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Original Research Article

Efficacy of certain Botanicals against *Tribolium castaneum* (Herbst) in Stored Wheat Grain

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Keywords

Wheat, *Tribolium castaneum*, Botanicals, LD50, Repellency and weight loss

A B S T R A C T

Present study was carried out in Department of Entomology, Assam Agricultural University, Jorhat-13 in 2019 in the reference of wheat storage. Wheat is the most important and widely cultivated in India for its seed and grain. Wheat grains are need to store for emerging population of the world but these storages are destroyed by several calamitous pest. Among all, *Tribolium castaneum* Herbst one of them, adult and larva both are considered as a distractive stage. That is why locally available medicinal plants dry powders (*A. indica*, *C. roseus*, *C. heptaphylla*, *D. stramonium*, *E. tereticornis*, *M. struthiopteris*, and *V. negundo*) were used against *T. castaneum*. *A. indica* (1.46%), *D. stramonium* (2.04%) and *E. tereticornis* (2.76%) showed highest LD_{50} values. The highest mean repellency was exhibited by *A. indica* (83.61%) followed by *D. stramonium* (70.86%) and *E. tereticornis* (74.81).On the behalf of highest LD_{50}andmean repellency *A. indica*, *D. stramonium* and *E. tereticornis* were selected for further work. All these botanicals *viz.*, *A. indica* (45.00, 53.75, 62.50, 81.25 and 93.75%), *D. stramonium* (40.00, 51.25, 51.25, 80.00 and 91.25%) and *E. tereticornis*(36.25, 47.50, 47.50, 76.25 and 88.75%) respectively provided continuous increase of mortality from 1 day after treatment to 28 days and reached 100 per cent mortality at 35 days. The lowest grain weight loss was found in *A. indica* (8.64%) followed by *D. stramonium* (9.87%) and *E. tereticornis* (17.38%), which were at par to each other. The highest grain weight loss was observed in control with 64.92 per cent.

Introduction

Among all stored food grains wheat is the most important one, cultivated widely in India for its seed and grain. It is used as staple food in most of the country. India is the second largest producer of wheat after China with 97.11 million metric tonnes grain production. Wheat seeds having basket of nutrition, per 100gm of edible portion contains energy (327 kcal), carbohydrates (71.18g), sugar (0.41%), fibres (12.2g), fat (1.54g), protein (12.61g), vitamins B_1 (33%), B_2 (10%), B_3 (36%), B_5 (19%), B_6 (23%), B_9 (10%), K (2%), E (7%), calcium (3%), iron (25%), phosphorus (41%), potassium (8%), sodium (2gm) and zinc (28%) (Anonymous, 2017). The emerging population is a big challenge to the agriculture scientist community. The expected population will reach up to 9.1 billion people by the year 2050, which need 70% extra food production to feed those. Storage of the food products is one of most important strategy to get red from this problem (Godfray *et al.,* 2010). But in storage, products were attack by different type of pests *viz.,* rodents, insects and microbes. More than 600 species of beetles, 70 species of moths, 355 species of mites, 40 species of rodents, and 150 species of fungi have been reported to be associated with various stored products, including food commodities (Nattudurai *et al.,* 2017). The grains are infested by varieties of insect-pests. Among them, *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) are the most widespread and destructive pests, feeding on different stored-grain and grain products (Weston and Rattlingourd, 2000; Mishra *et al.,* 2012a; 2012b).

The indiscriminate use of chemicals paves the way for developing resistant strains, toxic residue causes human and animals health hazards, workers safety and high cost of procurement (Sighamony *et al.,* 1990). In this scenario, it is necessary to find out eco-friendly, economically viable alternative pest control methods which are affordable by resource poor farming communities. One of the alternative methods tried worldwide is by using plant products (Cobbinah and Appiah-Kwarteng, 1989; Niber, 1994; Jembere *et al.,* 1995; Lajide *et al.,* 1998). Talukder (2006) listed 43 plant species as insect repellents, 21 plants as insect feeding deterrents, 47 plants as insect toxicants, 37 plants as grain protectants, 27 plants as insect reproduction inhibitors and 7 plants as insect growth and development inhibitors.

Moreover, the use of plants materials for storage protection is sustainable, biodegradable and do not have any negative impact on the environment (Golob *et al.,* 1999). Among the medicinal plants, several locally available species have been reported to be repellent and toxic to *S. oryzae and T. castaneum* (Sighamony *et al.,* 1984; Obeng-Ofori *et al.,* 1998; Golob *et al.,* 1999; Mareggiani *et al.,* 2000; Nikkon *et al.,* 2009; Suthisut *et al.,* 2011).Therefore, the present study is under taken to investigate the efficacy of locally available medicinal plant against *Tribolium castaneum* Herbst with following objectives.

Materials and Methods

The experiment on efficacy evaluation of twelve botanicals *viz. Azadirachta indica, Catharanthus roseus, Clausena heptaphylla, Datura stramonium, Eucalyptus tereticornis, Matteuccia struthiopteris,* and *Vitex negundo* dry powders against *Tribolium castaneum (Herbst)* was conducted in the Toxicology Laboratory, Department of entomology, AAU Jorhat- 13 during 2017-2019.

Tribolium castaneum (Herbst) adults were collected from Post Harvest Laboratory, Department of Agricultural Engineering, Jorhat-13. For mass rearing (Abbasipour *et al.,* 2011), the fresh wheat seed variety HD-3086 was provided to eight different plastic containers (2 No's 29cm×12cm, 2 No's 32cm×13.50, 2 No's 25cm×12cm, 2 No's 22cm×11cm) for feeding. The insect culture was maintained on room temperature 27-30^{0}Cat toxicology laboratory, Department of Entomology, AAU Jorhat- 13.

For selected of plants a preliminary survey worth was done and select those plants which were traditionally used by the farmers of Assam for protecting the storage rice seeds. Leaves were collected from selected plants and washed thoroughly with tap water to remove dirty material attached from the natural environment and plant materials were kept in shade for air- drying. After complete drying, powdered by using electric blender and fine powder was obtained by sieving through kitchen strainer. (Agha *et al.*, 2017) For each plant leaf powder was used as 0.25, 0.50, 0.75, 1.00, 1.25, 1.75 and 2.50 gm per 25g seed were thoroughly mixed which correspondence to 1, 2, 3, 4, 5, 7 and 10 per cent (wt./wt.), (Ojo and Ogunleye, 2013, Adarkwah *et al.*, 2017). The treated seeds were kept with three replications for each treatment in plastic containers (7cm × 6cm) on room temperature and 20 adults were released in each replication. At 24, 48 and 72 hr after treatment, mortality was counted and if there was mortality in control, corrected by using Abbott's formula (1925). Mortality data obtained were subjected to probit analysis to find out LD_{50} value (wt./wt.).

For repellency test, 9 cm diameter petri dish was divided into three parts, treated, untreated and without grain part (Karakas, 2016). In treated part of the plate filled with 0.3gm of dry powder from each plant were mixed with 3gm of wheat seed (10% wt./wt.) (Dhaniya and Dayanandan, 2016). One side was treated and the other side was untreated test chamber. Ten insects were released at the central portion of each petri dish and covered by a cover plate. Then the number of insects on each chamber was counted at hourly intervals up to sixth hour. The per cent repellency was calculated by following formula.

PR (%) = (Nc-50) x 2

Where: PR= Per cent repulsion,

Nc= Percentage of weevils present in the control half.

The classes of Repellency (% repellency rate) were categorized, according to Mc Donald *et al.*, 1970. The differences among various means were tested by using one ANOVA with JMP SAS and IBM SPSS 20 package.

> 0.01	-	0.1 0
0.1	-	20 I
20.1	-	40 II
40.1	-	60 III
60.1	-	80 IV
80.1	-	100 V

To observe the mortality of *T. castaneum* at stored wheat based on previous experiment of LD_{50}, three most effective botanicals were selected and 10 gm dry powder of these botanicals was mixed with 100gm (10% wt./wt.) seeds (Ojo and Ogunleye, 2013). Then the treated seeds were kept in containers (7cm × 6cm) and released 20 adults (male and female, 1:1 ratio) to observe the mortality of *T. castaneum.* To estimate the mortality numbers of dead insect were counted at 1, 3, 7, 14, 21, 28, 35 and 45 days. Counting was stop after 45 day to avoid the overlapping generation (Devi *et al.*, 2014). If mortality was found in control subjected to percentage of corrected mortality by Abbott's (1925).

Grain weight loss was calculated by the following formula.

% WL= (IW-FW) X 100 / IW

Where,

WL: Weight loss index.

IW: Initial weight and

FW is the final weight.

Results and Discussion

Efficacy of dry powders (during 2019) against *Tribolium castaneum*

The laboratory evaluation of LD_{50} and relative toxicity of seven plants leaf powder was done during the year 2019. LD_{50} has expressed in percentage with wt./wt. g and relative toxicity has expressed in percentage.

In year 2019, the LD_{50} (% wt./wt. g) values and relative toxicity of *A. indica, C. roseus, C. heptaphylla, D. stramonium, E. tereticornis, M. struthiopteris*, and *V. negundo* leaf power against *T. castaneum* after 24 hrs. of exposure were 2.42, 8.73, 6.66, 2.64, 2.44, 12.32 and 6.28 per cent respectively. After 48 hrs. of exposure, it was 1.55, 2.95, 3.66, 1.88, 1.87, 8.27 and 4.11 per cent and after 72 hrs. 1.46, 2.04, 2.76, 1.46, 1.62, 3.39 and 2.17 per cent, respectively (Table 1).

The toxicity order for *T. castaneum* (Herbst) based on LD_{50} values (% wt./wt. g) and considering *A. indica* as standard was *A. indica* > *E. tereticornis* > *D. stramonium* > *V. negundo* > *C. heptaphylla* > *C. roseus* > *M. struthiopteris* powder for the exposure period of 24 hrs., *A. indica* > *E. tereticornis* > *D. stramonium* > *C. roseus* > *C. heptaphylla* > *V. negundo* > *M. struthiopteris* powder for the exposure period of 48 hrs., *A. indica* > *D. stramonium* > *E. tereticornis* > *C. roseus* > *V. negundo* > *C. heptaphylla* > *M. struthiopteris* powder for the exposure period of 72 hrs. respectively (Table 1).

Based on relative toxicity it was found that *C. roseus* was 0.27, 0.52 and 0.71, *C. heptaphylla* was 0.36, 0.42 and 0.52, *D. stramonium* was 0.91, 0.82 and 0.97, *E. tereticornis* was 0.99, 0.82 and 0.90 *M. struthiopteris* was 0.19, 0.18and 0.37, *V. negundo* was 0.38, 0.37 and 0.67 times less toxic than *A. indica*, after 24, 48 and 72 hrs (Table 1).

Among these botanicals *A. indica*, *D. stramonium* and *E. tereticornis* were gave most effective results in comparison to other botanicals. Based on LD_{50}, relative toxicity, repellency and mortality per cent, *A. indica* leaf powder indicated the highest toxic effects against *T. castaneum* (Herbst) in treated wheat grains. Earlier workers also found the higher effectiveness of *A. indica* leaf powder against *T. castaneum* (Mamun *et al.*, 2009, Rehman *et al.*, 2019) which were in tune with this study.

The toxicity of *A. indica* against various storage pests were described by different authors.

They reported that the presence of triterpenoid /secondary metabolites azadirachtin, salanin, meliantriol (Mbailao *et al.*, 2006, Ileke and Oni 2011) were responsible for antifeedant, ovicidal, larvicidal, insect growth regulatory and repellent activity (Chaudhary *et al.*, 2017) of *A. indica.*

Repellency of dry powders against *Tribolium castaneum*

In repellency test *D. stramonium* (80.00%), *A. indica* (73.33%), *C. heptaphylla* (73.33%), *E. tereticornis* (73.33%) were showed significantly highest repellency rate after 1hr. of treatment and all are statistically at par during 2019. *C. roseus* (66.66%) gave more repellency rate in comparison to *M. struthiopteris*(26.66%) and *V. negundo* (26.66%). Which were significantly less in comparison to other treatments after 1hr. Gradual increase of repellency rate was observed from 1hr. to 72 hrs., in case of *A. indica* (86.66%) and *E. tereticornis*(80.00%).

There was no significant change of repellency rate was found in case *D. stramonium* (80.00%), *C. heptaphylla* (73.33%) and *C. roseus* (53.33%) after 72 hrs. of treatment.

Increase trend of repellency from 1hr. to 72hrs. was also observed in case of *V.*

negundo (53.33%),and *M. struthiopteris* (40.00%) (Table 2). Similar trend of mean repellency rate was observed after 72hrs. *A. indica* registered highest mean repellency rate (83.61%) under repellency (class V) followed by *C. roseus* (62.76%), *C. heptaphylla* (69.25%), *D. stramonium* (70.86%) and *E. tereticornis* (74.81) (class IV), *V. negundo* (52.21%) (class III) while *M. struthiopteris* was under the repellency (class II) with mean repellency value (30.73%) (Table 2).

Repellency effect of botanicals on *T. castaneum* (Herbst) was also observed in previous studies by Islam *et al.*, (2009) and Iram *et al.*, (2013) where botanicals has proved as a good alternate of pesticide.

Leaf powder of *D. stramonium* also showed higher repellency values after *A. indica* against *T. castaneum* (Herbst) in treated wheat grains. Previous works of many workers also reported the high toxicity of *D. stramonium* against storage pest (Jawalkar *et al.*, 2016 and Abbasipour *et al.*, 2011).

In another report of Manzoor *et al.*, (2011), datura showed maximum mortality in *Tribolium castaneum* and highest repellency in *Callosobruchus chinensis*. Hanif *et al.*, (2016) also reported the highest rate of repellency advocated by *A. indica* and *D. stramonium* (77.66%, 81.48% and 76.43%) against *T. castaneum*, *Rhyzopertha dominica* and *Trogoderma granarium*.

Mortality effect of plant dry leaves power and weight loss *Tribolium castaneum* (during 2019)

The experiment was done during 2019, at 1 day after treatment among all the botanicals *A. indica* ranked highest (35.00 %) in case of mortality followed by *D. stramonium* (32.50%) and *E. tereticornis* showed lowest (30.00 %) mortality in comparison to other botanicals but found significantly higher than control. The mortality was found at 3, 7, 14, 21 and 28 days after treatment. All these botanicals *viz., A. indica* (45.00, 53.75, 62.50, 81.25 and 93.75%, respectively), *D. stramonium* (40.00, 51.25, 51.25, 80.00 and 91.25%, respectively),*E. tereticornis*(36.25, 47.50, 47.50, 76.25 and 88.75%,respectively) provided continuous increase of mortality from 1 day after treatment to 28 days and reached 100 per cent at 35 days. In control treatment, no mortality was found (00.00%) (Table 3).

When wheat grains were treated with *A. indica*, *D. stramonium* and *E. tereticornis*to observe the mortality of *T. castaneum* it was found that all the released insects were died after 35 days.

Therefore, the weight loss of grains was measured after 35 days. *T. castaneum* released plant dry powder treated containers, the lowest grain weight loss was found in *A. indica* (8.64%) followed by *D. stramonium* (9.87%) and *E. tereticornis* (17.38%) during the experiment 2019, which were statistically similar.

The highest grain weight loss was observed in control with 64.92 per cent in 2019, which were significantly high than botanical treatments (Table 4).

Effect of botanicals on stored grain pests were also observed in previous studies by Kumar *et al.*, (2008) and Perera and Karunaratne (2012).

Leaf powder of *D. stramonium* also showed higher mortality and weight loss values after *A. indica* against *T. castaneum* (Herbst) in treated wheat grains. Previous works of many workers also reported the high toxicity of *D. stramonium* against storage pest (Jawalkar *et al.*, 2016 and Abbasipour *et al.*, 2011).

Table.1 LD_{50} and Relative toxicity of different plant powder against *Tribolium castaneum* (Herbst) after 24, 48 and 72 hours of treatment (2019).

Botanicals	Hours	Regression equation	Heterogeneity	LD50% (wt./wt. g)	Fiducial limit		Relative Toxicity	Order of toxicity
					L.B	U.B		
Catharanthus roseus	24	Y= 0.19+0.20X	8.9	8.73	4.97	98.6	0.27	VI
	48	Y= 0.11+0.23X	13.39	2.95	1.37	4.8	0.52	IV
	72	Y= 0.10+0.37X	12.92	2.04	1.14	2.83	0.71	IV
Clausena heptaphylla	24	Y= 0.18+0.22X	17.48	6.66	4.06	30.44	0.36	V
	48	Y= 0.10+0.18X	9.91	3.66	1.36	10.12	0.42	V
	72	Y= 0.09+0.22X	13.07	2.76	1.06	4.58	0.52	VI
Datura stramonium	24	Y= 0.13+0.30X	8.68	2.64	1.53	3.74	0.91	III
	48	Y= 0.11+0.43X	16.96	1.88	1.19	2.49	0.82	III
	72	Y= 0.10+0.60X	29.43	1.49	1.04	1.89	0.97	II
Eucalyptus tereticornis	24	Y= 0.09+0.24X	17.08	2.44	1.02	3.75	0.99	II
	48	Y= 0.09+0.36X	18.14	1.87	1.03	2.59	0.82	II
	72	Y= 0.10+0.47X	23.72	1.62	1.02	2.14	0.9	III
Matteucciastruthiopteris	24	Y= 0.42+0.39X	11.99	12.32	8.15	28.44	0.19	VII
	48	Y= 0.21+0.23X	8.68	8.27	5.03	40.03	0.18	VII
	72	Y= 0.18+0.31X	11.7	3.94	2.71	5.99	0.37	VII
Vitex negundo	24	Y= 0.19+0.24X	9.99	6.28	4.03	18.7	0.38	IV
	48	Y= 0.12+0.19X	18.76	4.11	2.08	11.12	0.37	VI
	72	Y= 0.10+0.31X	15.52	2.17	1.15	3.07	0.67	V
Azadirachta indica	24	Y= 0.15+0.39X	25.23	2.42	1.6	3.19	1	I
	48	Y= 0.09+0.50X	26.13	1.55	1.01	2.04	1	I
	72	Y= 0.15+0.90X	55.43	1.46	1	1.87	1	I

The data were found to be significantly heterogeneous at = 0.05
Y = Probit kill, X = log dose
Mortality based on 4 replications each with 20 individuals

Table.2 Repellency effect of different plant leaf powder against *Tribolium castaneum* (Herbst) after in 2019.

Botanicals	Repellency									Mean repellency rate%	Repellency class
	1hr.	2hrs.	3hrs.	4hrs.	5hrs.	6hrs.	24hrs.	48hrs.	72hrs.		
Azadirachta indica	73.33	86.66	80.00	93.33	80.00	86.66	80.00	85.92	86.66	83.61	V
	(59.21)^{c}	(72.29)^{c}	(68.06)^{b}	(81.14)^{c}	(68.06)^{c}	(72.29)^{c}	(68.06)^{b}	(71.76)^{cd}	(72.29)^{b}	-	
Catharanthus roseus	66.66	73.33	53.33	71.85	53.33	56.66	69.74	66.66	53.33	62.76	IV
	(54.99)^{bc}	(59.21)^{bc}	(46.92)^{b}	(58.35)^{bcd}	(46.92)^{bc}	(48.84)^{bc}	(56.83)^{b}	(54.99)^{bcd}	(46.92)^{b}	-	
Clausena heptaphylla	73.33	60.00	63.33	73.33	66.66	73.33	66.66	73.33	73.33	69.25	IV
	(59.21)^{c}	(51.14)^{bc}	(53.06)^{b}	(59.21)^{cd}	(55.36)^{bc}	(59.21)^{c}	(54.99)^{b}	(59.21)^{bcd}	(59.21)^{b}	-	
Datura stramonium	80.00	70.00	67.77	53.33	53.33	66.66	80.00	86.66	80.00	70.86	IV
	(68.06)^{c}	(57.29)^{bc}	56.19^{b}	(46.92)^{bc}	(46.92)^{bc}	(55.36)^{c}	(68.06)^{b}	(72.29)^{cd}	(68.06)^{b}	-	
Eucalyptus tereticornis	73.33	60.00	73.33	73.33	73.33	66.66	80.00	93.33	80.00	74.81	IV
	(59.21)^{c}	(51.14)^{bc}	(59.21)^{b}	(59.21)^{cd}	(59.21)^{bc}	(54.99)^{c}	(68.06)^{b}	(81.14)^{d}	(68.06)^{b}	-	
Matteucciastruthiopteris	26.66	26.66	30.00	33.33	26.66	20.00	33.33	40.00	40.00	30.73	II
	(30.78)^{b}	(30.78)^{b}	(32.71)^{ab}	(35.00)^{b}	(30.78)^{ab}	(26.56)^{b}	(35.00)^{ab}	(38.85)^{b}	(38.85)^{b}	-	
Vitex negundo	26.66	60.00	53.33	46.66	46.66	66.66	63.33	53.33	53.33	52.21	III
	(30.78)^{b}	(51.14)^{bc}	(46.92)^{b}	(43.07)^{bc}	(43.07)^{bc}	(54.99)^{c}	(53.06)^{b}	(46.92)^{bc}	(46.92)^{b}	-	
Control	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	-
	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	(00.00)^{a}	00.00	
F VALUE	17.41	13.08	8.39	24.13	9.20	20.58	9.01	15.50	10.02	-	-
P< VALUE	00.0001	00.0001	00.0001	00.0001	00.0001	00.0001	00.0001	00.0001	00.0001	-	-
df	7,16	7,16	7,16	7,16	7,16	7,16	7,16	7,16	7,16	-	-

Figures with in parentheses are transformed values

Data are based on 3 replications each with 10 individuals

Zero and cent per cent values were subjected to the formula ¼ n before angular transformation (after Steel and Torrie, 1960), where n= number of insects

Table.3 Mortality of *Tribolium castaneum* (Herbst) after using different plants powder in 2019

Treatment	Mean mortality of *Tribolium castaneum* (1-45) days						
	1D	3D	7D	14D	21D	28D	35D
Azadirachta indica	35.00 (36.24)[b]	45.00 (42.12)[c]	53.75 (47.15)[b]	62.50 (52.24)[b]	81.25 (64.69)[b]	93.75 (75.69)[c]	100.00 (90.00)
Datura stramonium	32.50 (34.74)[b]	40.00 (39.21)[bc]	51.25 (45.71)[b]	51.25 (51.50)[b]	80.00 (63.51)[b]	91.25 (72.93)[bc]	100.00 (90.00)
Eucalyptus tereticornis	30.00 (33.17)[b]	36.25 (36.98)[b]	47.50 (43.55)[b]	47.50 (49.31)[b]	76.25 (60.91)[b]	88.75 (70.47)[b]	100.00 (90.00)
Control	00.00 (00.00)[a]	00.00 (00.00)[a]	00.00 (00.00)[a]	00.00 (00.00)[a]	00.00 (00.00)[a]	00.00 (00.00)[a]	00.00 (00.00)
F VALUE	308.40	321	287.41	1318.57	310.14	1075.23	-
P< VALUE	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-
df	3,12	3,12	3,12	3,12	3,12	3,12	3,12

D= Day after spraying
Figures are average corrected mortalities of 4 replications with 20 insects
Figures with in parentheses are transformed values
Zero and cent per cent values were subjected to the formula ¼ n before angular transformation (after Steel and Torrie, 1960), where n= number of insects

Table.4 Wight loss due to *T. castaneum* in stored wheat during 2019

Botanicals	Dry leaves power
Azadirachta indica	**8.64[a]±5.76**
Datura stramonium	**9.87[a]±6.97**
Eucalyptus tereticornis	**17.38[a]±1.92**
Control	**64.92[b]±1.72**
P<VALUE	**0.0001**
F VALUE	**129.44**
df	**3,12**

Many workers reported that *D. stramonium* has both poisonous and medicinal properties (Soni *et al.*, 2012; Mukhtar *et al.*, 2019). All parts of *D. stramonium* are toxic to mammals. Various parts of the herb contain toxic levels of anticholinergic (block neurotransmitters) alkaloids used for psychoactive effects Mukhtar *et al.*, 2019). In Ayurvedic, *D. stramonium* is described (Kirtikar and Basu, 1999; Soni *et al.*, 2012)as potential remedial medicine for various human ailments (ulcers, wounds, inflammation, rheumatism and gout, sciatica, swellings, fever, asthma and bronchitis, toothache, cancer, microbial disease etc.). *Eucalyptus tereticornis* leaf powder found effective against *T. castaneum* (Herbst) based on mortality and weight loss experiment. Earlier workers also observed that eucalyptus was effective against *T. castaneum* (Siddique *et al.*,2017) and *Trogoderma granarium* (Agha *et al.*,2017). *E. globulus* registered 100 per cent mortality (Rupp *et al.*, 2006) and 71 per cent (Chagas *et al.*, 2002) feeding inhibition activity of *S. oryzae.*

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