar, S. Chandrasekaran, C. Vijayaraghavan and S. Selvaraj

ABSTRACT

India is the largest producer and consumer of pulses and shares 35.20 per cent area and 27.65 per cent of the global production. Among the insect pests infesting stored pulses, bruchid *Callosobrucrhus maculatus* (F.) (Coleoptera: Bruchidae) is the most serious one and it attacks invariably all the pulses under storage conditions with mild infestation in the field as well. It is therefore, imperative to save the stored pulses from this serious pest. In many storage systems, fumigants are the most economical and convenient tool for managing stored-grain insect pests. The increasing problem with today's fumigants makes it necessary for research to devise other control procedures and to identify new fumigants, which are eco-friendly and less expensive. Essential oils are potential sources of alternative compounds for currently used fumigants. The LC_{50} values of five essential oils *viz.*, eucalyptus, citronella, rosemary, cardamom and geranium were investigated against pulse beetle *C. maculatus* through fumigation bioassay were 11.66, 16.25, 21.35, 22.07 and 25.11 µl l^{-1} of air respectively. The lowest LD_{50} value was observed for eucalyptus oil (11.66 µl l^{-1} of air) and the LD_{50} value of geranium was the highest (25.11 µl l^{-1} of air). Fumigant effects of the essential oils are discussed in the context of the existing fumigants is likely to be phased out in 2015.

INTRODUCTION

India being major pulse growing country in the world, accounting roughly to one third of the total world area under pulses and one fourth of total world production. In India 22.83 million hectare of land is under pulses cultivation with annual production of 11.21 million tones. In Tamil Nadu, pulses are cultivated in 8.2 lakh ha with the production of 3.71 lakh metric tones. The average productivity of pulses in Tamil Nadu is about 449 kg / ha. Black gram is the major pulse crop in Tamil Nadu and it is grown in an area of 4.5 lakh ha, and its production is 2.05 lakh tones with a productivity a of 461 kg ha^{-1} (Anonymous, 2001). Legumes are more vulnerable to post harvest loss (Labeyrie, 1981). In 1970, Food and Agriculture Organization reported 8.5 per cent loss during post harvest handling and storage in India. Loss in pulses due to infestation of bruchids have been reported by Mookherjee *et al.* (1970) and Gangrade (1974).

Callosobruchus maculatus has involved the great attention because, it is widely distributed throughout the tropical and sub-tropical regions. It is an important pest of several pulses including cowpea [*Vigna unguiculata* (L.) (Walp.)], chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* Medik.), soyabean (*Glycine max* Mer.) and haricot beans (*Phaseolus vulgaris* L.). The pulses are very important source of vegetable protein for millions of people of tropical and subtropical regions. In order to keep these stored grain products free from pest attack, various synthetic chemicals have been used. Synthetic pesticides are currently the method of choice to protect stored grain from insect damage. But, continuous or heavy uses of synthetic pesticides has created serious problems arising from factors such as direct toxicity to parasites, predators, pollinators, fish and man. It also develops pesticides resistance (Zettler, 1991; Mahmud *et al.*, 2002), susceptibility of crop plant to insect pests (Pimentel, 1977) and increased environmental and social cost (Pimentel *et al.*, 1980).

Therefore, environment needs some other alternatives of chemical pesticides. One alternative to synthetic insecticides is the botanical pesticides i.e. insecticidal plants or plant compound and the use of natural compounds, such as essential oils that result from secondary metabolism in plants. Essential oil and their constituents have been shown to be a potent source of botanical pesticide. The toxicity of a large number of essential oils and their constituents has been evaluated against a number of bruchid pests (Keita, *et al.*, 2000, Tripathi *et al.*, 2002). Plant essential oils and their constituents in relation to contact (Choi et al., 2003; Gorur *et al.*, 2008) and fumigant insecticidal actions have been well demonstrated against stored product pests. Especially

their main compounds monoterpenoids, offer promising alternatives to classical fumigants (Papachristos and Stamopoulos, 2003) and also have some effects on biological parameters such as growth rate, life span and reproduction (Pascual-Villalobos, 1996). In the present investigation essential oils from, eucalyptus, citronella, rosemary, cardamom and geranium were studied for their fumigant effects on the adult *C. maculatus*.

MATERIALS AND METHODS

C. maculatus was reared on black gram seeds in glass jars covered with muslin cloth by following the method developed by Credland and Wright (1989). Based on the previous literature five essential oils, *viz.*, Eucalyptus - *Eucalyptus* spp., Rosemary - *Rosmarinus officinalis* (L.), Geranium - *Geranium* spp. and Citronella - *Cymbopogon nardus* (L.) were purchased from Horticulture Research Station, Ooty, Tamil Nadu and Cardamom - *Elettaria cardamomum* (L.),was purchased from Medicinal and Aromatic division at Nilgris shop at Coimbatore, Tamil Nadu and used to study the effect of fumigant toxicity against three major insect pests on stored products.

The fumigation chamber was designed by using a plastic jar of 250 ml capacity provided with screw lid (Rahman and Schmidt, 1999). The desired concentration of oils were dissolved in 1 ml of acetone and applied to Whatman No.1 filter paper, which was dried in air for 5 min and then pasted on the inner surface of the lid with adhesive tape and the lid was closed and sealed to create airtight condition in the chamber. The insects were confined in vials and placed inside the fumigation chamber. Five different concentrations of each selected essential oils were tested against the test insects to decide their level of susceptibility. Ten adults were taken in a vial (5 cm × 1.2 cm) and the mouth of the vial was covered with net (25 mesh) to prevent the insects from escaping and being in contact with the treated filter paper. Three such vials containing insects were placed in the fumigation chamber and considered as three replications. The required doses of essential oils were applied on the filter paper. One fumigation chamber without oil treatment was considered as control. Observations on the adult mortality were taken 24 hours after treatment. Insects showing any movements were considered to be alive. The LD_{50} and LD_{95} values were calculated by Probit analysis (Finney, 1971).

RESULTS AND DISCUSSION

The results of toxic effect of different essential oils applied as fumigation method are presented in Table 1. The essential oils of eucalyptus, citronella, rosemary, cardamom and geranium attained LD_{50} for *C. maculatus*, respectively at 11.66, 16.25, 21.35, 22.07 and 25.11 µl l^{-1} of air. The efficacy of the oils followed in the order: eucalyptus > citronella > rosemary > cardamom > geranium. The LD_{50} value in case of 24 h after treatment were 11.66, 16.25, 21.35, 22.07 and 25.11 µl l^{-1} of air respectively

Table 1. Fumigant toxicity of essential oils against pulse beetle, *C. maculatus*

Essential oil	LD_{50}	Fiducial Limits		Regression Equation	Chi square
		Lower	Upper		
Eucalyptus	11.66	9.30	14.62	Y = 2.943x + 1.8114	4.394
Citronella	16.25	14.11	18.72	Y = 3.3057x + 1.008	2.538
Rosemary	21.35	18.56	24.55	Y = 2.7457x + 1.364	1.954
Cardamom	22.069	19.009	25.622	Y = 2.5199x + 1.619	1.501
Geranium	25.11	21.85	28.85	Y = 2.516x + 1.490	1.428

The effectiveness of various oils against bruchids on pulses has been reported by several workers (Tripathy *et al.*, 2001; Singh, 2003; Singh and Yadav, 2003). Similarly the toxicity of a large number of essential oils and their constituents has been evaluated against a number of bruchid pests (Keita, *et al.*, 2000, 2001, Tripathi *et al.*, 2002).The fumigant toxicity to *C. maculatus* was found to be higher in eucalyptus oil followed by citronella oil. The order of toxicity of the essential oils against *C. maculatus* was eucalyptus (LC_{50} 11.66) > citronella (LC_{50} 16.25) > rosemary (LC_{50} 21.35) > cardamom (LC_{50} 22.069) > geranium (LC_{50} 25.11). It is in concordance with the observation of Srinivasan, (2008) who found that the eucalyptus oil showed toxicity against *C. maculatus* and Lee *et al.* (2001) who reported that eucalyptus oil showed fumigant activity against *S. oryzae*. Similarly Shaaya *et al.* (1997) reported the outstanding toxicity of eucalyptus oil showed against *S. oryzae* and *R. dominica*.

REFERENCE

Annoymous, 2001. National pulse development project 2000-2002 national symposium on pulses and oil seeds for sustainable agriculture directorate research, TNAU, Coimbatore.

Choi, W. I., Lee. L. H., Choi, R. B., Park, H. M. and Ahn, Y.

J. 2003. Toxicity of plant essential oils to *Trialeurodes varporariorum* (Homoptera: Aleyrodidae). *Journal of Ecological Entomology,* **96**: 1479–1484.

Credland, P. F. and Wright, A.W. 1989. Factors affecting female fecundity in the cowpea seed beetle, *Callosobruchus maculatus* (Coleoptera : Bruchidae). *Journal of Stored Product Research*, **25**(3): 125-139.

Finney, D. J. 1971. *Probit Analysis*, 3rd edition,Cambridge University, London.

Gangrade.G. A. 1974. Insects of soybean. *Technical Bulletin Jawaharlal Neru Krishi Vishwa Vidyalaya*, **24** : 88.

Görür, G., Abdullah, M. I. and Iºik, M. 2008. Insecticidal activity of the *Thymus, Veronica* and Agrimonia's essential oils against the cabbage aphid, *Brevicoryne brassicae*. *Acta Phytopathologica et Entomologica Hungarica*, **43**(1): 201-208

Keita, S. M., Vincent, C., Belanger, A. and Schmit, J. P. 2000. Effect of various essential oils on *Calloso bruchus maculatus* (F.) [Coleoptera: Bruchidae]. *Journal of Stored Product Research* **36:** 355–364.

Keita, S. M., Vincent, C., Schmit, J. P. Arnason, J. T. and Bélanger, A. 2001. Efficacy of essential oil of *Ocimum basilicum* L. and *O. gratissimum* L. applied as an insecticidal fumigant and powder to control *Callosobruchus maculatus* (Fab.) (Coleoptera: ruchidae). *Journal of Stored Product Research* **37:** 339-349.

Labeyrie, V. 1981. Vaincre la carence proteique per le development des legumineuses alimentaries et al protection de leurs recolltes contre les bruches . Food Nutrition Bulletin., **3:** 24-38.

Lee, B. H., Choi, W. S., Lee, S. E. and Park, B. S. 2001. Fumigant toxicity of essential oils and their constituent compounds towards the rice weevil, *Sitophilus oryzae* (L.). *Crop Protection,* **20**: 317 - 320.

Mahmud, M. K., Khan, M. M. H., Husain, M., Alam, M. I. and Afrad, M. S. I. 2002. Toxic effects of different plant oils on pulse beetle *Callosobruchus chinensis* Linn. (Coleoptera: Bruchidae). *Journal of Asiatic Society of Bangladesh Science*, **28**(1): 11-18.

Mookherjee, P. B., Jotwani, M. G., Yadav, T. D. and Sricar, P. 1970. Studies on incidence and extent of damage due to insect pest in stored seeds II leguminous and vegetable seeds. *Indian Journal of Entomolgy,* **32** : 350-355.

Papachristos, D.P. and Stamopoulos, D. C. 2003. Selection of *Acanthoscelides obtectus* (Say) for resistance to lavender essential oil vapour. *Journal of Stored Product Research,* 39: 433 - 441.

Pascual-Villalobos, J. M. 1996. Evaluation of the insecticidal activity of *Chrysanthemum coronarium* L. plant extracts. *Bol. Sanidad Vegetable. Plagas.* **22:** 411–420.

Pimentel, D. 1977. Ecological basis of insect pest, pathogen and weed problems. **In:** *Origin of pest, parasites, disease and weed problems.* (Cherrett, S. M. and Sagar, G. R. eds.), p. 3. Blackwell's scientific publications, Oxford, UK.

Pimentel, D., Andow, D., Dyson-Hudson, R., Gallahan, D., Jacobson, S., Irish, M., Croop, S., Moss, A., Schreiner, I., Shepard, M., Thompson, T. and Vinzant, B. 1980. Environmental and social costs of pesticides: A preliminary assessment. *Oikos,* **34:** 125-140.

Rahman, M. M. and G. H. Schmidt. 1999. Effect of *Acorus calamus* (L.) (Araceae) essential oil vapours from various origins on *Callosobruchus phaseoli* (Gyllenhal) (Coleoptera: Bruchidae). *Journal of Stored Product Research,* **35**(4): 285 - 295.

Shaaya, E., Kostjukovski, M., Eilberg, J. and Sukprakarn, C. 1997. Plant oils as fumigants and contact insecticides for the control of stored product insects. *Journal of Stored Product Research,* **33**(1): 7 - 15.

Singh, P. K. 2003. Effect of some oils against pulse beetle, *Callosobruchus chinensis* infecting pigeonpea. *Indian Journal of Entomology,* **65**(1): 55 - 58.

Singh, V. and Yadav, D. S. 2003. Efficacy of different oils against pulse beetle *Callosobruchus chinensis* in greengram, *Vigna radiate* and their effect of germination. *Indian J. Ent.*, **65**(2): 281 - 286.

Srinivasan, G. 2008. Efficacy of certain plant oils as seed protectant against pulse beetle, Callosobruchus chinensis Linn. on pigeonpea. *Pesticide Research Journal,* **20**(1): 13 - 15.

Tripathi, A. K., Prajapati, V., Verma, N., Bhal, J. R., Bansal, R. P., Khanuja, S. P. S. and Kumar, S. 2002. Bioactivities of the leaf essential oil of *Curcuma longa* (Var. Ch-66) on three species of stored-product beetles (Coleoptera). *Journal of Economic Entomology,* **95** (1): 183-189.

Tripathy, M. K., Sahoo, P., Das, B. G. and Mohanty, S. 2001. Efficacy of botanical oils, plant powders and extracts against *Callosobruchus chinensis* Linn. attacking blackgram. *Legume Research,* **24**(2): 82 - 86.

Zettler, J. L. 1991. Pesticide resistance in *Tribolium castaneum* and *T. confusum* (Coleoptera: Tenebrionidae) from flour mills in the United States. *Journal of Economic Entomology,* **84**: 763-767.

C. Sivakumar, S. Chandrasekaran, C. Vijayaraghavan and S. Selvaraj

Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India, *Email: shivaento@gmail.com