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Effect of different locally available botanicals against stored cocoon pest, Dermestid Beetle

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Abstract
The study was conducted to evaluate the effect of different locally available botanicals on the mortality percentage, repellency, antifeeding effect and emergence of Dermestid species. The test botanicals were screened at different concentrations (5%, 10% and 20%) at different time intervals. The treatment details were T_1 (5% *Capsicum annum*), T_2 (10% *Capsicum annum*), T_3 (20% *Capsicum annum*), T_4 (5% *Artemesia absinthium*), T_5 (10% *Artemesia absinthium*), T_6 (20% *Artemesia absinthium*), T_7 (5% *Datura stramonium*), T_8 (10% *Datura stramonium*), T_9 (20% *Datura stramonium*), T_{10} (5% *Pyrethrum*), T_{11} (10% *Pyrethrum*), T_{12} (20% *Pyrethrum*) and T_{13} (Control). Significantly the highest mortality percentage (97.83%) was recorded in T_3 (20% *Capsicum annum*) followed by T_{12} (20% *Pyrethrum*) with mortality percentage of 81.93 percent at 72 hours after treatment and the lowest mean mortality percentage (13.33%) was found in T_{13} (control) at 72 hours after treatment. The maximum mean repellency (40.21%) was observed in T_3 (20% *Capsicum annum*) followed by T_{12} (20% *Pyrethrum*) with the mean repellency of 35.27 percent and the minimum mean repellency (5.37%) was observed in T_{13} (control). Significantly the maximum antifeeding effect of treated silkworm pupae was observed in T_3 (20% *Capsicum annum*) followed by T_{12} (20% *Pyrethrum*) and the minimum anti feeding effect was found in T_{13} (control). The grubs treated with B1 (*Capsicum annum*) have shown significantly zero emergence percentage at all the concentrations (5%, 10% and 20%). However B4 (*Pyrethrum*) at 20 percent concentration did not differ significantly with B1 (*Capsicum annum*) at 20 percent concentration. From the above findings, it is concluded that the extract of *Capsicum annum* in the best bio-insecticide, it has the highest repellent and toxic effect against Dermestid species. Thus the application of eco-friendly and locally available *Capsicum annum* extract for disinfection of cocoon storage rooms/ bags can help the silkworm rearers/ reelers to reduce the post storage loss of silkworm cocoons.

Keywords: Silkworm, Cocoons, dermestid beetles, botanicals, Mortality, repellency and emergence.

Introduction
Sericulture is an agro-based cottage industry which requires lowest investment and has high employment generation capacity. This activity generates high income which helps rural masses for improving their economic position (Hiware, 2001) [8]. Asia is the major producer of silk in the world and produces over 98.5 percent of the global output, although there are more than forty countries on the world silk map, but the bulk of silk comes from China and India followed by Brazil, Uzbekistan, Thailand, Vietnam, Korea and Japan (Bhat, 2014) [4]. India has a unique distinction of cultivating all the four types of silks which are commercially known varieties of natural fibers *viz*., Mulberry, Tasar, Eri and Muga. Among them, the mulberry silk is produced by the mulberry silkworm, *Bombyx mori* L. and it occupies a giant share of country's raw silk production. Mulberry sericulture is mainly practiced in five states namely, Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir, which jointly account for about 96.37 percent of the total mulberry raw silk production in the country.
Sericulture is an agro-based industry. It involves Cultivation of mulberry Plants and rearing of Silkworms for the production of raw silk. Sericulture provides gainful employment, economic development and improvement in the quality of life to the people in rural areas and therefore it plays an important role in antipoverty programme and prevents migration of rural people to urban areas in search of employment.

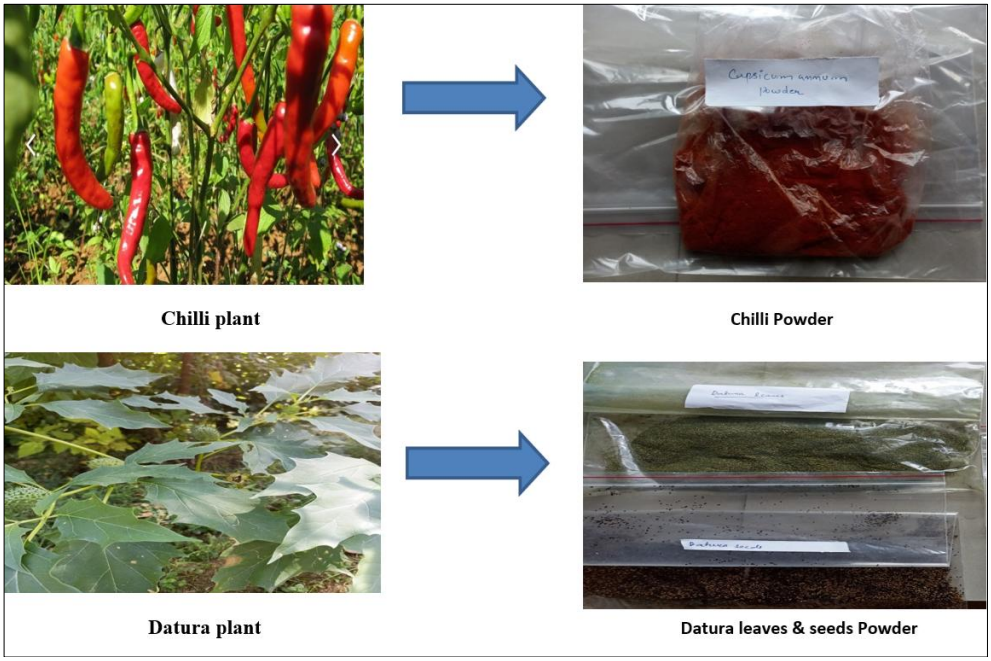
In Jammu and Kashmir sericulture is a subsidiary occupation and is mainly practiced in spring season and the cocoons are sold after a period of storage as there is no ready market available. So during this period of storage cocoons are attacked by a number of insect and non-insect pests. Among various insect pests dermestid beetles are of particular importance, posing a great threat to silk industry. The dermestid beetles mainly damage stifled and stored cocoons, raw silk and silk fabrics. In grainages the dermestid beetles damage live cocoons kept for production of new generation of moths, seed (silkworm eggs) and live caterpillars. Exceptionally *Dermestes maculatus* Degeer was reported in Italy as a vector of pebrine disease of silkworm caused by *Nosema bombycis* Nageli (Candura, 1931) [5]. Hinton (1945) [7] recorded 19 species of Dermestidae as pests of silkworm in India. Thiagarajan and Govindaiah (1987) [19] reported 20 percent loss in a Mysore grainage due to this pes. The reelers purchase a huge quantity of cocoons from the farmers from the market occurring only once in a year and store it for a period of 8 to 10 months before further processing hence, encounter a great economic loss due to the dermestid beetle attack. In silk industry, the chemical insecticides like Deltamethrin solution helps to reduce the pest infestation. Fumigation with Methyle Bromide (0.5g/3m2) effective in controlling the pest. Chemical insecticides can also be used against dermestid beetle but the associated risks involved like cost, poisoning, other health issues and environmental pollution etc overweigh the benefits. In order to reduce those risks exploration of naturally occurring plant material has achieved paramount importance in pest and disease management. The importance of research on eco-friendly, natural and biological source have been realized in recent years due to hazards of toxic chemicals on human beings and animals, that are being used in management of diseases and pests (Jagannanthan and Narasimhan, 1988) [9]. Use of botanicals for stored cocoon and other silk products are non-toxic, biodegradable and non-pollutant and will serve as an alternative strategy for management of post-harvest pests in sericulture. Thus the present investigation was undertaken to evaluate the effect of locally available botanicals on mortality, repellency, emergence and antifeeding effect of dermestid beetles.

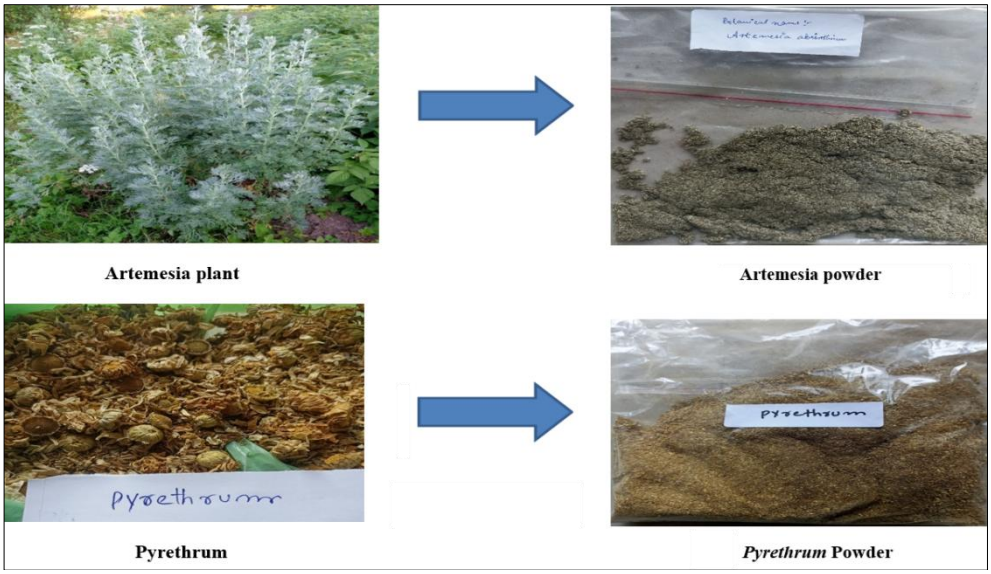
Material and Methods

The present investigation was carried out in Laboratory of Division of Cocoon Crop Production at College of Temperate Sericulture, Mirgund

Botanicals used during present study:

S. No.	Botanicals to be used	Common name	Family	Part to be used	Active ingredients present
1.	*Capsicum annum*	Chilli	Solanaceae	Berry	Capsaicin
2.	*Artemesia absinthium*	Tethwaan	Asteraceae	Leaves	α – Thujone
3.	*Datura stramonium*	Datura	Solanaceae	Seeds	Atropine, Scopolamine, Hyoscyamine
4.	*Pyrethrum*	Daisy/ chamomile	Asteraceae	Flowers	Pyrethrin I&II, Cinerin I&II and Jasmolin I&II





Culturing of dermestid beetle:
The dermestid beetles were collected from naturally infested cocoons from reeling units /fields/cocoon banks etc and were mass reared on silkworm pupae in insect cages. To have new progenies cotton wool was placed in each jar to induce oviposition. After incubation the dermestid grubs were used for the study.

Collection and processing of material:
The plants were collected in their fresh form then washed with water to remove the adhering material like dust. The material was shade dried and later on dried in hot air electric oven at 60°C till it attained a constant weight and was fit to be powdered, then was powered separately with the help of a mixer. Ten grams from each of the sample (powder) was taken and mixed with 100 ml acetone. The mixture was stirred for 30 minutes by a magnetic stirrer (at 3000 rpm) and left for 24 hours at room temperature. The mixture was filtered through a fine cloth before filtering through Whatman No. 1 filter paper. The filtrate was taken into a round bottom flask and condensed by evaporation of the solvent in a water bath at 45°C temperature so as to obtain a volume of 10 ml. The extracts were then preserved in an airtight bottle labelled and stored in refrigerator for future use.

Preparation of stock solution:
Stock solution of plants extracts was prepared separately by diluting the plant extracts with the distilled water to get desired concentrations viz; 5, 10 and 20 percent.

Method of application of prepared stock solution:
For each experiment per treatment per replication 15 grubs were released into each cage containing 30 pupae. The openings of the plastic cages were secured with netting material. Desired concentration of prepared solution was applied to the grubs. Each treatment was replicated three times and the number of dead grubs was counted after 24 hours, 48 hours and 72 hours to determine the mortality rate of dermestid beetle grubs.

Repellence test:
This was conducted as per (Akinwumi *et al*., 2007) [2]. Plastic containers approx. of 25x12x10 cm were used for the investigation on repellency. An aliquot of different concentrations of each of the plant extracts was rubbed thoroughly on the skin of pupal samples. The samples treated with each of the plant extract were placed separately at the center of each of the plastic container. This was immediately followed by the introduction of 15 dermestid grubs. The grubs used in this study were pre-starved for forty-eight hours before introducing them into the containers. Daily observations were made for five days immediately after application and the number of dermestid grubs found on and away from treated pupae were recorded. The average count was expressed as a percentage of repellency.

Observations recorded:
Corrected mortality:
For calculation of corrected mortality rate Abbott's formula was used

$$\text{Corrected mortality} = \frac{\text{Mortality in treatment-Mortality in control}}{\text{100-Mortality in control}} \times 100$$

Repellency test:
The data is expressed as percentage repulsion (PR%) by using the following scale described by Laudani *et al*. (1995) [11].

Class Repellency rate (%)

Class of repellency	Rate of repellency (%)
0	>0.01 to 0.1
I	0.1 to 20
II	20.1 to 40
III	40.1 to 60
IV	60.1 to 80
V	80.1 to 100

Weight loss of treated pupae:
The weight loss of treated pupae caused by dermestid beetles infestation was calculated by using the formula:

$$\text{Weight loss of treated pupae} = \frac{\text{Initial weight-final weight}}{\text{Initial weight}} \times 100$$

Emergence of treated grubs:
The adult emergence of treated grubs was calculated by using the formula:

$$\text{Adult emergence of treated grubs} = \frac{\text{No. of adults emerged}}{\text{Total No. of grubs treated}} \times 100$$

Results and Discussion

Mortality percentage

The results of mortality percentage of dermestid grubs at different hours, treated with different botanical extracts with different concentrations have been summarized in Table-1.

The application of different botanical formulations showed significant effect on the mean mortality percentage of dermestid grubs at different (HAT), ranged from (80.43-11.06) which was higher as compared to control group.The maximum mortality percentage, irrespective of the botanicals were observed at 20 percent concentration at 72 HAT (hours after treatment).Significantly the higher mortality percentage (97.83%) was observed in B1 (*Capsicum annum*) at 72 HAT followed by B4 (*Pyrethrum*) and B2 (*Artemesia absinthium*) with 81.93 and 53.83 percent respectively. While as B3 (Datura stramonium) showed 33.23 percent mortality. However the lowest mortality percentage 13.33 percent was recorded in control group. During the present study, in B4 (*pyrethrum*) the rectal protrusion was noticed in some of the treated grubs.

However the grubs treated with each of the tested botanical became paralyzed immediately after the application and turned black before their death. The extract of B1 (*Capsicum annum*) recorded the fastest action in killing and kills (80.16%) of the dermestid grub population within 24 hours of treatment even at 5 percent concentration while as the B3 (Datura stramonium) extract was the least toxic to the dermestid grubs even at increased dose of 20 percent concentration.

This observation is in conformity with the studies of Nowsad *et al*. (2009) [13] who reported the higher mortality percentage of adults of dermestid species treated with red chili when compared to neem and garlic extracts. He further reported that mortality percentage increased with an increase in time and concentration. This study is also in harmony with the results of Saranya *et al*. (2019) [16] who reported (33.33% to 56.67%) mortality of *Dermestesater* grubs on application of plant extracts of various botanicals. He also reported that mortality percentage increased significantly with an increase in time and concentration. In *Capsicum annum* highest mortality might be due to the presence of Capsaicin as reported by Antonious *et al* (2006) [3].

In the present study the toxic effects like rectal protrusion was also observed in some of the *Pyrethrum* treated grubs. The insecticidal activity of *Pyrethrum* is due to the presence of esters called pyrethrins which includes the pyrethrin I & II as reported by Wenli *et al* (2020) [18] and the dermestid grubs became paralyzed immediately after the application and turned black before their death. These observations are in line with the observations of Copping (2001) [6] who reported that, in insects Capsaicin toxicity appears to be through metabolic disruption, membrane damage and nervous system disfunction. The increased mortality percentage in *Artemesia absinthium*when compared to the control might be due to the main active ingredients present in *Artemesia absinthium i.e.* α- Thujone and β- Thujone as reported by Vourch *el al* (2002) [20], Maia *et al* (2011) [12], Rojht *et al* (2009) [15] and Sener *et al* (2009) [17]. The increased mortality percentage in *Datura stramonium* when compared to the control might be due to active ingredients present in its seed extracts as reported by Abbasipour *et al* (2011b) [1].

Table 1: Mortality percentage of dermestid beetle grubs caused by different botanicals at different HAT (hours after treatment)

Botanicals	Treatments	Mortality of grubs (%) after treatment (Durations hours)			Mean
		24	48	72	
B1: *Capsicum annum*	T_1 (5%)	80.16 (63.52)	80.53 (63.79)	80.60 (63.84)	80.43
	T_2 (10%)	82.23 (65.13)	80.83 (64.01)	82.06 (64.92)	81.70
	T_3 (20%)	92.36 (73.98)	95.10 (77.24)	97.83 (81.68)	95.09
Sub mean		84.91 (67.54)	85.48 (68.34)	86.83 (70.14)	85.74
B2: *Artemesia absinthium*	T_4 (5%)	20.00 (26.55)	13.23 (21.32)	27.00 (31.29)	20.07
	T_5 (10%)	20.93 (27.21)	13.26 (21.35)	33.23 (35.18)	22.47
	T_6 (20%)	52.43 (46.37)	45.73 (42.53)	53.83 (47.17)	50.66
Sub mean		31.12 (33.37)	24.07 (28.4)	38.02 (37.88)	31.06
B3: *Datura stramonium*	T_7 (5%)	6.66 (14.91)	13.10 (21.20)	13.43 (21.49)	11.06
	T_8 (10%)	13.26 (21.35)	13.66 (21.68)	19.96 (26.52)	15.62
	T_9 (20%)	25.70 (30.44)	33.16 (35.14)	33.23 (35.18)	30.69
Sub mean		15.19 (22.23)	19.97 (26.00)	22.20 (27.73)	19.12
B4: *Pyrethrum*	T_{10} (5%)	33.03 (35.06)	40.33 (39.41)	46.06 (42.72)	39.80
	T_{11} (10%)	33.60 (35.41)	53.23 (46.83)	53.43 (46.94)	46.75
	T_{12} (20%)	73.96 (59.29)	82.60 (65.39)	81.93 (64.84)	79.49
Sub mean		46.85 (43.25)	58.72 (50.58)	60.47 (51.5)	55.35
Control	T_{13} (acetone)	0.00	6.66	13.33	6.66
C.D ($p \leq 0.05$)					
	Botanicals (B): 0.524	Factor means			
	Conc. (C):0.453	Botanicals	Conc.	Duration	
	Duration (t):0.453	B1: 85.74 (68.68)	C1:37.84 (37.09)	T_1: 44.52 (41.06)	
	BxC:0.907	B2: 31.06 (33.22)	C2:41.64 (39.71)	T_2: 47.06 (43.32)	
	Bxt: 0.907	B3: 19.12 (25.33)	C3:63.99 (54.94)	T_3: 51.88 (46.82)	
	Cxt: 0.726	B4: 55.35 (48.83)			
	BxCxt: 1.572				

Values in parenthesis are arc sine transformed values

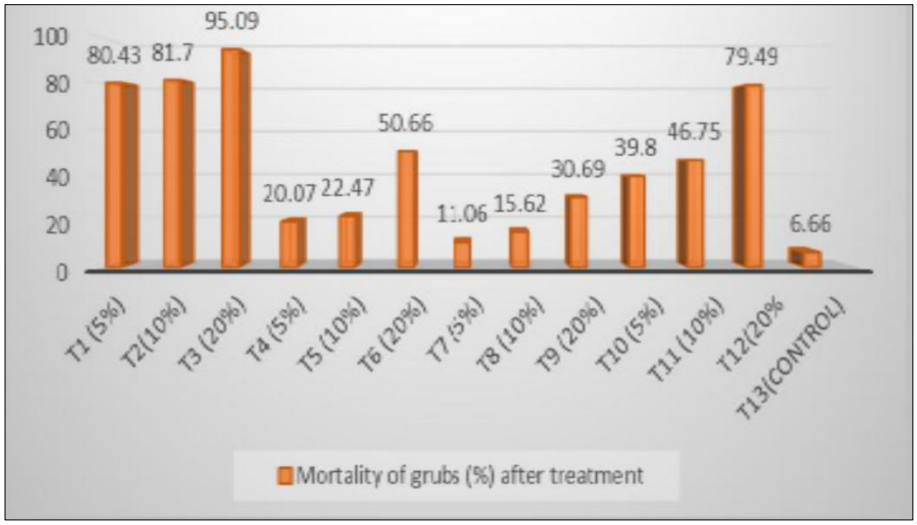


Fig 1: Mortality percentage of dermestid beetle grubs caused by different botanicals at different HAT (hours after treatment) T_1-T_3 = B1 (*Capsicum annum*) T_4-T_6= B2 (*Artemesia absinthium*) T_7-T_9=B3 (*Datura stramonium*) T_{10}-T_{12}= B4 (*Pyrethrum*)

Repellency percentage

The results of repellency percentage of dermestid grubs are summarized in table-2.

After the release of dermestid grubs on the silkworm pupae treated with different botanical extracts. The dermestid grubs repelled much more rapidly from the treated pupae then the control. There was a significant difference in repellency percentage of dermestid grubs from the beginning to the end i.e. from day 1st to day 5th after application of different botanical extracts in all the treatment groups when compared to control.

The repellency percentage increased progressively with increasing concentration but decreased with time of exposure in all the four tested botanicals. Significantly, the repellency effect of botanical extracts on dermestid grubs was higher in 20 percent *Capsicum annum* extract from day 1st to day 5th (42.13%-37.56%) followed by *Pyrethrum* (35.90%-35.03%) and *Artemesia absinthium* (32.66%-32.03%). The lowest repellency percentage was recorded on control (6.03%-4.83%), followed by *Datura stramonium* (32.83%-30.83%) from day 1st-day 5th of treatment.

On the basis of mean repellency, the repellency class for *capsicum annum* at 20 percent concentration came to be class III while as *Artemesia absinthium, Datura stramonium and Pyrethrum* came under class II of repellency.

These results are in line with the earlier reports of Nowsad *et al*. (2009) [13] who reported significant repulsion percentage i.e. 38.44 percent in red chili, followed by neem (62.67%) and garlic (33.33%) when compared to control. These results are also in harmony with the findings of Luke *et al.* (2018) [14] who reported the significant repulsion percentage of dermestid grubs in all the tested botanicals when compared with the control.

In *Capsicum annum* highest repulsion percentage might be due to presence of Capsaicin as reported by Antonious *et al*. (2006) [3]. The results of repulsion percentage of dermestid grubs increased progressively with increase in concentration and decreased with the increase in time in all the tested botanical extracts. These results correlate well with the earlier reports of Nowsad *et al.* (2009) [13] and Luke *et al.* who reported significantly higher repulsion percentage of dermestid beetle in botanical treated batches with increase in concentration and the percentage of repulsion decrease with the increase in the time of exposure when compared with the control.

Significantly the increased repellency percentage of dermestid grubs in all the tested botanical extracts might be due to the smell of repellent compounds present in them as reported by Sener *et al* (2009) [17].

Therefore due to the smell of repellent compounds the grubs accelerate their moment away from the treated silkworm pupae.

Table 2: Repellency percentage of dermestid grubs influenced by different botanical extracts

Botanicals	Treatments	Repellency percentage					Mean repellency	RepellencyClass
		Day1	Day2	Day3	Day4	Day5		
Capsicum annum	T_1(5%)	37.67(6.21)	29.33(5.52)	29.33(5.52)	28.50(5.42)	24.86(5.80)	29.93	II
	T_2(10%)	36.86(6.15)	35.93(6.07)	35.20(6.01)	32.83(5.81)	32.16(5.75)	34.59	II
	T_3(20%)	42.13(6.56)	42.13(6.56)	41.06(6.48)	38.20(6.26)	37.56(6.21)	40.21	III
Artemesia absinthium	T_4(5%)	24.23(5.02)	22.33(4.83)	22.06(4.80)	20.60(4.64)	20.06(4.80)	21.88	II
	T_5(10%)	25.03(5.10)	24.43(5.04)	23.90(4.98)	23.73(4.97)	22.00(4.79)	23.81	II
	T_6(20%)	32.66(5.79)	32.36(5.77)	32.10(5.75)	32.03(5.74)	32.03(5.74)	32.23	II
Datura stramonium	T_7(5%)	15.76(4.09)	15.76(4.09)	15.16(4.02)	15.00(4.00)	14.76(3.97)	15.28	I
	T_8(10%)	25.96(5.19)	25.33(5.13)	25.00(5.09)	24.76(5.07)	24.43(5.04)	25.09	II
	T_9(20%)	32.83(5.81)	32.03(5.74)	31.76(5.72)	30.83(5.64)	30.83(5.64)	31.66	II
Pyrethrum	T_{10}(5%)	31.16(5.76)	28.76(5.63)	28.56(5.61)	28.23(5.58)	24.60(5.53)	28.26	II
	T_{11}(10%)	33.00(5.83)	32.36(5.77)	32.36(5.77)	32.06(5.75)	31.46(5.69)	32.24	II
	T_{12}(20%)	35.90(6.07)	35.36(6.03)	35.03(6.00)	35.03(6.00)	35.03(6.00)	35.27	II
Control(100%acetone)	T_{13}	6.03(2.65)	5.50(2.54)	5.50(2.54)	5.00(2.44)	4.83(2.41)	5.372	I
C.D ($p \leq 0.05$)								

	Botanicals (B) : 0.042
	Conc. (C): 0.036
	Duration (t): 0.047
	BxC: 0.073
	Bxt: 0.094
	Cxt: 0.081
	BxCxt: 0.163

Values in parenthesis are sq. root transformed values

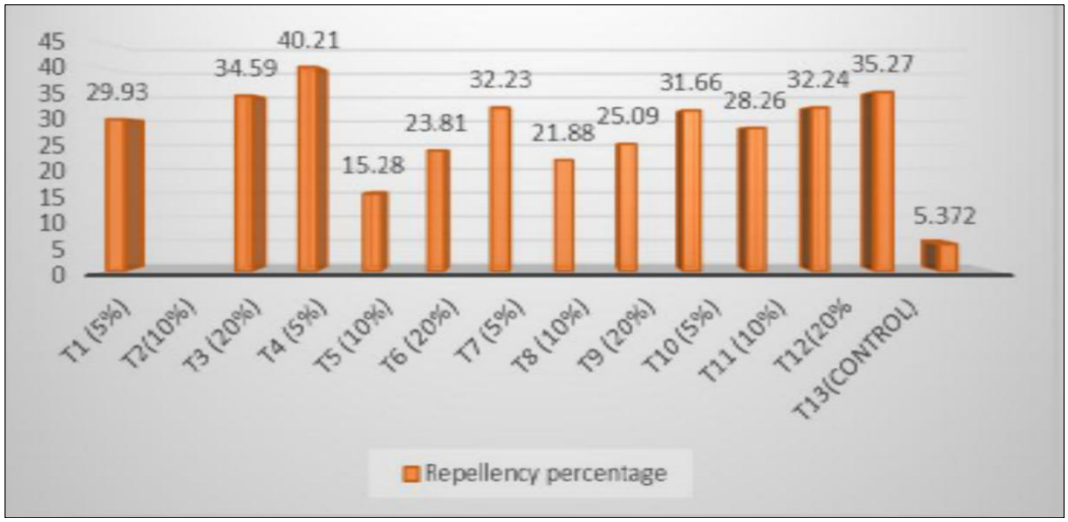


Fig 2: Repellency percentage of Dermestid grubs influenced by different botanical extracts T_1-T_3 = B1 (*Capsicum annum*) T_4-T_6= B2 (*Artemesia absinthium*) T_7-T_9=B3 (*Datura stramonium*) T_{10}-T_{12}= B4 (*Pyrethrum*

Weight loss of treated silkworm pupae

The results of the plant extracts on the weight loss percentage of treated silkworm pupae have been summarized in table-3.

The weight loss percentage of treated silkworm pupae due to dermestid grubs infestation ranged from (5%-41.83%).

The application of selected botanical extracts on silkworm pupae resulted significant decrease in the weight loss caused by feeding of dermestid grubs. The weight loss percentage of treated silkworm pupae decreased gradually with increase in concentration of botanical extracts in all the tested botanicals.

At 5% concentration, significant difference was observed in B1, B2, B3 and B4, when compared to control. The least weight loss percentage of silkworm pupae caused by the dermestid grub infestation was recorded in B1 (*Capsicum annum*) i.e.11.0 percent followed by B4 (*Pyrethrum*) i.e.13.00 percent. The highest weight loss was recorded in control group of silkworm pupae (41.83%) followed by B2 (*Artemesia absinthium*) and B3 (*Datura stramonium*) i.e.18.83 and 18.16 percent respectively.

At 10 percent concentration significant difference was also observed in all the four botanicals used in the study when compared to the control. However B2 (*Artemesia absinthium*) and B3 (*Datura stramonium*) did not differ significantly from each other.

Significantly the effect of botanical extracts on weight loss was highest at 20% of concentration in B1 (*Capsicum annum*) with a loss of 5.00 percent followed by B4 (*Pyrethrum*) i.e.8.50 percent. The highest weight loss was recorded in control group i.e. 41.83 percent followed by B2 (*Artemesia absinthium*) i.e.12.00 percent and B3 (*Datura stramonium*) i.e.11.50 percent.

The results related to the decreased weight loss of treated silkworm pupae are in harmony with the earlier findings of Luke *et al*. (2018) [14] and Keeler (1999) [10] who reported that application of botanical extracts on smoked cat fish significantly decreased the weight loss percentage caused by *Dermestes maculatus*.

The results of decreased weight loss in treated silkworm pupae were significantly lower with increase in concentration in all the tested botanicals when compared to control. Similar results regarding decreased weight loss of treated silkworm pupae with increase in concentration have been observed earlier also by Luke *et al.* (2018) [14] and Keeler (1999) [10]. The decreased weight loss of treated silkworm pupae fed to dermestid grubs might be due to primary and secondary antifeedant effect of the botanicals as reported earlier by Keelar (1999) [10].

Table 3: Weight loss of treated silkworm pupae caused by dermestid grubs

Botanicals \ Conc. (%)	Weight loss (%)			
	B1(*Capsicum annum*)	**B2(*Artemesia absinthium*)**	**B3 (*Datura stramonium*)**	**B4 (*Pyrethrum*)**
5	11.00 (3.46)	18.83 (4.46)	18.16 (4.37)	13.00 (3.74)
10	8.00 (2.99)	11.00 (3.46)	11.00 (3.46)	10.83 (3.43)
20	5.00 (2.44)	12.00 (3.60)	11.50 (3.53)	8.50 (3.07)
Control (100% acetone)	41.83 (6.54)	41.83 (6.54)	41.83 (6.54)	
Factor mean (botanicals)	16.45 (3.86)	20.91 (4.51)	20.62 (4.47)	18.54 (4.20)
Factor mean (conc.)	15.25 (4.00)	10.20 (3.34)	9.25 (3.16)	41.83 (6.54)
C.D ($p \leq 0.05$)				
	Botanicals (B): 0.1018			
	Conc. (C): 0.1018			
	BxC: 0.2037			

Values in parenthesis are sq. root transformed values

Fig 3: Weight loss of treated silkworm pupae caused by Dermestid grubs T_1-T_3 = B1 (*Capsicum annum*) T_4-T_6= B2 (*Artemesia absinthium*) T_7-T_9=B3 (*Datura stramonium*) T_{10}-T_{12}= B4 (*Pyrethrum*)

Emergence percentage of treated grubs

The results of the plant extracts on the emergence percentage of dermestid grubs have been summarized in table-4.

The emergence percentage of dermestid grubs treated with different botanical extracts ranged from (0.00-82.20%).

The application of selected botanical extracts on dermestid grubs resulted significant decrease in their emergence percentage. The emergence percentage of dermestid grubs decreased gradually with increase in concentration of botanical extracts in all the tested botanicals. However in case of B1 (*Capsicum annum*) in which there was zero emergence percentage at all the concentrations.

At 5% concentration, significant difference was observed in B1, B2, B3 and B4, when compared to control. The zero emergence percentage of dermestid grubs was recorded in B1 (*Capsicum annum*) followed by B4 (*Pyrethrum*) i.e. 25.03 percent. The highest emergence percentage was recorded in control group of Dermestid grubs (82.20%) followed by B3 (*Datura stramonium*) and B2 (*Artemesia absinthium*) i.e. 47.16 and 40.20 percent respectively.

At 10 percent concentration significant difference was also observed in all the four botanicals used in the study when compared to the control.

Significant effect of botanical extracts on emergence percentage was recorded at 20 percent concentration also in all the tested botanicals but in case of B1 (*Capsicum annum*), the zero emergence percentage was observed irrespective of the concentrations used. However, B1 (*Capsicum annum*) and B4 (*pyrethrum*) did not differ significantly from each other. The highest emergence percentage was recorded in control group i.e. 82.20 percent followed by B3 (*Datura stramonium*) i.e. 26.20 percent and B2 (*Artemesia absinthium*) i.e. 25.90 percent.

These results collaborate well with the earlier results of Keelar (1999) [10] and Luke *et al.* (2018) [14] who found significant difference in mortality of grub and adult emergence of *Dermestes maculatus* treated with the botanical extracts of *Afrostyraxkamerunensis*, *Monodoramyscistica*, *Moringa oleifera* and *Azadirachta indica*.

In the present study the emergence was totally inhibited in *Capsicum annum* treated batches at all the concentrations used and in *Pyrethrum* 100 percent adult emergence was also totally inhibited at 20 percent concentration. These results also coincide with the results of Luke *et al* (2018) [14] who reported zero percent emergence of *Dermestes maculates* in *Afrostyraxkamerunensis* and *Azadirachta indica* treated batches al all the concentrations used.s

The inhibition in adult emergence of dermestid beetle species treated with different botanical extracts might be due to insecticidal property of active ingredients of these tested botanicals, which causes metabolic disruption, membrane damage and nervous system dysfunction as reported by Copping (2001) [6].

Table 4: Emergence of dermestid grubs treated with different botanical extracts

Botanicals \ Concentration	Emergence (%)			
	B1 (*Capsicum annum*)	B2 (*Artemesia absinthium*)	B3 (*Datura stramonium*)	B4 (*Pyrethrum*)
5%	0.00 (1.00)	40.20 (6.64)	47.16 (6.93)	25.03 (5.10)
10%	0.00 (1.00)	39.96 (6.38)	41.06 (6.47)	12.76 (3.71)
20%	0.00 (1.00)	25.90 (5.18)	26.20 (4.80)	0.00 (1.00)
Control (100% acetone)	82.20 (9.11)	82.20 (9.11)	82.20 (9.11)	82.20 (9.11)
Factor mean (botanicals)	20.55 (3.02)	47.06 (6.77)	48.15 (6.83)	30.00 (4.73)
Factor mean (conc.)	28.10 (4.86)	23.45 (4.39)	12.02 (2.99)	82.20 (9.11)
C.D ($p \leq 0.05$)				
	Botanicals (B): 0.187			
	Conc. (C): 0.187			
	BxC: 0.375			

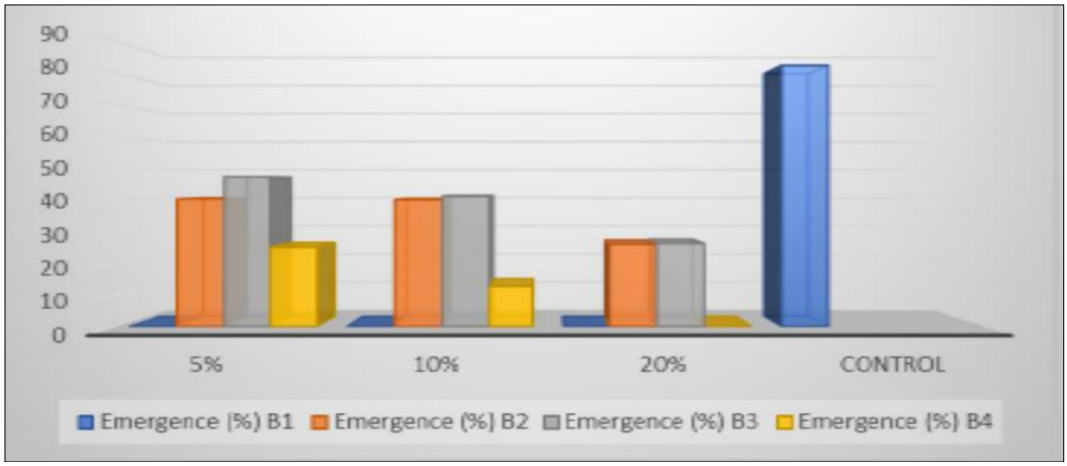


Fig 4: Emergence of Dermestid grubs treated with different botanical extracts T_1-T_3 = B1 (*Capsicum annum*) T_4-T_6= B2 (*Artemesia absinthium*) T_7-T_9=B3 (*Datura stramonium*) T_{10}-T_{12}= B4 (*Pyrethrum*)

Probit analysis of mortality percentage of grubs

The result of the probit analysis for the estimation of LC_{50} values and fiducial limits at 72 hours of treatment for the mortality of dermestid grubs are presented in table 5.

The LC_{50} value of *Capsicum annum*, *Artemesia absinthium*, *Datura stramonium* &*pyrethrum* were 0.44, 0.97, 1.13 & 0.5 ml per 10ml solution respectively at 72 hours after treatment, which indicates that *capsicum annum* was the most toxic against dermestid species. The application of 4.4% of *Capsicum annum* extract helps to kill 50% of the population of dermestid beetle species.

In the present investigation the LC_{50} values of *Capsicum annum*, *Artemesia absinthium*, *Datura stramonium* and *Pyrethrum* were 0.44, 0.97, 1.13 & 0.5 ml per 10ml of solution respectively at 72 hours after treatment, which indicates that *capsicum annum* was the most toxic to dermestid species. The results of LC_{50} are in line with the findings of Nowsad *et al* (2009) [13] who reported the lowest LC_{50} value i.e 1.11 percent in red chili followed by neem and garlic.

Table 5: Relative toxicity of different plant extracts against dermestid beetle grubs (at 72 hours after treatment)

Botanicals	No. of grubs used	Time of exposure in hrs.	X^2	LC_{50} values in ml/10ml	Fiducial limits
Capsicum annum	15	72	0.43	0.44	0.10-0.59
Artemesia absinthium	15	72	0.420	0.97	0.47-1.82
Datura stramonium	15	72	0.402	1.13	0.51-5.95
Pyrethrum	15	72	0.656	0.5	0.17-6.8

Conclusion

On the basis of above findings, it is concluded that the extract of *Capsicum annum* is the best bio-insecticide, it has the highest repellent and toxic effect against dermestid species.

Thus the application of ecofriendly and locally available *Capsicum annum* extract for disinfection of cocoon storage rooms/ bags can help the silkworm rearers/ reelers to reduce the post storage loss of silkworm cocoons.

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