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Insecticidal, Oviposition Deterrent and Antifeedant Property of Certain Plant Extracts against Pulse Beetle, *Callosobruchus chinensis* Linn. (Coleoptera: Bruchidae)

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ABSTRACT

Background: The bruchid *Callosobruchus chinensis* (L.) is one of the major store grain pest of pulses capable of attacking wide range of legumes *viz*., green gram, black gram, chick pea and pigeon pea and causes 50 per cent damage during storage within 3 to 4 months. The infestation starts in the field, but heavy damage is done in storage. Hence, the current study was aimed to evaluate the insecticidal, oviposition deterrent and antifeedant activity of certain plant extracts against pulse beetle, *C. chinensis* under storage condition.

Methods: The aquous extracts (10%) of *Vitex negundo*, *Pongamia glabra, Cassia angustifolia* and *Calotropis gigantea* were evaluated against the pulse beetle, *Callosobruchus chinensis* Linn. were carried out at the Department of Agricultural Entomology, Imayam Institute of Agriculture and Technology, Thuraiyur during 2019-20. The commercial product Azadirachtin was kept as a check and the mortality rate was assessed every 24 Hours after treatment (HAT) for three days.

Result: The mortality rate after 72HAT was 85.8-87.5% with *V. negundo*, followed by *C. angustifolia* (73.33-80.00%) and *P. glabra* (70.0-75.0%). Azadirachtin gave 100% mortality of the beetle. The oviposition deterrence percentage for pulse beetle, *C. chinensis* was found to be highest in *Calotropis gigantea* (37.66-68.16%) followed by *Pongamia glabra* (30.91-41.50) and *Vitex negundo* (7.58-46.75) per cent, respectively. The antifeedant activity for pulse beetle was found to be very high when treated with Azadirachtin where there was no food consumption. This was followed by *V. negundo* (0.1 g) and *C. angustifolia* (0.2 g).

Key words: Antifeedant, Azadirachtin, Botanicals, Oviposition, Plant extracts, Pulse beetle, Storage pest.

INTRODUCTION

Pulses have a prominent place in daily diet and they are rich source of vegetable proteins, minerals and vitamins. They are of special significance of the people in developing countries like India, who can hardly afford animal protein in adequate quantities. India has achieved a record of pulse production of 17.82 million ton in 2016-2017. Post-harvest losses are often more significant than crop losses which occur in the field. As in field crops, a wide range of insect pests also attack stored products. In pulses, over 200 species of insects have been recorded in India (Saranya *et al.,* 2019). Among the insect pests attacking stored products, the Pulse beetle *Callosobruchus chinensis* L. is reported to be the major pest infesting all types of pulses both in the field and in storage condition in India, Bangladesh and other tropical and subtropical countries (Mummigatti and Krishnaiah, 2007). *C. chinensis* is also known to attack cotton seed, sorghum and maize (Ahmed *et al*., 2003) The beetles breed rapidly in the storage condition in the tropical and subtropical environment. Their larvae can easily penetrate the grain and feed the endosperms, (Ahad *et al*., 2015) while feeding scoop out the contents of grains. The pulse beetles assume serious proportions usually during July-August in the stores (Varma and Anandhi, 2010). The infested grains become unsuitable for human consumption, deteriorate nutritional value and loss germination potential (Deeba *et al.,* 2006). Ratnasekera and Nayanathara (2010) reported that the moisture content in pulse grains to less than 10% could significantly reduce the beetle infestation. Fumigation with synthetic chemicals like methyl bromide and phosphine is

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an effective method being used only in the warehouses. This method is expensive and unbearable to rural farmers and impractical in the primitive nature of storage in many of the villages. On the contrary, injudicious application of the synthetic fumigants creates serious health hazards and environment pollution (Kim *et al.,* 2003). These problems directed the need for biodegradable pesticides in the management of stored grain pests (Daglish, 2008). Control of the pest using botanical pesticides, pressurized carbon dioxide and temperature management techniques are becoming popular (Yuya *et al.,* 2009). The plant-derived materials are selective in action and their compounds are readily biodegradable and less likely to contaminate the environment. A number of authors have reported the toxicity, repellency, antifeedant, growth and progeny inhibition activity of plant materials against field and stored grains. Moreover, the farmers and small-scale industrialists can easily produce and store the crude or partially purified extracts from leaves, stems, fruits or roots of the plants. Recently, attention has been given to the possible use of plant products or plant derived compounds as promising alternative to synthetic insecticides in controlling insect pests of stored products (Ratnasekera and Rajapakse, 2009). The present study aims at investigating the insecticidal property, ovipositional and antifeedant effect of different plant extracts against *C. chinensis.*

MATERIALS AND METHODS

Mass culturing of pulse beetle

Freshly harvested pulse seeds were obtained from farmers of Thuraiyur region. Seeds of the following crops like black gram, green gram and bengal gram and local varieties VBN 8, VBN (Gg) 3 were used in the storage experiments. Mass culturing of pulse beetle*, C. chinensis* was done at the Department of Agricultural Entomology, Imayam Institute of Agriculture and Technology, Thuraiyur during 2019-20. The adult pulse beetle *w*as collected from Black gram and Bengal gram seed samples of the Department of Seed Science and Technology and from Department of Plant Breeding and Genetics and utilized for mass culturing. These beetles were reared on fresh black gram and green gram seeds following the method developed by Credland and Wright (1989). Black gram and green gram seeds @ 500 g each were placed in 600 ml plastic jars, into which approximately 30 pairs of freshly emerged adult beetles were introduced. The plastic jars were covered with muslin cloth and placed in dark to facilitate maximum oviposition, maintained at a room temperature of 30±5°C and 70±5% RH throughout the period of study. After 25 to 30 days, adults that emerged from the culture were utilized for maintenance of sub cultures following the same procedure as described above. Sub culturing of this beetle was done at weekly intervals so as to get continuous supply of insects for experiments. Freshly emerged adults were used for conducting the experiments.

Collection and aqueous extraction of plants

Locally available plants *viz*., Notchi (*Vitex negundo* Linn.), Senna (*Cassia angustifolia* Vahl), Calotropis (*Calotropis gigantea* Linn.) and Pungam (*Pongamia glabra* Linn.) were collected from the farm of IIAT, Thuraiyur. Leaves of above mentioned plants were shade dried for one week and ground into fine powder (Vanmathi *et al.,* 2010). Plant powders were sieved through 0.25 mm pore size mesh sieve to obtain uniform fine dust particles (Jembere *et al*., 2005). The resulting powders were kept separately in plastic containers with tight cap and stored at room temperature in dark prior to use. Ten gram of each powder was soaked in 100 ml of distilled water and left for 24 hrs. Thereafter, the extracts were decanted and filtered using muslin cloth. Later the resultant solutions were used for laboratory study.

Insecticidal action of plant extracts

Seeds of green gram, black gram and bengal gram were taken @ 10gram in each plastic container. Plant extracts were added to the pulse seeds in each container individually at concentration of 10% and shaken thoroughly. Ten newly emerged adults of *C.chinensis* were released in each plastic container with treated seeds and were covered firmly and kept at the room temperature. Untreated pulse seeds were maintained as control and Azadirachtin was used as a standard check. Mortality (lack of locomotion and/or response to repeated probing) was recorded at 24 h interval for three days. The experiments were conducted in complete randomized block design (CRBD) with six treatments and four replication.

$$\text{Mortality (\%)} = \frac{\text{Number of insects died}}{\text{Total number of insects released}} \times 100$$

Ovipositional deterrent

In order to study the ovipositional deterrent effect of plant extract, seeds *viz.,*Green gram, Black gram and Bengal gram were taken @ 20 grams in each plastic container and mixed with plant extracts at the concentration of 10%. Five pairs of newly emerged adults of pulse beetle, *C. chinensis* were released in each plastic container and covered firmly and were kept under the laboratory conditions. Four replications were maintained for each treatment. The number of eggs laid was recorded after 48 h and oviposition deterrence was calculated with the following formula (Pascual-Villalobos and Robledo, 1998).

$$\text{Oviposition deterrence} = 100 \times (1 - NE_t/NE_c)$$

Where

NE_t is the number of eggs in treatment and NE_c is the number of eggs in control.

Antifeedant effect

After 24 hours of treatment, grains were taken from the treated seeds of each treatment. Total weight loss in each replication was measured using a weighing balance. After data collection, grains were kept in plastic container of the respective treatments. The extent of damage caused by pulse beetle on black gram, bengal gram and green gram seeds was determined on the basis of the weight loss from the total weight was calculated. The data was recorded for each replication. Effect on infestation was calculated by computing infested/unhealthy grain after 48 and 72 hours after release (HAR).

Statistical analysis

The data collected under different laboratory experiments were analyzed using analysis of variance (ANOVA) using AGRES 3.01 and AGDATA software. Data in the form of percentages were transformed to arcsine values and those in numbers were transformed to $\sqrt{x + 0.5}$ and analyzed. The mean values of the treatments were compared using LSD at 5 per cent level of significance.

RESULTS AND DISCUSSION

Insecticidal effect of plant extracts on *C. chinensis* in different hosts

The results of insecticidal activity of different plant extracts *viz., Vitex negundo, Cassia angustifolia*, *Calotropis gigantea, Pongamia glabra* on pulse beetle, *C. chinensis* in green gram, black gram and bengal gram are furnished in Table 1. On 24 HAT, the highest mortality was recorded in Azadirachtin with 100 per cent followed by *V. negundo* (72.5%), *P. glabra* (57.5%), *C. angustifolia* (52.50%) and lowest mortality was recorded in *C. gigantea* (7.50%) and control(12.5.%). On 72 HAT, the highest mortality was recorded in Azadirachtin with 100 per cent, *V. negundo* (97.5%), *C. angustifolia* (87.5%), *P. glabra* (85.0%) and lowest mortality was recorded in *C. gigantea* (27.5%) and control (20%). The insecticidal activity of different plant extracts on pulse beetle in black gram, on 24HAT the highest mortality was recorded in Azadirachtin (100%) followed by *V. negundo* (72.5%), *C. angustifolia* (57.5%), *P. glabra* (55%) and lowest mortality was recorded in *C. gigantea* (12.5%) on par with control. On 72 HAT, the highest mortality was recorded in Azadirachtin (100%) followed by *V. negundo* (97.5 %), *C. angustifolia* (92.5%), *P. glabra* (90%) and lowest mortality was recorded in *C. gigantea* (40%). The results of insecticidal activity of different plant extracts in On 72 HAT, the highest mortality was recorded in Azadirachtin (100%) followed by *V. negundo* (97.5%), *C. angustifolia* (90%), *P. glabra* (77.5%) and lowest mortality were recorded in *C. gigantea* (27%). The results are in line with the findings of Fabiola *et al.* (2016) have studied the larvicidal effect of *V. negundo* extract (50 ppm) on *Aedes aegypti* and reported 77.80 per cent mortality in the 1st instar larvae at 24 HAT. Insecticidal property of 10% *V. negundo* extracts were reported earlier by Sahayaraj (1998). Similar effects were observed by Gautham *et al.* (2003) in which they reported 51.7% mortality of *Spodoptera litura* at 6% aqueous extract of *V. negundo* leaves. Sharma *et al.* (2018) reported that mortality range (84-100%) against pulse beetle was observed in neem treated pigeonpea grains.

Table 1: Insecticidal activity of 10% aqueous plant extracts on *Callosobruchus chinensis*.

Treatments	Cumulative mortality of *C. chinensis** (%)											
(10% aquouse extract)	Green gram				Black gram				Bengal gram			
	24 HAT	48 HAT	72 HAT	Mean	24 HAT	48 HAT	72 HAT	Mean	24 HAT	48 HAT	72 HAT	Mean
T1: *Vitex negundo*	72.5^{d}	92.5^{d}	97.5^{d}	87.5	72.5^{d}	90.0^{d}	97.5^{b}	86.6	72.5^{c}	87.5^{b}	97.5^{b}	85.8
	(58.38)	(74.12)	(80.96)		(58.32)	(71.52)	(80.06)		(80.90)	(69.29)	(81.61)	
T2: *Pongamia glabra*	57.5^{c}	77.55^{c}	85.0^{c}	73.33	55.0^{c}	77.5^{c}	92.5^{c}	75.0	62.5^{b}	70.0^{c}	77.5^{d}	70.0
	(49.31)	(61.32)	(67.28)		(47.87)	(61.68)	(74.12)		(74.14)	(56.79)	(61.70)	
T3: *Cassia angustifolia*	52.5^{b}	80.0^{b}	87.55^{b}	73.33	57.5^{b}	75.0^{b}	90.0^{d}	74.1	62.5^{b}	87.5^{b}	90.0^{c}	80.0
	(46.43)	(63.43)	(69.39)		(49.31)	(60.01)	(70.36)		(71.56)	(69.32)	(71.67)	
T4: *Calotropis gigantea*	7.50^{e}	15.0^{e}	27.5^{e}	'6.66	12.5^{e}	32.5^{e}	40.0^{e}	28.3	12.5^{d}	15.0^{d}	27.5^{d}	18.3
	(15.84)	(22.78)	(31.62)		(20.73)	(34.75)	(36.06)		(39.23)	(22.78)	(31.62)	
T5: *Azadirachta indica*	100^{a}	100^{a}	100^{a}	100.0	100^{a}	100^{a}	100^{a}	100.0	100^{a}	100^{a}	100^{a}	100.0
	(84.04)	(84.04)	(84.04)		(84.04)	(84.04)	(84.04)		(84.04)	(84.04)	(84.04)	
T6: Control	0.00^{f}	0.00^{f}	0.00^{f}	0.00	0.00^{f}	0.00^{f}	0.00^{f}	0.00	0.00^{f}	0.00^{e}	0.00^{e}	0.00
	(0.58)	(0.58)	(0.58)		(0.58)	(0.58)	(0.58)		(0.58)	(0.58)	(0.58)	
CD (5%)	1.378	1.891	2.071	-	0.468	0.356	0.285	-	1.199	1.524	1.965	-
SEd	0.626	0.860	0.941		0.213	0.162	0.130		0.545	0.693	0.893	

* Mean of four replications; HAT – Hours after treatment.

Table 2: Comparative oviposition deterrent (OD) efficiency of plant extracts on *C. chinensis.*

Treatments	Green Gram				Black gram				Bengal gram			
(10% aquous extract)	24 HAT	48 HAT	72 HAT	OD(%)	24 HAT	48 HAT	72 HAT	OD (%)	24 HAT	48 HAT	72 HAT	OD (%)
T1: *Vitex negundo*	39.25	41.75	44.5	54.66	31.25	49.75	59.25	51.25	6.75	8.00	8.00	91.86
	(6.25)^{c}	(6.45)^{c}	(6.66)^{b}		(5.58)^{c}	(7.04)^{c}	(7.68)^{c}		(2.59)^{e}	(2.82)^{e}	(2.82)^{e}	
T2: *Pongamia glabra*	37.75	39.5	41.75	57.01	32.50	40.00	52.00	56.73	24.25	30.00	38.50	66.82
	(6.13)^{c}	(6.27)^{c}	(6.45)^{c}		(5.69)^{c}	(6.31)^{d}	(7.20)^{c}		(4.91)^{c}	(5.47)^{c}	(6.19)^{c}	
T3: *Cassia angustifolia*	40.25	42.5	44.25	68.56	36.00	47.00	58.00	50.65	9.50	11.25	12.25	88.19
	(6.33)^{c}	(6.51)^{c}	(6.64)^{c}		(5.99)^{c}	(6.64)^{c}	(7.60)^{c}		(3.07)^{d}	(3.35)^{d}	(3.49)^{d}	
T4: *Calotropis gigantea*	61.25	68.0	75.25	26.11	45.00	56.75	70.00	40.30	29.00	36.50	47.50	59.57
	(7.82)^{b}	(8.24)^{b}	(8.67)^{b}		(6.70)^{b}	(7.52)^{b}	(8.36)^{b}		(5.38)^{b}	(6.03)^{b}	(6.88)^{b}	
T5: *Azadirachta indica*	7.5	7.75	7.75	91.70	7.75	7.50	7.25	92.18	3.50	3.00	4.50	96.07
	(2.73)^{a}	(2.78)^{a}	(2.78)^{a}		(2.78)^{a}	(2.73)^{a}	(2.69)^{a}		(1.87)^{a}	(1.73)^{a}	(2.12)^{a}	
T6: Control	88	92.5	96.25	0.00	90.5	98.15	99.05	0.00	90.50	92.25	96.50	0.00
	(9.37)^{d}	(9.61)^{d}	(9.80)^{d}		(9.50)^{d}	(9.90)^{e}	(9.95)^{d}		(9.50)^{f}	(9.60)^{f}	(9.81)^{f}	
CD (5%)	0.448	0.456	0.478	-	0.411	0.475	0.527	-	0.317	0.340	0.367	-
SEd	0.204	0.207	0.217	-	0.187	0.216	0.240	-	0.144	0.155	0.167	-

* Mean of four replications; HAT – Hours after treatment; OD- Oviposition deterrent.

Table 3: Comparative antifeedant activity of plant extracts on *C. chinensis.*

Treatments (10% aquous extract)	Weight of the grains after consumption (10 g)											
	Green gram				Black gram				Bengal gram			
	24 HAT	48 HAT	72 HAT	Mean	24 HAT	48 HAT	72 HAT	Mean	24 HAT	48 HAT	72 HAT	Mean
T1: *Vitex negundo*	9.97	9.97	9.95	9.96	9.92	9.85	9.97	9.91	9.97	9.90	9.90	9.92
	(3.15)^{a}	(3.15)^{a}	(3.15)^{a}		(3.14)^{a}	(3.13)^{a}	(3.15)^{a}		(2.82)^{a}	(3.14)^{a}	(3.14)^{a}	
T2: *Pongamia glabra*	9.6	9.52	9.42	9.51	9.82	9.75	9.82	9.79	9.80	9.70	9.67	9.72
	(3.09)^{a}	(3.08)^{a}	(3.06)^{a}		(3.13)^{a}	(3.11)^{a}	(3.13)^{a}		(6.19)^{a}	(3.11)^{a}	(3.10)^{a}	
T3: *Cassia angustifolia*	9.97	9.95	9.87	9.92	9.92	9.92	9.92	9.92	9.87	9.80	9.80	9.82
	(3.15)^{a}	(3.15)^{a}	(3.13)^{a}		(3.14)^{a}	(3.14)^{a}	(3.14)^{a}		(3.49)^{a}	(3.12)^{a}	(3.12)^{a}	
T4: *Calotropis gigantea*	9.9	9.85	9.82	9.85	9.77	9.80	9.82	9.79	9.87	9.70	9.60	9.72
	(3.14)^{a}	(3.13)^{a}	(3.13)^{a}		(3.12)^{a}	(3.12)^{a}	(3.13)^{a}		(6.88)^{a}	(3.11)^{a}	(3.09)^{a}	
T5: *Azadirachta indica*	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	(3.16)^{a}	(3.16)^{a}	(3.16)^{a}		(3.16)^{a}	(3.16)^{a}	(3.16)^{a}		(2.12)^{a}	(3.16)^{a}	(3.16)^{a}	
T6: Control	8.5	8.0	7.9	8.13	8.65	9.10	9.00	8.91	9.80	8.70	8.30	8.93
	(2.91)^{b}	(2.82)^{b}	(2.80)^{b}		(2.93)^{b}	(3.01)^{b}	(2.99)^{b}		(9.81)^{b}	(2.94)^{b}	(2.87)^{b}	
CD (5%)	0.054	0.070	0.060	-	0.049	0.063	0.059	-	0.068	0.088	0.077	-
SEd	0.024	0.032	0.027	-	0.022	0.028	0.023	-	0.022	0.041	0.036	-

* Mean of four replications; HAT – Hours after treatment.

Oviposition deterrent effect of plant extracts on *C. chinensis* in different hosts

The results of the oviposition deterrent activity study showed that egg laying of *C. chinensis* was lowest in Azadirachtin with oviposition deterrent 91.70% followed by *Cassia angustifolia* (68.56%) and Pongamia (57.01%) treated green gram. In black gram, highest oviposition deterrent effect (92.18%) was observed in Azadirachtin treated seeds. *Calotropis* showing least oviposition deterrent effect (40.30%) in black gram. In the case of bengal gram, *Vitex negundo* treated seed showed 91.86%. oviposition deterrent (Table 2). Highest oviposition deterrent indicates minimum egg laying capacity by *C. chinensis* on pulses. Current findings were supported by the results of Vanmathi *et al*. (2010) who reported the oviposition deterrent effect of 1, 3 and 5 per cent aqueous extracts of *C. gigantea* and *V. negundo* on *C. maculates* in black gram seeds. It appears that these plant extracts might possess repellent or oviposition deterrent principles. Olaifa and Erhun (1988), who observed a complete suppression of oviposition by *C. maculatus* when treated with 42% powder of *P. guineense.* Elhag (2000) studied the oviposition deterrence of nine plant materials on *C. maculatus* and found seed treatment with 0.1% crude extract resulted in significant reduction in egg-laying by the bruchid. Oviposition deterrence may be due to the changes induced in physiology and behaviour in the adult of *C*. *chinensis* as reflected by their egg laying capacity.

Antifeedant effect of plant extracts on *C. chinensis*in different hosts

Any substance that reduces food consumption by an insect can be considered as an antifeedant or feeding deterrent (Isman, 2002). In green gram, the mean food consumption was minimum (0.05g) in *V. negundo* treated seeds. In Black gram and Bengal gram seeds, the mean food consumption was 0.03g and 0.10g, respectively (Table 3). Haridasan *et al.* (2017) exhibited the feeding deterrence activity of methanol and petroleum ether extracts of *V. negundo* on *Tribolium castaneum.* The results of the present study is in concordance with the findings of Arivoli and Samuel (2013) who recorded maximum antifeedant activity (86.41%) of *V. negundo* extract on *S. litura.* This indicated that the active principles present in the *V. negundo* inhibit feeding behaviour or make the food unpalatable or the substances directly act on the chemo sensilla of the beetle resulting in feeding deterrence.

CONCLUSION

The present investigation has brought out the efficacy of different plant extracts on *C. chinensis.* Especially, Notchi (*Vitex negundo)* leaf extract at 10 per cent concentration has highest insecticidal, antifeedant and oviposition deterrent activity on pulse beetle. Preparation of these aqueous extracts and application on the seeds are comparatively easy and cost effective. *Vitex negundo* is traditionally used by farmers as a storage insecticide and a common insecticide. Hence, the plant extracts of *V. negundo* can be used as one of the component in Integrated Pest Management especially in small godowns or shop retailer for short term storage.

REFERENCES

Ahad, M.A., Nahar, M.K., Amin, M.R., Suh, S.J. and Kwon, Y.J. (2015). Biological activities of five weed extracts against *Callosobruchus chinensis* L. (Coleoptera: Bruchidae). Korean Journal of Applied Entomology. 54(2): 83-89.

Ahmed, K.S., Itino, T. and Ichikawa, T. (2003). Duration of developmental stages of *Callocobruchus chinensis* L. (Coleoptera: Bruchidae) on adzuki bean and the effects of neem and sesame oils at different stages of their development. Pakistan Journal of Biological Sciences. 6(10): 932-935.

Ahmed, M.S., Kabir, K.H., Nahar, G., Miah, M.R.U. and Rahman, M.A. (2006). Use of different containers, chemicals and indigenous materials for the management of pulse beetles in storage. Bangladesh Journal of Entomology. 16(2): 11-12.

Arivoli, S. and Samuel, S. (2013). Antifeedant activity, developmental indices and morphogenetic variations of plant extracts against *Spodoptera litura* (Fab) (Lepidoptera: Noctuidae). Journal of Entomology and Zoology Studies. 1(4): 87-96.

Credland, P.F. and Wright, A.W. (1989). Factors affecting female fecundity in the cowpea seed beetle, *Callosobruchus maculatus* Coleoptera: Bruchidae. Journal of Stored Products Research. 25(3): 125-136.

Daglish, G.J. (2008). Impact of resistance on the efficacy of binary combinations of spinosad, chlorpyrifos-methyl and s-methoprene against five stored-grain beetles. Journal of Stored Products Research. 44(1): 71-76.

Deeba, F., Sarwar, M. and Khuhro, R.D. (2006). Varietal susceptibility of mungbean genotypes to pulse beetle, *Callosobruchus analis* (Fabricius)(Coleoptera: Bruchidae). Pakistan Journal of Zoology. 38(4): 265.

Elhag, E.A. (2000). Deterrent effects of some botanical products on oviposition of the cowpea bruchid *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). International Journal of Pest Management. 46: 109-113.

Fabiola and Simon Joseph. (2016). Insecticidal activity of *Vitex negundo* on the larvae and pupae of *Aedes aegypti.* World Journal of Pharmacy and Pharmaceutical Sciences. 5(1): 971-975.

Gautham, K., Rao, P.B. and Chauhan, S.V.S. (2003). Insecticidal properties of some plants of family *Asteraceae* against *Spilosoma obliqua*. Indian Journal of Entomology. 65(3): 363-367.

Haridasan, P., Gokuldas, M. and Ajaykumar, A.P. (2017). Antifeedant effects of *Vitex negundo* L. leaf extracts on the stored product pest, *Tribolium castaneum* H. (Coleoptera: Tenebrionidae). International Journal of Pharmacy and Pharmaceutical Sciences. 9(3): 17-22.

Isman, M.B. (2002). Insect antifeedants. Pesticide Outlook. 13: 152-157.

Jembere, B., Getahun, D., Negash, M. and Sevoum, E. (2005). Toxicity of Birbira (*Milletia ferruginea*) Seed Crude Extracts to Some Insect Pests as Compared to Other Botanical and Synthetic Insecticides. Proceedings of the 11th NAPRECA Symposium on Natural Products and Drug Delivery, August 9-12, 2005, Astanarivo, Madagaskar, pp: 88-96.

Kim, K.H., Kabir, E. and Jahan, S.A. (2017). Exposure to pesticides and the associated human health effects. Science of the Total Environment. 575: 525-535.

Mummigatti, S.G. and Krishnaiah, H.E. (2007). Technique to isolate *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae) eggs. Journal of Stored Products Research. 43(4): 402-403.

Olaifa, J.I. and Erhun, W.O. (1988). Laboratory evaluation of piper guineense for the protection of cowpea against *Callosobruchus maculatus*. Insect Science and its Application. 9: 55-59.

Pascual-Villalobos, M.J. and Robledo, A. (1998). Screening for anti-insect activity in Mediterranean plants. Industrial Crops and products. 8(3): 183-194.

Ratnasekera, D. and Rajapakse, R. (2012). The potential use of indigenous plant materials against Callosobruchus chinensis L. and *Callosobruchus maculatus* L. (Coleoptera, Bruchidae) in stored legumes in Sri Lanka. Journal of Biopesticides. 5:88.

Sahayaraj, K. (1998). Antifeedant effect of some plant extracts on the Asian armyworm, *Spodoptera litura* (Fabrious). Current Science. 74: 523-525.

Saranya, M., Nelson, S.J., Paramasivam, M. and Mahalingam, C.A. (2019). Evaluation of different solvent extracts of sweet flag rhizome, *Acorus calamus* (L.) on pulse beetle, *Callosobruchus maculatus* (F.). Indian Journal of Agricultural Research. 53(4): 373-382.

Sharma, R., Devi, R., Yadav, S. and Godara, P. (2018). Biology of pulse beetle, *Callosobruchus maculatus* (F.) and its response to botanicals in stored pigeonpea, *Cajanus cajan* (L.) grains. Legume Research- An International Journal. 41(6): 925-929.

Vanmathi, J.S., Padmalatha, C., Ranjit Singh, A.J.A. and Chairman, K. (2010). Effect of chosen botanicals on the oviposition deterrence and adult emergence of *Callosobruchus maculatus* (F.) (coleoptera: bruchidae). Elixir Bio Technology International Journal. 51: 11120-11123.

Varma, S. and Anandhi, P. (2010). Biology of pulse beetle (*Callosobruchus chinensis* Linn., Coleoptera: Bruchidae) and their management through botanicals on stored mung grains in Allahabad Region. Legume Research: An International Journal. 33(1): 38-41.

Yuya, A.I., Tadesse, A., Azerefegne, F. and Tefera, T. (2009). Efficacy of combining Niger seed oil with malathion 5% dust formulation on maize against the maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae). Journal of Stored Products Research. 45(1): 67-70.