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PLANT PATHOLOGY

Comparative efficacy of eighteen essential Oil against *Rhyzopertha dominica* (F.)

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Abstract

Plants are known to be a potential source of chemicals affecting feeding, breeding and survival of insects. Present study was conducted to study the fumigant toxicity of essential oils against major insect pest of stored grain *Rhizopertha dominica.* The bio-efficacy of essential oils extracted from eighteen plants, namely, *Aegle marmelos, Cinnamomum camphora, Citrus* sp., *Eucalyptus globules, Psidium guajava, Thuja orientalis, Cymbopogon flexuosus, Bidens pilosa, Ageratum conyzoides, Saraca asoca, Cannabis sativa, Murraya koenigii, Tagetes erecta, Citrus limetta, Artemisia annua, Callistemon citrinus, Ocimum gratissimum* and *Citrus limon* was studied against *R. domanica* at 0.2, 0.1, 0.05, 0.025, and 0.012 % concentration (v/w).The study revealed that most of the essential oils inhibited the development of the test insect. However, the level of inhibition was highly correlated with the dose at which oils were used for treatment. Among eighteen essential oils, *A. marmelos, C. camphora E. globulus* and *T. orientalis* were most effective against *R. dominica* because no insect developed from the grain treated with it even at lower concentration of 0.05 %. All the essential oils were found highly effective at 0.2 and 0.1 % concentration except *A. conyzoides, S. asoca, C. sativa, O. gratissimum and Citrus* sp, which permitted adult emergence during test. None of the oil was found highly effective against *R. domanica* at 0.025 and 0.012 % concentration. The essential oil of *E. globulus* and *T. orientalis* were found moderately effective at 0.025% concentrations at which they caused 83.92 and 87.17 % inhibition, respectively. Rests of the treatments were found less effective against *R. dominica* due to less than 70 % inhibition of progeny production

Highlights

- Testing of eighteen different plant oils against Ryzopertha dominica (F) Plant essential oils can be used in a variety of ways to control biotic stress.

Keywords: Different plant oils, *Rhyzopertha dominica* (F), stored conditions

Insects are major pests of stored food causing losses estimated around 20% of the annual world crop production (Sallam, 1999). Essential oils (EOs) of aromatic plants are effective natural products as contact and fumigant insecticides and as repellents against stored food pests (Isman, 2000; Nerio *et al*. 2009; Conti *et al*. 2011; Athanassiou *et al*. 2013; Bougherra *et al*. 2015)Among the most serious economic insect pests of grains, internal feeders such as lesser grain borer, *Rhyzopertha dominica* F., are primary insect pests. *R. dominica* is a destructive insect pest of stored grains. Both larvae and adults of the pest attack whole, sound grains and cause extensive damage (Dowdy, AK and Gaughey, WH, 1992). Due to the high potential and wide host range of products such as wheat, barley, rice and oats it was considered as major stored product insect pest (Phillips and Throne 2010) Although, several physical, mechanical, biological and chemical methods have been developed for the management of these insect pests, significant control is achieved mainly by insecticide and fumigant which play decisive role in protection of grain under storage condition (Islam *et al.* 2010), however, due to extreme toxicity their use is restricted in many countries where they are permitted to be used only under technical supervision, which is not available easily. Although, such fumigants can be used effectively in central storage of food grain in warehouses, their applicability at farmer or consumer level is highly questionable as these users lack completely airtight storage facility which is prerequisite for fumigation. Injudicious use of insecticides and fumigants have resulted in development of resistance in insect pests leading to increase in dose and cost of protection in addition to environmental pollution and human health hazards (Champ and Dyte 1977; Zettler and Cuperus 1990; Taylor 1989; White 1995; Subramanyan and Hagstrum 1995; White and Leesch 1995; Collins *et al.* 2002; Ribeiro *et al.* 2003). In view of these problems, scientists over world are looking towards safe alternatives for prophylactic and curative treatment of stored commodities and some encouraging results have been obtained from plants belonging to different families (Golob and Webley 1980; Grainge and Ahmed 1988).

Plants are known to be a potential source of chemicals affecting feeding, breeding and survival of insects (Golob and Webley 1980; Jacobson 1983; Jilani 1984; Shaaya *et al.* 1997; Dunkel and Scars 1998; Lee *et al.* 2001). In due course of evolution, plants have developed numerous secondary plant metabolites for their defense against herbivores, however, these phytochemicals have also been found to influence the behaviour, growth and development of insects not developed with it. Many of such chemicals belonging to various groups such as terpenoids, phenolic compounds and glucosinolates have been found to possess significant pest control properties against fields and storage pests (Saxena and Koul 1978; Singh and Upadhyay 1993; Regnault-Roger 1997; Isman 1999; Ranjendran and Sriranjini 2008). The *Eucalyptus* essential oil has been used commercially in food, flavoring, and perfumery, and in the pharmaceutical industries and its pesticidal effects has been evaluated by many workers (Batish *et al.* 2008). *Eucalyptus* contains a rich source of bioactive constituents, possessing fungicidal, insecticidal and herbicidal activities (Zhang *et al.* 2010)

To make these plants more useful, a necessity is being felt to explore more and more plants for getting higher efficacy at very low concentrations. Since many plants are edible, presence of anti-insect activity in it may lead to development of herbal fumigants which may be used for the control of insect pests in house hold storage where phosphine or methyl bromide are not much useful. In the present investigation attempt has been made to search the fumigants toxicity of some unexplored essential oils against major insect pests of stored grain.

Materials and Methods

Details of experiment

The experiments were conducted in Post Harvest Entomology Laboratory of Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar.

Culture of insects

Pure culture of test insects was developed in the laboratory at 27 ± 1^0C temperature and 70 ± 5 % relative humidity. Plastic jars of about 0.50 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 adult of *R. dominica* were reared on the grain of wheat variety PBW-343 disinfested in the oven at 60^0C for 12 hrs before use. After disinfestations the moisture content of the grain was measured and raised to 13.5 % by mixing water in the grain. The quantity of water required to raise the moisture content was calculated by using following formula (Pixton, 1967).

$$\text{Quantity of water to be added} = \frac{W_1 (M_2 - M_1)}{100 - M_2}$$

Where,

W_1 = Initial weight of grain

M_1 = Initial moisture content

M_2 = Final moisture content

After mixing the water in the grain it was kept in closed polythene bags for a week so that moisture content of the grain could equilibrate. The grain was then filled in plastic jar and 50 adults were released in each jar after which it was kept in control room. First generation adults (0-7 days old) were used for experimental purpose.

Extraction of oils

Semi-dried plants and peels collected from different localities were subjected to steam distillation to obtain the essential oils. The distillation process was carried out using a Clevenger Apparatus (Gunter, 1946). Anhydrous sodium sulphate was used to remove trace of moisture from essential oil and stored in air tight container in a refrigerator at 4^0 C.

Effect of essential oils on development of insect pests of stored grain

The experiments were conducted twice on *R. dominica,* to confirm the efficacy of essential oils. Untreated grain was used as control. The experiments were conducted under controlled conditions at 27 ± 1^0C temperature and $70\pm$ 5 % relative humidity in the plastic vials (10×4cm). Fifty gram wheat grain (moisture content 13.5 %) was filled in plastic vials. Ten adults of *R. dominica,* (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, which was then placed inside the grain filled in vial. Screw cap of vial was tightly closed and made completely airtight by sealing with parafilm wax strip. Each treatment was replicated thrice. Untreated grain was used as control. Insects were then allowed to feed and breed for one month. Observation was recorded on F1 progeny by counting adults emerged in each vial after one month. The emerging adults were counted thrice and their sum was used to indicate the number of adults emerged in each vial. Experimental details are presented in Table 3.1.

Results and Discussion

E. globulus and *T. orientalis* were most effective against *R. dominica* because no insect developed from the grain treated with it even at lower concentration of 0.05 % during both preliminary and confirmatory tests. All the essential oils were found highly effective at 0.2 and 0.1 % concentration except *A. conyzoides, S. asoca, C. sativa, O. gratissimum and Citrus* sp. which permitted adult emergence during both tests. None of the oil was found highly effective against *R. domanica* at 0.025 and 0.012 % concentration. The essential oil of *E. globulus* and *T. orientalis* were found moderately effective at 0.025% concentrations at which they caused 83.92 and 87.17 % inhibition, respectively. Rests of the treatments were found less effective against *R. dominica* in both the preliminary and confirmatory test due to less than 70 % inhibition of progeny production. No significant difference could be obtained in the grain treated with oils at 0.012 % concentration and untreated grain. Similar trends were observed during preliminary and confirmatory tests against this insect. The effectiveness of essential oils depends on the susceptibility of the insects to particular oil and their doses. One insect can be susceptible, and another may found tolerant for the same oil e.g. Oil of *O. gratissimum* at 1 micro L/L air after 24 h of exposure, caused 98%, 99% and 100% mortality in *R. dominica, O. surinamensis and C. chinensis*, respectively while *T. castaneum* which was more tolerant for this oil **(**Ogendo, J.O. *et al.* 2008**)**. *Eucalyptus pauciflora* (Alpine snow gums) at 5% concentration killed *R. dominica*, *S. oryzae*, *T. granarieum*, and *C. chinensis* in 40-60 minutes after application (contact toxicity) fumigant killed *R. dominica* and *S. oryzae* in 7 h. **(**Shukla *et al*. 2002**).** The pesticide potentiality of the essential oils from the Artemisia absinthiumL. Against *R. Dominica* and *Spodoptera littoralis*, one of the most dangerous pests of protected crops, was investigated by Dhen *et al.* 2014. *Eucalyptus* essential oils can have repellent effect on pests. *E. citriodora* essential oil had strong repellent activity on *T. castaneum* insects(Olivero-Verbel *et al.* 2010). Based on the reports of Negahban *et al*. (2007) *Artemisia siberi* oil in 37 µl/l concentration for 24 hours was caused 100% mortality of *C. maculatus* and LC50 for this oil was1.45 µl/l on *C. maculatus*. Manzoomi *et al*. (2010) survey toxicity of three essential oils *Lavandula officinais* L., *Artemisia dracunculus* L. and *Heracleum persicum* Desf. against *C. maculatus* and calculated LC50 has been 41.52, 210.61, 337.58 µl/l air respectively that are showen less toxic than the oil in this study.

Table 3.1: Scientific and common name of the plant the essential oil of which was used to study fumigant toxicity against storage insect pests

S. No.	Scientific name of plant	Common name of plant	Family	Concentration % (v/w)
1	*Aegle marmelos* (L.)	Bael	Rutaceae	0.2, 0.1, 0.05, 0.025, 0.012
2	*Cinnamomum camphora* (L.)	Camphor	Lauraceae	0.2, 0.1, 0.05, 0.025, 0.012
3	*Citrus* sp.	Wild lemon	Rutaceae	0.2, 0.1, 0.05, 0.025, 0.012
4	*Eucalyptus globules* Labill.	Eucalyptus	Myrtaceae	0.2, 0.1, 0.05, 0.025, 0.012
5	*Psidium guajava* (L.)	Guava	Myrtaceae	0.2, 0.1, 0.05, 0.025, 0.012
6	*Thuja orientalis* (L.)	Morpankhi	Cupressaceae	0.2, 0.1, 0.05, 0.025, 0.012
7	*Cymbopogon flexuosus* (Watson)	Lemmon Grass	Poaceae	0.2, 0.1, 0.05, 0.025, 0.012
8	*Bidens pilosa* (L.)	Broom stick	Asteraceae	0.2, 0.1, 0.05, 0.025, 0.012
9	*Ageratum conyzoides* (L.)	Goat weed	Fabaceae	0.2, 0.1, 0.05, 0.025, 0.012
10	*Saraca asoca* (Roxb)	Ashok	Fabaceae	0.2, 0.1, 0.05, 0.025, 0.012
11	*Cannabis sativa* (L.)	Hemp	Cannabaceae	0.2, 0.1, 0.05, 0.025, 0.012
12	*Murraya koenigii*	Curry leaf	Rutaceae	0.2, 0.1, 0.05, 0.025, 0.012
13	*Tagetes erecta* (L.)	Marry Gold	Asteraceae	0.2, 0.1, 0.05, 0.025, 0.012
14	*Citrus limetta* (L.)	Mosambi	Rutaceae	0.2, 0.1, 0.05, 0.025, 0.012
15	*Artemisia annua* (L.)	Sweet annie	Asteraceae	0.2, 0.1, 0.05, 0.025, 0.012
16	*Callistemon citrinus* Risso	Bottle brush	Myrtaceae	0.2, 0.1, 0.05, 0.025, 0.012
17	*Ocimum gratissimum* Curtis	Holy basil	Lamiaceae	0.2, 0.1, 0.05, 0.025, 0.012
18	*Citrus limon* L.	Lemon	Rutaceae	0.2, 0.1, 0.05, 0.025, 0.012

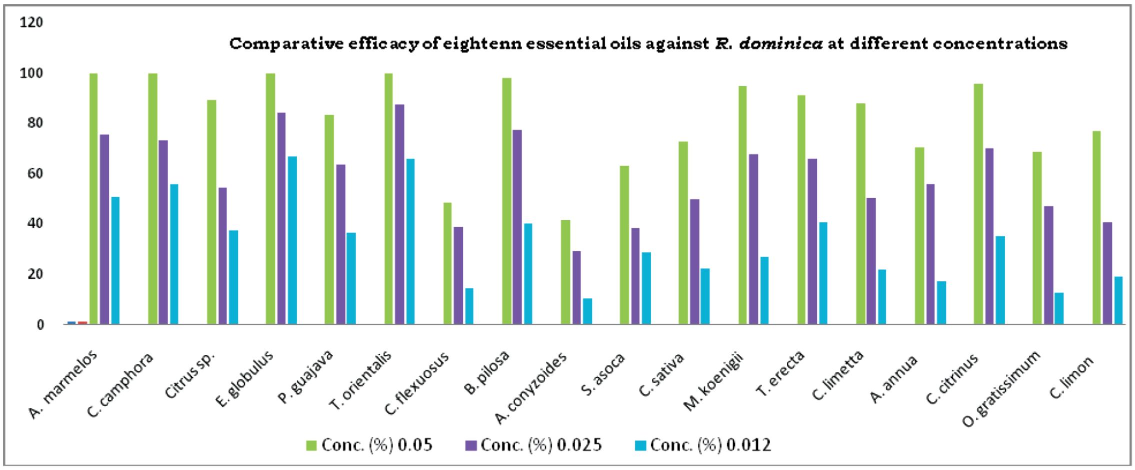

Table 4.1: Comparative efficacy of essential oils against *R. dominica* at different concentrations

Treatment	Essential oils	Conc. % V/W	Preliminary test		Confirmatory test		Mean % inhibition
			Total no of adult emerged	% inhibition	Total no of adult emerged	% inhibition	
T1	A. marmelos	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	A. marmelos	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	A. marmelos	0.05	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	A. marmelos	0.025	21.00 (3.45)	74.07	20.67 (3.44)	75.34	75.34
	A. marmelos	0.012	39.00 (3.90)	51.85	45.00 (4.00)	50.45	50.45

T2	C. camphora	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. camphora	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. camphora	0.05	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. camphora	0.025	12.33 (3.15)	84.77	34.33 (3.79)	72.95	72.95
	C. camphora	0.012	26.33 (3.61)	67.49	49.67 (4.10)	55.63	55.63
T3	Citrus sp.	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	Citrus sp.	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	Citrus sp.	0.05	1.33 (2.50)	98.35	17.67 (3.28)	89.18	89.18
	Citrus sp.	0.025	29.33 (3.66)	63.79	48.67 (4.08)	54.35	54.35
	Citrus sp.	0.012	49.67 (4.10)	38.68	56.33 (4.19)	37.45	37.45
T4	E. globules	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	E. globules	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	E. globules	0.05	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	E. globules	0.025	15.67 (3.27)	80.66	11.33 (3.02)	83.92	83.92
	E. globules	0.012	27.00 (3.62)	66.67	29.33 (3.66)	66.73	66.73
T5	P. guajava	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	P. guajava	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	P. guajava	0.05	14.00 (3.19)	82.72	14.00 (3.19)	83.44	83.44
	P. guajava	0.025	21.00 (3.41)	74.07	41.67 (3.95)	63.45	63.45
	P. guajava	0.012	41.67 (3.94)	48.56	67.00 (4.34)	36.36	36.36
T6	T. orientalis	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	T. orientalis	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	T. orientalis	0.05	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	T. orientalis	0.025	0.00 (2.40	100.00	22.67 (3.50)	87.17	87.17
	T. orientalis	0.012	21.33 (3.47)	73.66	37.33 (3.87)	65.70	65.70
T7	C. flexuosus	0.2	0.00 (2.40)	100.00	4.00 (2.64)	97.74	97.74
	C. flexuosus	0.1	16.67 (3.31)	79.42	26.67 (3.62)	74.62	74.62
	C. flexuosus	0.05	41.00 (3.93)	49.38	47.00 (4.02)	48.09	48.09
	C. flexuosus	0.025	39.67 (3.91)	51.03	65.33 (4.32)	38.53	38.53
	C. flexuosus	0.012	65.67 (4.33)	18.93	80.00 (4.49)	14.18	14.18
T8	B. pilosa	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	B. pilosa	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	B. pilosa	0.05	3.67 (2.63)	95.47	0.00 (2.40)	97.74	97.74
	B. pilosa	0.025	29.00 (3.68)	64.20	8.67 (2.90)	77.20	77.20
	B. pilosa	0.012	59.33 (4.25)	26.75	41.67 (3.96)	39.79	39.79
T9	A. conyzoides	0.2	11.67 (3.05)	85.60	14.00 (3.14)	84.88	84.88
	A. conyzoides	0.1	31.33 (3.74)	61.32	35.33 (3.81)	60.66	60.66
	A. conyzoides	0.05	51.00 (4.12)	37.04	48.33 (4.06)	41.16	41.16
	A. conyzoides	0.025	57.33 (4.22)	29.22	63.33 (4.29)	28.76	28.76
	A. conyzoides	0.012	74.67 (4.45)	7.82	77.00 (4.47)	10.33	10.33
T10	S. asoca	0.2	3.33 (2.61)	95.88	10.67 (2.99)	91.90	91.90
	S. asoca	0.1	18.00 (3.36)	77.78	18.00 (3.36)	78.70	78.70
	S. asoca	0.05	31.33 (3.74)	61.32	31.33 (3.74)	62.93	62.93
	S. asoca	0.025	52.33 (4.14)	35.39	52.33 (4.14)	38.07	38.07
	S. asoca	0.012	61.33 (4.27)	24.28	59.67 (4.25)	28.37	28.37

T11	C. sativa	0.2	15.00 (3.13)	81.48	9.33 (3.01)	85.46	85.46
	C. sativa	0.1	10.67 (3.06)	86.83	10.67 (3.06)	87.38	87.38
	C. sativa	0.05	23.00 (3.52)	71.60	23.00 (3.52)	72.78	72.78
	C. sativa	0.025	36.33 (3.84)	55.14	49.33 (4.09)	49.65	49.65
	C. sativa	0.012	70.00 (4.38)	13.58	61.00 (4.27)	22.26	22.26
T12	M. koenigii	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	M. koenigii	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	M. koenigii	0.05	6.67 (2.78)	91.77	2.00 (2.56)	94.76	94.76
	M. koenigii	0.025	33.00 (3.77)	59.26	21.33 (3.47)	67.56	67.56
	M. koenigii	0.012	68.00 (4.37)	16.05	55.00 (4.19)	26.89	26.89
T13	T. erecta	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	T. erecta	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	T. erecta	0.05	11.33 (3.01)	86.01	3.33 (2.64)	91.12	91.12
	T. erecta	0.025	34.67 (3.81)	57.20	22.67 (3.51)	65.77	65.77
	T. erecta	0.012	61.33 (4.28)	24.28	38.33 (3.89)	40.44	40.44
T14	C. limetta	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. limetta	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. limetta	0.05	12.33 (3.05)	84.77	8.00 (2.88)	87.86	87.86
	C. limetta	0.025	45.00 (3.99)	44.44	39.33 (3.91)	49.96	49.96
	C. limetta	0.012	70.67 (4.40)	12.76	61.33 (4.28)	21.66	21.66
T15	A. annua	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	A. annua	0.1	0.00 (2.40)	100.00	2.67 (2.58)	98.49	98.49
	A. annua	0.05	29.67 (3.70)	63.37	20.00 (3.43)	70.37	70.37
	A. annua	0.025	39.00 (3.90)	51.85	36.00 (3.84)	55.55	55.55
	A. annua	0.012	80.00 (4.50)	1.23	59.67 (4.25)	16.84	16.84
T16	C. citrinus	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. citrinus	0.1	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. citrinus	0.05	7.00 (2.82)	91.36	0.00 (2.40)	95.68	95.68
	C. citrinus	0.025	29.33 (3.67)	63.79	21.33 (3.45)	69.82	69.82
	C. citrinus	0.012	60.33 (4.27)	25.51	49.00 (4.06)	35.02	35.02
T17	O. gratissimum	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	O. gratissimum	0.1	3.33 (2.64)	95.88	9.33 (2.99)	92.66	92.66
	O. gratissimum	0.05	27.00 (3.63)	66.67	26.00 (3.58)	68.62	68.62
	O. gratissimum	0.025	47.67 (4.06)	41.15	42.00 (3.94)	46.80	46.80
	O. gratissimum	0.012	72.00 (4.42)	11.11	76.00 (4.46)	12.54	12.54
T18	C. limon	0.2	0.00 (2.40)	100.00	0.00 (2.40)	100.00	100.00
	C. limon	0.1	2.67 (2.58)	96.71	0.00 (2.40)	98.36	98.36
	C. limon	0.05	18.67 (3.38)	76.95	20.67 (3.41)	76.78	76.78
	C. limon	0.025	50.67 (4.12)	37.45	49.67 (4.09)	40.61	40.61
	C. limon	0.012	68.00 (4.36)	16.05	69.33 (4.38)	18.78	18.78
	Control		81.00 (4.51)		88.33 (4.60)		
	S.Em. ±		(0.94)		(0.12)		
	CD at 5%		(0.30)		(0.34)		

Data in parentheses indicate log (X+1) transformed value

Conclusion

Efficacy of essential oils and their constituents have been studied against stored product insect, aiming the better protection of pre and post harvest products. Plant essential oils can be used in a variety of ways to control large number of insect pest. It may require frequent replication, as they are effective for particular time duration considerably. Due to their volatile nature they have lower level of risk to the environment and mammals, hence compatible with integrated pest management program.

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