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Comparative efficacy of some indigenous plant materials as repellent against pulse beetle, *Callosobruchus chinensis* (L.)

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ABSTRACT

A laboratory experiment was carried out in the Department of Entomology, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland, to study the repellent effect of some indigenous plant materials against *Callosobruchus chinensis* (L.). The plant materials were leaves of *Jatropha curcas L., seeds of Litsea citrata* and *Piper nigrum*. Plant extracts were prepared with two different solvent, acetone and distilled water at five different doses of 10, 25, 50, 75 and 100 mg/ml. The repellent effect, test was carried out by half disc of filter paper method with a pipette at different doses of each plant extracts. The repellent effect was recorded after 1, 2, 3, 4 and 5 hours of the treatment application. In acetone extracts of plant material, the highest repellent effect was observed in *Litsea citrata* @ 100 mg/ml (86.67%) followed by *Piper nigrum* (80%) and *Jatropha curcas* L. (73.33%). In distilled water extract, the highest repellent effect was observed in *Litsea citrata* @ 100 mg/ml (86.67%) followed by *Piper nigrum* (83.33%) and *Jatropha curcas* L. (73.33%). The finding showed the strong repellent effect of *Litsea citrata* extract against pulse beetle. All the plant materials with water extract was comparatively more effective than acetone extract.

1. Introduction

Chickpea (*Cicer arietinum* L.) popularly names as Gram, Bengal gram, Garbenzo bean, Egyptian pea, homes, Chana, or Garbanzo bean is the first grain legume to be domesticated in the old world by humans. It is one of the most important crops among the various pulse crops which play an important role in our daily diet. Chickpea is a rich source of proteins, vitamins, complex carbohydrates, minerals (calcium, potassium, phosphorus, magnesium, iron and zinc), fibre, unsaturated fatty acids and β-carotene (Gaur, 2011; Gowda, 2011 and Jukanti, 2012). It is the third most important pulse crop in the world and have been grown in over 50 countries. Chickpea is a major legume food in Southern Europe, North Africa, India and Middle East countries (Iqbal *et al*., 2006). In India, pulses are consumed to be the third most important group of crops after cereals and oilseeds (Nishad *et al.,* 2017). Pulses are grown on an area of 40.31 thousand hectares in Nagaland, where they yield 46.78 thousand tones and the chickpea cultivation area is 760 hectares and total production is 640 metric ton (Directorate of Agriculture, 2021).

The storage of pulses has always been a problem (Mishra *et al.,* 2017), as their infestation causes economic loss (Proctor, 1994). Due to humid conditions, poor sanitation, and inappropriate storage facilities, insect infestation is the most serious issue during storage, particularly in the towns and villages of tropical and subtropical countries. In India, insect infestation accounts for 6.5% losses of stored grain (Raju, 1984). Among the insect pests of chickpea, pulse beetle, *Callosobruchus chinensis* (L.) cause damage to both stored seeds as well as in the field, but heavy infestation in stored condition. It causes quantitative as well as qualitative damage and it is commonly encountered pests in stored pulses of Nagaland. Insecticides are typically used to manage insect pests, however due to the risks associated with pesticides, researchers are attempting to adopt alternate means of pest control. Botanicals not only inhibit insect infestation but also are free of residual hazards.

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Indigenous plant materials are cheaper and hazard free in comparison with synthetic chemical insecticides. Keeping this in view, the present study entitled "Comparative efficacy of some indigenous plant materials as repellent against pulse beetle, *Callosobruchus chinensis* (L.)" on stored chickpea was undertaken to observe the repellent effect of different plant extracts against pulse beetle.

2. Materials and Methods

Site of the laboratory

The experiment was carried out in the storage laboratory, Department of Entomology, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema, Nagaland, India which is located at 24°45'45'' latitude and 93°53'04'' longitude and at an elevation of 310 m. above mean sea level.

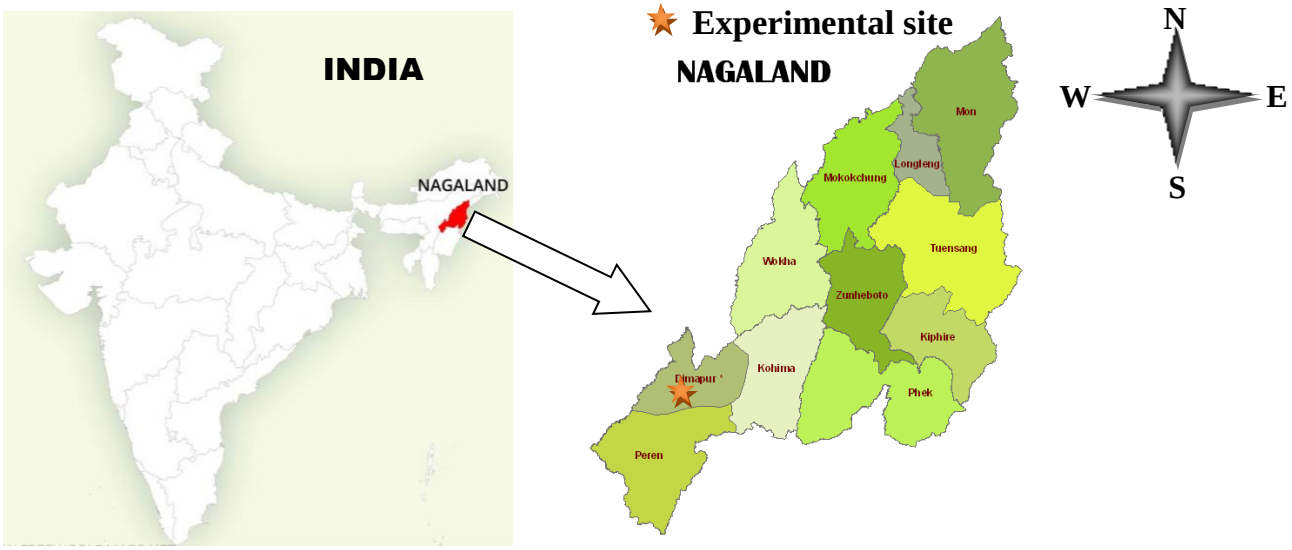

Figure 1. Location of the experimental site.

Table 1. Experimental Details

Stored grain	**Desi Chickpea (Cicer arietinum L.)**
Experimental Design	CRD (Factorial)
Factor	02
Number of replication (R)	03
Number of plant extracts (T)	03
Control (Solvent)	02
Doses of plant extracts (D)	05
Number of insect released	10 Adult Pulse beetles
Repellency interval (After treatment)	1 hours
	2 hours
	3 hours
	4 hours
	5 hours

Table 2. Treatment details

Treatment		
Factor - I	**Plant extracts (T)**	
		Plant part used
	T_1 = Jatropha	Leaf
	T_2 = *Litsea citrata*	Seed
	T_3 = Black pepper	Seed
		solvent
	T_0 = control	Acetone
		Distilled water
Factor - II	**Doses (D)**	
	10 mg/ml	
	25 mg/ml	
	50 mg/ml	
	75 mg/ml	
	100 mg/ml	

Maintenance of stock culture of *Callosobruchus chinensis* (L.)

The stock culture of *C. chinensis* was obtained from the storage laboratory of the department of Entomology, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema and were maintained on the seeds of chickpea in plastic jar which was covered by muslin cloth fastened with the help of rubber band to prevent the escape of the pulse beetles and allow air flow. The stock culture was kept in the cabin of storage laboratory at ordinary room temperature and relative humidity. This culture was used for obtaining the adults of same age for conducting the experiment.

Preparation of plant extracts

The plant materials were collected from various local sources and after collection these were washed with distilled water and kept in the laboratory for 7 days for air drying followed by 1 day of sun drying before making it into a powder. Electric grinder was used to obtain coarse powder. Powders were kept in airtight polythene bags at room temperature and properly sealed to prevent quality loss.

Preparation of solution

50 g of each plant extract was taken in a 500 ml beaker separately. Then, 250 ml of distilled water and acetone added in each beaker. The mixture was stirred for 30 minutes in magnetic stirrer. The mixture was filtered through fine cloth and condensed by evaporation in a water bath at 70-90°C temperature with the constant weight gained. After complete evaporation of solvent, the semi-solid extracts were obtained, cooled and preserved in the refrigerator for later use. The 10, 25, 50, 75 and 100 mg/ml stock solution of distill water and acetone extract of different plants was prepared from preserved semi-solid solution by diluting in distill water and acetone for insect bioassay. Control was maintained by using only solvent.

Repellency test

Substrates were prepared in filter paper discs cut into half following Talukder and Howse (1994). 1 ml of each category extract solution was applied to a half filter paper disc uniformly with a pipette. The treated half discs were air dried to evaporate the solvent completely and attached with the untreated (control) half with cello tape and placed in a petri dish (9×1.3 cm^2). The insects were released at the centre of each filter paper discs in the petri dish.

Observation recorded

In the repellency test, insects present on each strip were counted at an interval of 1 hour up to the 5th hour. The average was converted to express percentage repellency. The repellency classes were classified as given by Mc Donald *et al.* (1970).

Table 3. Repellency classes

CLASSES	REPELLENCY %
class I	0.1 to 20. 0%
class II	20.1 to 40.0%
class III	40.1 to 60.0%
class IV	60.1 to 80.0%
class V	80.1 to 100.0%

3. Results and Discussion

Repellency rate of different plant extracts against pulse beetle *Callosobruchus chinensis* (L.)

The data on repellent effect of different plant extracts and doses against pulse beetle, *Callosobruchus chinensis* (L.) at 1, 2, 3, 4 and 5 hours of exposures are presented in table 4, 5, 6 and 7.

Acetone Extract:

The repellent effects of three plant extracts with acetone solutions on pulse beetle in different hours at different doses were found statistically different (Table 4). After 1 hour of exposure, the repellency rate was found highest in Litsea (45.33%) followed by Black pepper (44%) and Jatropha (42%) which was statistically at par with each other. After 2 and 3 hours of exposure, the highest repellency rate was observed in Litsea (47.33 and 47.33%) followed by Jatropha (43.33 and 42.67%) and Black pepper (42.67 and 42.00%). After 4 and 5 hours of exposure, the repellency rate was statistically similar in all the three extracts ranging from 48.00 to 50.00 % in Litsea, 46.00 to 47.33% in Black pepper and 46.00 % in Jatropha. Among the five doses, the highest dose @ 100 mg/ml of all plant extracts showed highest repellent effect after treatment application of 1 hour (56.67%), 2 hours (58.33%), 3 hours (58.33%), 4 hours (61.67%) and 5 hours (63.33%). The repellent effect decreased proportionally with the decrease of dose and time.

The interaction between acetone plant extracts and doses were found to be statistically different (Table 5). Maximum repellent effect was recorded at 100 mg/ml in Litsea (76.67, 83.33, 83.33, 83.33 and 86.67%) followed by black pepper (73.33, 73.33, 70.00, 76.67 and 80.00%) and Jatropha (63.33, 66.67, 66.67, 73.33 and 73.33%) after 1, 2, 3, 4 and 5 hours of exposure, respectively. Minimum repellent effect was recorded at 10 mg/ml in Litsea (23.33, 23.33, 26.67, 26.67 and 26.67%) followed by black pepper (23.33, 23.33, 23.33, 26.67 and 26.67%) and Jatropha (23.33, 23.33, 23.33, 23.33 and 23.33%) after 1, 2, 3, 4 and 5 hours of exposure, respectively. The result also indicated that the repellency action increased proportionally to the doses and repellency classes was in increasing order from class II to class V.

Distilled water extract:

The repellent effects of three plant extracts with distilled water solutions on pulse beetle in different hours at different doses were found statistically different (Table 6). After 1 hour of exposure, the repellency rate was found highest in Litsea (46.00%) followed by Black pepper (43.33%) and Jatropha (43.33%) which was statistically at par with each other. After 2 hours of exposure, the repellency rate was at par in three extracts, while after 3 hours of exposure, the highest repellency was observed in Black pepper (48.00 %) followed by Litsea (46.67%) and Jatropha (42.67%). After 4 hours of exposure, the repellency rate was statistically similar in all the three extracts ranging from 46.00 to 50.00 %, while after 5 hours of exposure Litsea recorded the highest repellency with 54.00 %. Among the five doses, the highest dose @ 100 mg/ml of all plant extracts showed highest repellent effect with 55.83, 60.00, 60.00, 65.00 and 66.67% after treatment application of 1, 2, 3, 4 and 5 hours, respectively. The repellent effect decreased proportionally with the decrease of dose and time.

The interaction between distilled water plant extracts and doses were found to be statistically different (Table 7). Maximum repellent effect was recorded at 100 mg/ml in Litsea (76.67, 76.67, 80.00, 83.33 and 86.67%) followed by black pepper (66.67, 73.33, 73.33, 83.33 and 83.33%) and Jatropha (63.33, 66.67, 66.67, 73.33 and 73.33%) after 1, 2, 3, 4 and 5 hours of exposure, respectively. Minimum repellent effect was recorded at 10 mg/ml in Litsea (26.67, 30.00. 30.00, 33.33 and 36.67%) followed by Jatropha (26.67, 33.33, 23.33, 26.67 and 33.33%) and black pepper (23.33, 23.33, 26.67, 23.33 and 26.67%) after 1, 2, 3, 4 and 5 hours of exposure, respectively. The result also indicated that the repellency action increased proportionally to the doses and repellency classes was in increasing order from class II to class V.

The present results are in conformity with the findings of Wang *et al.* (2015) who reported that the repellent activity in Litsea was almost 50%. Mossa (2016) reported that Litsea is a multipurpose plant with many properties and it has many chemical components such as pinene, D–limonene, Caryophyllene, 6-methyl-5-hepten-2-one, 6–octadienal, (E)-3, 7-dimethyl-2, 6-octadienal and other compounds with considerable repellent potential.

Ishii *et al*. (2010) reported the moderate repellent activity of black pepper at 20 to 50 mg/ml. Huang and Ho (1998) and De Paula *et al*. (2000) reported that piperine, a pungent substance in black pepper possess insecticidal activities. In agreement with studies of Kemabonta *et al.* (2018) who found that the repellency increased with the increase in the concentration of extracts and time of exposure. The present study was also similar with Mutalib *et al*. (2017) who reported that the black pepper extracts might be considered to be effective as repellent.

The results of present study are also in agreement with Lawati *et al.* (2002) who reported that Jatropha leaf extracts possess moderate repellent activity against pulse beetle, *Callosobruchus chinensis*.Rehman *et al.* (2018) recorded highest mean repellency with Jatropha leaf extracts ranging from 42.57 to 58.45 %. These findings were close to our repellency result. Similar findings have been disclosed by Khani *et al.* (2012).

Table 4. Repellency effect of different plant extracts and doses against pulse beetle, *Callosobruchus chinensis* with acetone solution

Treatments	**Repellency rateagainst pulse beetle, *Callosobruchus chinensis* (%)**					**Repellency Class**
	1 hour	***2 hours***	***3 hours***	***4 hours***	***5 hours***	
Plant extracts						
Jatropha curcas: T_1	42.00[a]	43.33[b]	42.67[b]	46.00[a]	46.00[a]	III
	(40.13)	(40.91)	(40.59)	(42.58)	(42.58)	
Litsea citrata: T_2	45.33[a]	47.33[a]	47.33[a]	48.00[a]	50.00[a]	III
	(42.20)	(43.63)	(43.57)	(43.97)	(45.40)	
Piper nigrum: T_3	44.00[a]	42.67[b]	42.00[b]	47.33[a]	46.00[a]	III
	(41.37)	(40.60)	(40.16)	(43.59)	(42.80)	
Untreated (Control): T_0	15.78[b]	11.83[c]	15.78[c]	15.78[b]	15.78[b]	I
	(21.14)	(18.43)	(20.46)	(21.14)	(21.14)	
SEm±	**1.49**	**1.29**	**1.56**	**1.56**	**1.45**	
$CD_{(P=0.05)}$	**4.26**	**3.69**	**4.47**	**4.47**	**4.15**	
CV	**15.96**					
Doses						
D_{10}	20.83[d]	20.00[d]	21.67[c]	22.50[d]	22.50[d]	II
	(26.87)	(26.19)	(26.57)	(27.98)	(27.98)	
D_{25}	23.33[d]	23.33[d]	23.33[c]	25.00[d]	25.00[d]	II
	(28.53)	(28.41)	(28.53)	(29.59)	(29.64)	
D_{50}	36.67[c]	34.17[c]	36.67[b]	36.67[c]	35.83[c]	II
	(36.63)	(34.99)	(36.63)	(36.63)	(36.15)	
D_{75}	43.33[b]	43.33[b]	41.67[b]	47.50[b]	47.50[b]	III
	(40.48)	(40.28)	(39.52)	(42.90)	(42.90)	
D_{100}	56.67[a]	58.33[a]	58.33[a]	61.67[a]	63.33[a]	III
	(48.54)	(49.59)	(49.72)	(52.00)	(53.23)	
SEm±	**1.92**	**1.67**	**2.02**	**2.02**	**1.88**	
$CD_{(P=0.05)}$	**5.50**	**4.76**	**5.77**	**5.77**	**5.36**	
CV	**15.96**					

Note: Data in parenthesis are transformed to angular values.

Within column values followed by similar letter(s) are statistically at par by DMRT

Table 5. Interaction of repellency effect of different plant extracts and doses against pulse beetle, with acetone solution

Plant extracts x Doses Interaction (T x D)	**Repellency rateagainst pulse beetle, *Callosobruchus chinensis* (%)**					**Repellency Class**
	1 hour	***2 hours***	***3 hours***	***4 hours***	***5 hours***	
T_1D_{10}	23.33	23.33^{f}	23.33^{f}	23.33^{g}	23.33^{f}	II
	(28.78)	(28.78)	(28.78)	(28.78)	(28.78)	
T_1D_{25}	26.67^{e}	26.67^{f}	30.00^{f}	30.00^{g}	30.00^{f}	II
	(31.00)	(31.00)	(33.21)	(33.21)	(33.21)	
T_1D_{50}	43.33^{d}	43.33^{de}	46.67^{de}	46.67^{de}	46.67^{de}	III
	(41.15)	(41.15)	(43.08)	(43.08)	(43.08)	
T_1D_{75}	53.33^{cd}	56.67^{c}	46.67^{de}	56.67^{cd}	56.67^{cd}	III
	(46.92)	(48.85)	(43.08)	(48.85)	(48.85)	
T_1D_{100}	63.33^{bc}	66.67^{b}	66.67^{bc}	73.33^{ab}	73.33^{b}	IV
	(52.78)	(54.78)	(54.78)	(59.00)	(59.00)	
T_2D_{10}	23.33e	23.33^{f}	26.67^{f}	26.67^{g}	26.67^{f}	II
	(28.78)	(28.78)	(31.00)	(31.00)	(31.00)	
T_2D_{25}	26.67^{e}	30.00	23.33^{f}	23.33^{g}	30.00^{f}	II
	(31.00)	(33.21)	(28.78)	(28.78)	(33.21)	
T_2D_{50}	46.67^{d}	43.33^{de}	46.67^{de}	43.33^{ef}	43.33^{e}	III
	(43.08)	(41.15)	(43.08)	(41.15)	(41.15)	
T_2D_{75}	53.33^{cd}	56.67^{c}	56.67^{cd}	63.33^{bc}	63.33^{c}	III
	(46.92)	(48.85)	(48.85)	(52.78)	(52.78)	
T_2D_{100}	76.67^{a}	83.33^{a}	83.33^{a}	83.33^{a}	86.67^{a}	V
	(61.22)	(66.14)	(66.14)	(66.14)	(68.86)	
T_3D_{10}	23.33^{e}	23.33^{f}	23.33^{f}	26.67^{g}	26.67^{f}	II
	(28.78)	(28.78)	(28.78)	(31.00)	(31.00)	
T_3D_{25}	26.67^{e}	26.67^{f}	26.67^{f}	33.33^{fg}	26.67^{f}	II
	(31.00)	(31.00)	(31.00)	(35.22)	(31.00)	
T_3D_{50}	43.33^{d}	40.00^{e}	40.00^{e}	43.33^{ef}	40.00^{e}	III
	(41.15)	(39.23)	(39.23)	(41.15)	(39.23)	
T_3D_{75}	53.33^{cd}	50.00^{cd}	50.00^{de}	56.67^{cd}	56.67^{cd}	III
	(46.92)	(45.00)	(45.00)	(48.85)	(48.850	
T_3D_{100}	73.33^{ab}	73.33^{b}	70.00^{b}	76.67^{a}	80.00^{a}	IV
	(59.00)	(59.00)	(56.79)	(61.71)	(63.93)	
T_0D_{10}	13.33^{f}	10.00^{g}	13.33^{g}	13.33^{h}	13.33^{g}	I
	(21.14)	(18.43)	(21.14)	(21.14)	(21.14)	
T_0D_{25}	13.33^{f}	10.00^{g}	13.33^{g}	13.33^{h}	13.33^{g}	I
	(21.14)	(18.43)	(21.14)	(21.14)	(21.14)	
T_0D_{50}	13.33^{f}	10.00^{g}	13.33^{g}	13.33^{h}	13.33^{g}	I
	(21.14)	(18.43)	(21.14)	(21.14)	(21.14)	
T_0D_{75}	13.33^{f}	10.00^{g}	13.33^{g}	13.33^{h}	13.33^{g}	I
	(21.14)	(18.43)	(21.14)	(21.14)	(21.14)	

T_0D_{100}	13.33[f]	10.00[g]	13.33[g]	13.33[h]	13.33[g]	I
	(21.14)	(18.43)	(21.14)	(21.14)	(21.14)	
SEm±	**3.33**	**2.89**	**3.50**	**3.50**	**3.25**	
$CD_{(P=0.05)}$	**9.53**	**8.25**	**9.99**	**9.99**	**9.29**	

Note: Data in parenthesis are transformed to angular values.
Within column values followed by similar letter(s) are statistically at par by DMRT

Table 6. Repellency effect of different plant extracts and doses against pulse beetle, *Callosobruchus chinensis* with distilled water solution

Treatments	**Repellency rateagainst pulse beetle, *Callosobruchus chinensis* (%)**					**Repellency class**
	1 hour	***2 hours***	***3 hours***	***4 hours***	***5 hours***	
Plant extracts						
Jatropha curcas: T_1	43.33[a] (40.97)	46.00[a] (42.60)	42.67[b] (40.54)	46.00a (42.66)	48.67[b] (44.27)	III
Litsea citrata: T_2	46.00[a] (42.64)	46.00[a] (42.70)	46.67[ab] (43.16)	50.00[a] (45.32)	54.00[a] (47.83)	III
Piper nigrum: T_3	43.33[a] (40.91)	44.67[a] (41.76)	48.00[a] (43.75)	50.00[a] (45.18)	51.33[ab] (46.03)	III
Untreated (Control): T_0	19.72[b] (23.86)	27.61[b] (28.78)	23.67[c] (26.57)	23.67[b] (26.47)	27.61[c] (28.78)	II
SEm±	**1.56**	**1.76**	**1.73**	**1.53**	**1.56**	
$CD_{(P=0.05)}$	**4.47**	**5.04**	**4.95**	**4.37**	**4.47**	
CV	**17.05**					
Doses						
D_{10}	23.33[c] (28.66)	27.50[d] (31.50)	25.00[d] (29.84)	25.83[d] (30.27)	30.00[d] (33.05)	I
D_{25}	25.00[c] (29.71)	27.50[d] (31.45)	28.33[d] (31.95)	30.00[d] (33.05)	30.83[d] (33.61)	I
D_{50}	38.33[b] (37.79)	38.33[c] (38.04)	38.33[c] (37.97)	40.00[c] (38.95)	41.67[c] (39.98)	II
D_{75}	44.17[b] (41.16)	46.67[b] (42.87)	45.00[b] (41.83)	46.67[b] (42.79)	52.50[b] (46.30)	III
D_{100}	55.83[a] (48.16)	60.00[a] (50.95)	60.00[a] (50.95)	65.00[a] (54.46)	66.67[a] (55.70)	IV
SEm±	**2.02**	**2.28**	**2.24**	**1.97**	**2.02**	
$CD_{(P=0.05)}$	**5.77**	**6.51**	**6.39**	**5.64**	**5.77**	
CV	**17.05**					

Note: Data in parenthesis are transformed to angular values.
Within column values followed by similar letter(s) are statistically at par by DMRT

Table 7. Interaction of repellency effect of different plant extracts and dose against pulse beetle, with distilled water solution

Plant extracts x Doses Interaction (T x D)	**Repellency rateagainst pulse beetle, *Callosobruchus chinensis* (%)**					**Repellency Class**
	1 hour	***2 hours***	***3 hours***	***4 hours***	***5 hours***	
T_1D_{10}	26.67^{e} (31.00)	33.33^{ef} (35.22)	23.33^{h} (28.78)	26.67^{e} (31.00)	33.33^{gh} (35.22)	II
T_1D_{25}	30.00^{e} (33.00)	30.00^{f} (33.00)	30.00^{gh} (33.00)	33.33^{de} (35.22)	33.33^{gh} (35.22)	II
T_1D_{50}	43.33^{d} (41.15)	43.33^{de} (41.15)	43.33^{ef} (41.15)	46.67^{c} (43.08)	46.67^{ef} (43.08)	III
T_1D_{75}	53.33^{cd} (46.92)	56.67^{bc} (48.85)	50.00^{de} (45.00)	50.00^{bc} (45.00)	56.67^{de} (48.85)	III
T_1D_{100}	63.33^{bc} (52.78)	66.67^{ab} (54.78)	66.67^{bc} (54.78)	73.33^{a} (59.00)	73.33^{bc} (59.00)	IV
T_2D_{10}	26.67^{e} (31.00)	30.00^{f} (33.21)	30.00^{gh} (33.00)	33.33^{de} (35.22)	36.67^{fg} (37.22)	II
T_2D_{25}	26.67^{e} (31.00)	30.00^{f} (33.00)	33.33^{fg} (35.22)	33.33^{de} (35.22)	33.33^{gh} (35.22)	II
T_2D_{50}	46.67^{d} (43.08)	40.00^{de} (39.15)	40.00^{efg} (39.15)	43.33^{cd} (41.15)	46.67^{ef} (43.08)	III
T_2D_{75}	53.33^{cd} (46.92)	53.33^{cd} (46.92)	50.00^{de} (45.00)	56.67^{bc} (48.85)	66.67^{cd} (54.78)	III
T_2D_{100}	76.67^{a} (61.22)	76.67^{a} (61.22)	80.00^{a} (63.43)	83.33^{a} (66.14)	86.67^{a} (68.86)	V
T_3D_{10}	23.33^{e} (28.78)	23.33^{f} (28.78)	26.67^{h} (31.00)	23.33^{ef} (28.78)	26.67^{h} (31.00)	II
T_3D_{25}	26.67^{e} (31.00)	26.67^{f} (31.00)	30.00^{gh} (33.00)	33.33^{de} (35.22)	33.33^{gh} (35.22)	II
T_3D_{50}	46.67^{d} (43.08)	46.67^{cd} (43.08)	50.00^{de} (45.00)	50.00^{bc} (45.00)	50.00^{e} (45.00)	III
T_3D_{75}	53.33^{cd} (46.92)	53.33^{cd} (46.92)	60.00^{cd} (50.77)	60.00^{b} (50.77)	63.33^{cd} (52.78)	III
T_3D_{100}	66.67^{ab} (54.78)	73.33^{a} (59.00)	73.33^{ab} (59.00)	83.33^{a} (66.14)	83.33^{ab} (66.14)	IV
T_0D_{10}	16.67^{f} (23.86)	23.33^{f} (28.78)	20.00^{h} (26.57)	20.00^{e} (26.07)	23.33^{h} (28.78)	II
T_0D_{25}	16.67^{f} (23.86)	23.33^{f} (28.78)	20.00^{h} (26.57)	20.00^{e} (26.57)	23.33^{h} (28.78)	II
T_0D_{50}	16.67^{f}	23.33^{f}	20.00^{h}	20.00^{e}	23.33^{h}	II

	(23.86)	(28.78)	(26.57)	(26.57)	(28.78)	
T_0D_{75}	16.67[f] (23.86)	23.33[f] (28.78)	20.00[h] (26.57)	20.00[e] (26.57)	23.33[h] (28.78)	II
T_0D_{100}	16.67[f] (23.86)	23.33[f] (28.78)	20.00[h] (26.57)	20.00[e] (26.57)	23.33[h] (28.78)	II
SEm±	**3.50**	**3.94**	**3.87**	**3.42**	**3.50**	
$CD_{(P=0.05)}$	**9.99**	**11.27**	**11.07**	**9.76**	**9.99**	

Note: Data in parenthesis are transformed to angular values.

Within column values followed by similar letter(s) are statistically at par by DMRT

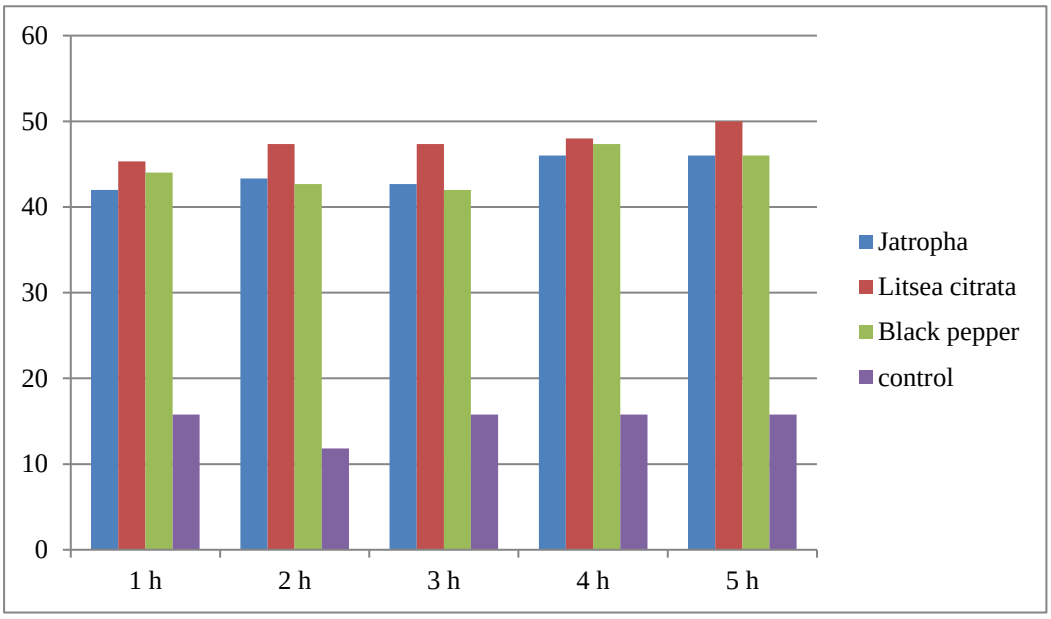

Figure 1. Repellency effect of different plant extracts against pulse beetle, *Callosobruchus chinensis* with acetone solution

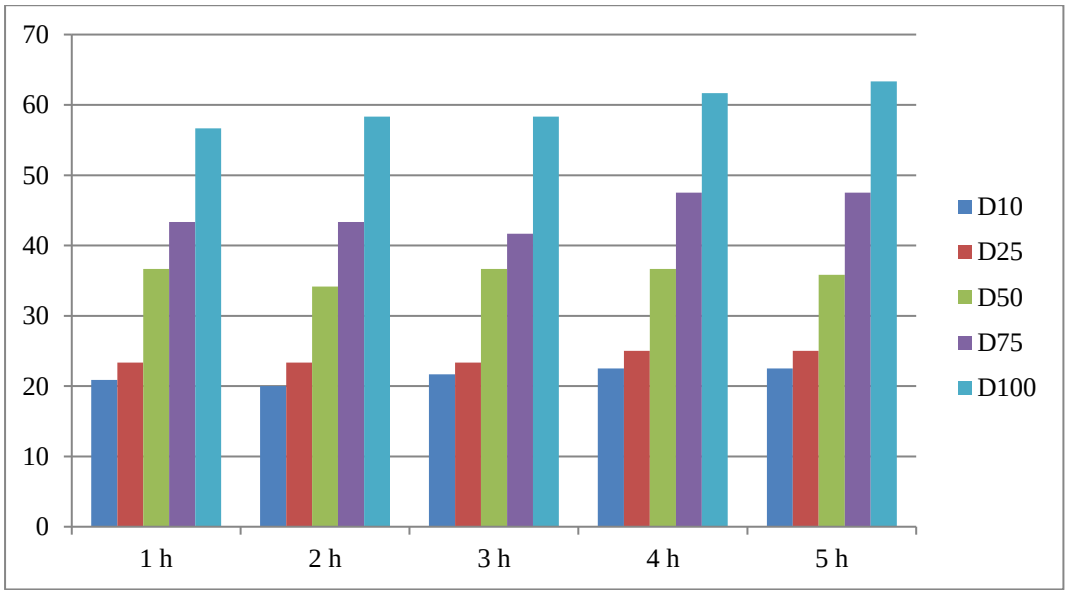

Figure 2. Repellency effect of different doses against pulse beetle, *Callosobruchus chinensis* with acetone solution

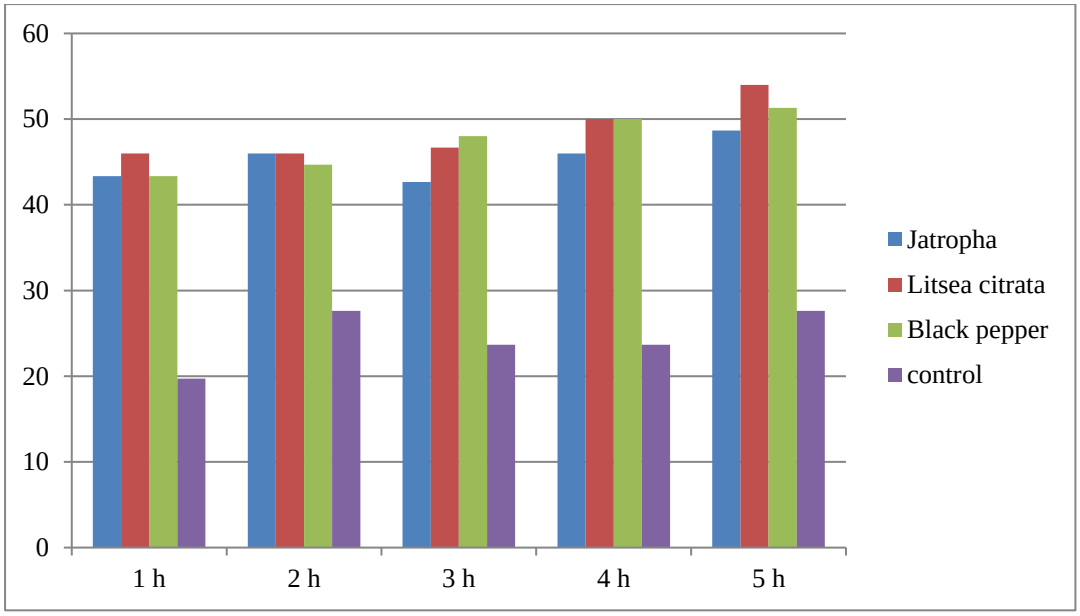

Figure 3. Repellency effect of different plant extracts against pulse beetle, *Callosobruchus chinensis* with distilled water solution

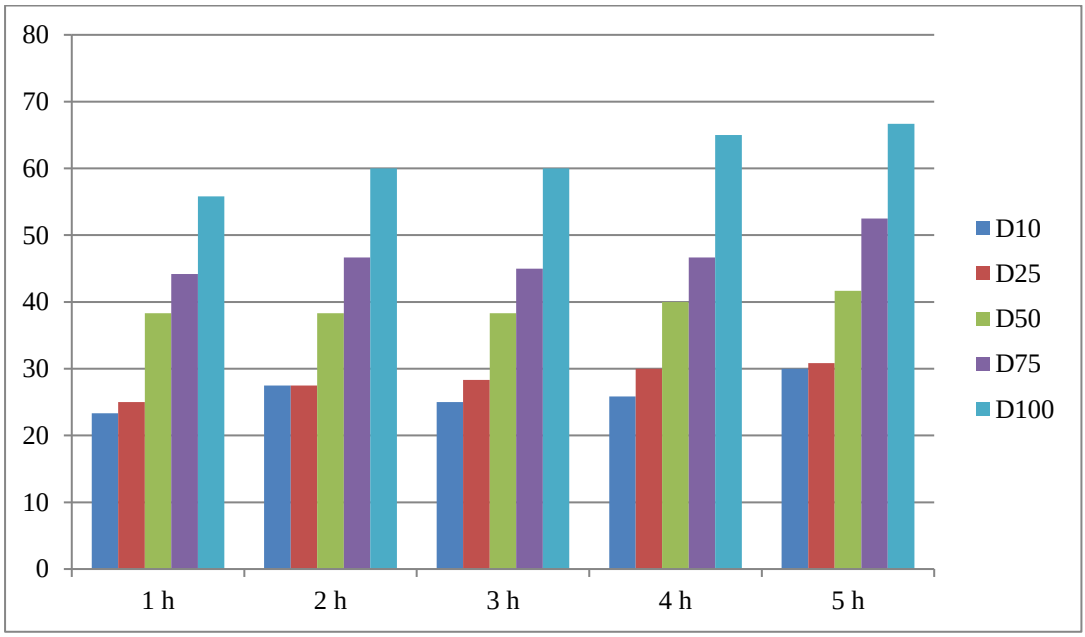

Figure 4. Repellency effect of different doses against pulse beetle, *Callosobruchus chinensis* with distilled water solution

4. Conclusions

It can be concluded that the indigenous plant *Litsea citrata* extracts can be utilised to repel pulse beetles from stored chickpea and other pulses as the study indicated that higher repellent effect was observed in *Litsea citrata* in comparison to *Piper nigrum* and *Jatropha curcas*. The distilled water plant extracts were found to be more effective than the acetone plant extracts and among the five different doses, the highest dose @ 100 mg/ml of all plant extracts showed the maximum repellent effect and repellency decreased proportionally with the decrease of doses.

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