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RESEARCH ARTICLE

Developmental impairment and Oviposition deterrence in *Callosobruchus maculatus* (Fabricius) infesting *Vigna radiata* (L.Wilczeck) upon treatment with five different plant products

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Abstract

Background/Objectives: The toxic synthetic pesticides must be replaced by safe, cheap, non-toxic, target-specific insecticides such as natural plant products. This study is to investigate the ovipositional and eclosion inhibitory activities of five plant products against the pulse beetle, *Callosobruchus maculatus* infesting green gram (*Vigna radiata*). **Method:** Fine powders prepared from various parts of the plants *Piper longum, Adhatoda vasica, Illicium verum, Cinnamomum zeylanicum* and *Syzygium aromaticum* at various concentrations (0.2, 0.4, 0.6, 0.8 g) were added to 30 g of *V. radiata* seeds and two pairs of adult *C. maculatus* were introduced. Inhibitory effect of oviposition was studied by counting the number of eggs periodically (24, 48, 72, 96 and 120 hours) and the eclosion failure was also assessed. The control was similar to the experimental setup except for the absence of plant powders. **Findings:** The oviposition deterrence values which provide a comparison between the control and treatments showed *S. aromaticum* to be the strongest deterrent with a value of 85.77 followed by *C. zeylanicum* (76.33), *P. longum* (66.91), *I. verum* (62.96) and *A. vasica* (42.93) at 0.8 g. Also *S. aromaticum* recorded the highest eclosion failure of 22.06% and the lowest with *A. vasica* (11.08%) at 0.8 g. Statistical analysis showed an overall significant difference ($p < 0.05$) between the different plants, concentration wise. Though all the five selected plants exhibited insecticidal activity, *S. aromaticum* was the strongest in inhibiting oviposition and impairing larval growth of *C. maculatus*. **Novelty:** Previous works have demonstrated the insecticidal activity of the essential oils of *S. aromaticum* and *C. zeylanicum* but this study has shown that prepared powders of both these spices are quite effective at low concentrations, so can be easily used by farmers.

Keywords: Insecticidal; Oviposition deterrence; Callosobruchus maculatus; Syzygium aromaticum; Piper longum; Pest

1 Introduction

There is a high global demand for plant proteins owing to the rising populations and an increased production of plant proteins is a sustainable approach to meet the ever-increasing nutritional demands[1]. *Vigna radiata* L Wilczek., (green gram or mung bean) a highly nutritious pulse is most widely grown in the tropical and subtropical regions[2,3]. A variety of pests infest *V. radiata* in storage and a common Coleopteran pest, *Callosobruchus maculatus* (Fab.) the common pulse beetle, is responsible for excessive damage world-wide[4].

India is the largest producer, consumer and importer of pulses in the world and accounts for 45% of the total global production of *V. radiata* grown over an area of 3.38 million ha[5]. The long term storage of *V. radiata* is challenged by the infestation of bruchids of the genus, *Callosobruchus* (Coleoptera: Bruchidae) with a sizeable proportion of the production being damaged during storage, within 3-6 months[4,6]. Apart from direct damage to the stored pulses, they also promote secondary fungal infections, resulting in mycotoxin contamination[7].

Among the bruchids in South India, *C. maculatus* is the most predominant[8]. The females of *C. maculatus* oviposit on the surfaces of legume seeds and pods. Oviposition reaches a peak within 2 days and declines thereafter till the non-feeding female stops egg laying and dies around the eighth day[9]. The larvae hatch out in about 5 days and bore into the seeds beneath the oviposition site and complete their development within the respective grains. Adult eclosion from the seeds occurs through the tunnels excavated by the larvae, leading to translucent windows in the seed coat[6], usually at temperatures of about 27°C and the beetles emerge 24–30 days after oviposition[10].

To save the pulses from insect pests, synthetic chemical insecticides are routinely applied, resulting in poisonous residues. A much safer alternate method is the use of plant products to control insect pests[11,12]. Botanical insecticides are more safe, biodegradable and less toxic but very much suitable for effective control of insect pests[13,14]. Use of plant products for controlling pests is highly advantageous especially in stored products, since majority of the plant based control-agents do not leave behind toxic residues on the finished stored food products, which are ready for immediate consumption. Various plant products such as leaf powders, oils and extracts of varied kinds of plants are known to possess insecticidal properties[15]. Different powders of plants have been researched widely, to find the plant which was most lethal to *C. maculatus*, thereby providing complete protection to the pulses while being non-toxic to the consumers[16–18].

Piperadine alkaloids and other phytochemicals from *Piper longum* (L.) were reported to possess insecticidal and acaricidal properties[19–21]. *Adhatoda vasica* (L.) Nees was shown to be effective against many insect pests[22,23]. Essential oils of Cinnamomum zeylanicum and Syzygium aromaticum (L.) were used as insecticidal agents[24–26]. *Illicium verum* Hook. f. (star anise) was reported to possess acaricidal[27] and insecticidal activity[28]. Studies on Petroleum ether extracts of *Azadirachta indica* and *Curcuma longa* were found to be good protectants of bean seeds from the weevil *Aphis craccivora* for nearly one year[29]. Vegetable oils have also shown to exhibit insecticidal activity. *Acorus calamus* oil at low concentrations greatly decreased the oviposition of *C. maculatus* and at high concentrations caused sterility in females[30].

In this study, *P. longum* dried fruit powder, leaf powder of *A. vasica* bark powder of *C. zeylanicum,* fruit pericarp powder of *I. Verum*, and flower bud powder of *S. aromaticum* were smeared in different proportions on *V. radiata* grains and *C. maculatus* adults were allowed to oviposit. The efficacy of these plant products to deter oviposition and impair normal development was assessed. *P. longum* is a medicinal plant which is commonly called as the 'Indian long pepper' and it belongs to the family Piperaceae. *A. vasica* that belongs to the family Acanthaceae, is commonly called as 'Malabar nut'. *Cinnamomum zeylanicum,* commonly called as 'cinnamon' and *Syzygium aromaticum* commonly known as 'cloves' are spices used as flavouring agents. They belong to the family Lauraceae and Myrtaceae respectively. *Illicium verum* is also a spice, very commonly known as 'star anise' and it belongs to the family Schisandraceae.

2 Materials and Methods

2.1 Work-design

C. maculatus lays eggs on *V. radiata* grains and the eggs hatch in two days, with the larvae moving into the grains after fifth day. The only means of protecting the grains is to dissuade the pulse beetle from laying eggs on the grains. In this study, the deterrence properties of five different medicinal and spice-plant extracts were tested by manually coating them on *V. radiata* grains and then allowing the gravid females to lay eggs on the surface of the treated grains. Ovipositional deterrence and changes in the developmental schedule caused by the plant products were analysed. The plant products were selected on the basis of their palatability and absence of toxicity to human consumers.

2.2 *C. maculatus* culture

C. maculatus stock cultures were maintained in green gram (*Vigna radiata* L.Wilczeck) taken in 1 litre closed containers, stored in a room at 26±5º C. The newly emerged adults from the stock cultures were used in the experiments. New cultures were started with fresh grain stocks after two generations, to prevent fungal contamination of the pulses.

2.3 Plant materials

Dried fruits of *P. longum* were procured from the local Ayurvedic Pharmacy and fresh, green leaves of *A. vasica* were collected from the garden of medicinal plants in the college campus. *C. zeylanicum* bark rolls, star-shaped pericarps of *I. verum* and dried flower buds of *S. aromaticum* were purchased from the local spice market. All the plant products were dried well, under shade and ground to fine powder separately in an electric blender and sifted in a metal sieve of size 0.1 mm and stored in separate sterile glass containers.

2.4 Oviposition deterrence experiments

Good quality *V. radiata* bought from the retail store were sun dried for two days to disinfect the grains and prevent carry-over infestations if any. *C. maculatus,* collected from the nearby grain shops were introduced into the dried grains and allowed to lay eggs. The larvae, hatching out from the eggs completed their life-history within the grains and the eclosing adults were allowed into fresh containers containing *V. radiata*, to propagate the second generation. The adult beetles freshly emerging from the second generation cultures were used in the experiments. The sexes were separated based on the taxonomic techniques, with females maculated with four elytral spots, whereas males, plain with less distinct spots [(31)].

Weighed quantities (0.2, 0.4, 0.6, 0.8 g) of each plant powder of *P. longum, A. vasica, C. zeylanicum, S. aromaticum and I.verum* were separately coated on to the surface of 30g of *V. radiata* grains taken in plastic containers (diameter-5.5 cm, depth-10 cm). Five replicates were maintained for each weight group of separate plant powders and for the untreated control groups. The plant powders were first sprinkled on the grains little by little and the grains in the containers were shuffled thoroughly by placing the containers in a laboratory rocker for about 1 hour.

Two newly emerged mating pairs of *C. maculatus* were introduced into each of the containers and closed securely. The pulse beetles started laying eggs on the grains from the second day onwards. The pulse beetles preferred to lay a single egg on a grain when grains are available in plenty. The grains with eggs deposited on them were removed carefully and fresh sterile grains were replaced in the containers so that the number of grains available for oviposition remained unchanged. This was done to ensure that the beetles laid only one egg on a grain and this helped when enumeration of emergence holes was made. The number of eggs laid every 24 hours was counted till the 5th day, after which the adults, if alive, were removed. The egg-laden pulses were placed separately for assessment of eclosion.

The total eggs in the control and in the treatment containers were noted. The percent oviposition deterrence was calculated [(32,33)].

Percent OD = [(NC – NT) / NC] x100

where OD = oviposition deterrence; NC = total number of control eggs and NT = total number of treatment eggs

2.4 Assessment of Eclosion

Failure of eclosion is inferred by the absence of emergence holes in pulses with a single egg even after 30 days. The number of adults that eclosed in each treatment group and the control were noted. The number of larvae that eclosed and those that failed to eclose was cross-checked with the total number of eggs laid and the eclosion failure percentage was calculated.

3 Results and Discussion

3.1 Oviposition

All the five tested plant powders caused decrease in the number of eggs laid with increasing concentration. Among the five plant powders *S. aromaticum* deterred oviposition most at 0.8g where the mean eggs laid in 5 days was 10.8 compared to control with 77.2, followed by *C. zeylanicum* 18.25. *A. vasica* leaf powder showed the least inhibition of oviposition where the mean eggs laid at 0.8 g was 43.6 [Table 1]. Increased production of eggs during 48 h period was noted in control and in all the treatments.

3.2 Eclosion

Eclosion failure increased with the increase in plant powder concentration. Highest eclosion failure was noted for *S. aromaticum* at 0.8g (22.06%) compared to control (7.72%). *A. vasica, P. longum* and *Illicium verum* showed almost similar eclosion failure values at 0.8 g (11.08, 12.41and 13.95% respectively). At 0.8g concentration, the percent eclosion failure values recorded for *C. zeylanicum* was 18.83% [Figure 1].

Among the five plant powders *S. aromaticum* exhibits highest percent oviposition deterrence with 85.77 at a concentration of 0.8g [Table 2]. The lowest ovipositional deterrency of 9.38 was recorded by *I.verum* at 0.2 g. Comparing the values of percent oviposition deterrence at 0.8 g *P. longum* and *I. verum* similar in their effect with percent oviposition deterrence values 66.91 and 62.96 respectively.

Means in a column, superscripted by the same alphabets not significantly different among themselves (Tukey's test of multiple comparisons)

Botanical insecticides are proved to be better alternatives to synthetic pesticides and world over studies are conducted for finding out plant products with significantly high insecticidal potential. In addition to crop pests, stored product pests are also controlled using plant-based pesticides. Some botanicals are used to protect the stored pulses from bruchid infestations which otherwise have to be managed with toxic synthetic chemical pesticides.

Use of chemical pesticides on table-ready products like grains and pulses is much more injurious than using them on field crops. Exclusive stored product pesticides are slightly expensive but it is advisable to use them in grain storage, since such pesticides will not pose problems to the eventual consumer of the grains, if all the necessary precautions are followed. Pesticides meant for field application should not be used on stored grains. Grains treated with pesticides should be consumed only after the 'waiting period' which depends on the type of pesticide used, mode of application and the residual period [(34,35)]. Grains treated with Pirimiphos methyl and the fumigant Aluminium phosphide are considered to be fit for consumption only after exposure to air for 6 weeks and 4 hours respectively [(36)]. It is not advisable to consume grains treated with pesticides immediately because of the inherent toxic effect. Botanical pesticides are more desirable for controlling insect pests of stored products as the ill effects associated with chemical pesticides are not observed in them.

Table 1. Oviposition capacity and eclosion percentage in *C. maculatus* (n=5; $\bar{X}$±SD)

Plant	Conc. (in g)	Time Interval (h)					Total Eggs	Percenteclosion failure
		24	48	72	96	120		
		No. of eggs						
	Control	16±1.14	19±2.07	18±1.58	14±1.48	9±1.30	77.2±5.21	7.72±2.24
P. longum	0.2	14±1.14	17±2.17	15±1.14	11±1.22	8±1.30	65.0±1.22	8.92±1.26
	0.4	14±1.58	16±1.48	12±1.30	9±0.83	6±1.30	56.6±3.91	9.89±1.34
	0.6	9±1.14	11±1.52	7±1.00	5±1.30	4±0.89	36.0±4.82	10.89±3.43
	0.8	7±1.64	9±1.30	6±1.14	3±0.83	1±0.89	25.8±3.70	12.41±2.97
A. vasica	0.2	15±1.22	17±1.92	16±2.07	11±1.14	9±1.30	67.6±5.81	7.97±1.42
	0.4	11±1.92	15±1.58	14±1.48	10±1.52	8±1.67	58.0±3.39	9.31±1.88
	0.6	10±1.58	14±1.64	11±1.67	10±1.14	7±1.14	53.4±3.91	10.06±1.64
	0.8	9±0.84	12±1.14	10±1.58	7±1.48	5±1.79	43.6±3.44	11.08±1.96
I. verum	0.2	14±1.79	18±1.41	16±1.48	12±1.67	9±1.00	69.8±1.92	8.59±1.40
	0.4	12±1.30	17±1.64	14±1.95	8±1.14	6±1.58	57.8±4.43	9.35±1.86
	0.6	10±1.30	16±1.52	11±1.30	7±1.34	5±1.00	50.2±2.68	9.57±1.66
	0.8	7±1.92	8±1.10	6±1.30	6±0.89	2±1.00	28.4±3.65	13.95±4.95
C. zeylanicum	0.2	13±1.14	15±1.48	13±1.92	9±1.22	7±1.14	57.0±3.24	12.27±1.59
	0.4	9±1.14	12±1.22	8±0.71	7±1.10	3±0.84	39.0±1.87	14.8±1.60
	0.6	8±1.14	10±1.58	6±1.00	4±1.10	2±0.84	29.6±2.70	16.90±2.02
	0.8	5±0.84	8±1.14	4±1.30	2±1.14	0±0.55	18.25±1.30	18.83±3.83
S. aromaticum	0.2	10±1.48	12±1.58	9±0.84	5±0.71	3±0.84	38.8±2.77	13.90±2.26
	0.4	7±1.14	10±1.58	8±0.84	4±1.14	2±1.00	31.6±3.78	16.01±2.83
	0.6	6±1.14	8±1.30	5±1.22	2±0.84	0±0.55	21.8±1.79	18.53±4.09
	0.8	4±1.00	5±1.64	1±0.89	0±0.55	0±0.45	10.8±3.56	22.06±5.38

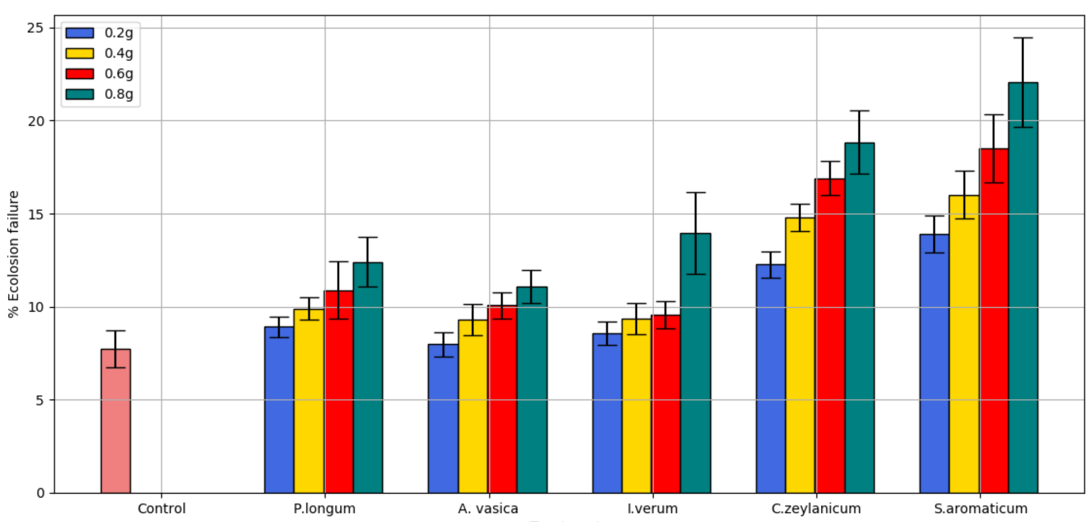

Fig 1. Percent eclosion failure in *C.maculatus* developing from eggs deposited on treated grains

Table 2. Oviposition deterrence index in *C.maculatus* on plant powder - treated grains ($\bar{X}\pm$SD)

Plant	Quantity of plant powder (in g)			
	0.2	0.4	0.6	0.8
	Percent oviposition deterrence			
P. longum	15.54 ± 5.01^{bc}	28.37 ± 6.29^{a}	53.47 ± 7.02^{a}	66.91 ± 4.60^{a}
A. vasica	21.85 ± 4.97^{b}	26.71 ± 2.34^{a}	28.83 ± 4.52^{b}	42.93 ± 4.66^{b}
I. verum	9.38 ± 3.09^{c}	24.82 ± 7.9^{a}	34.82 ± 4.28^{b}	62.96 ± 6.22^{a}
C. zeylanicum	25.76 ± 8.21^{b}	49.22 ± 4.58^{b}	61.44 ± 4.45^{a}	76.33 ± 2.25^{c}
S. aromaticum	49.63 ± 3.57^{a}	58.86 ± 6.2^{b}	71.59 ± 3.56^{c}	85.77 ± 5.41^{d}

For pests of stored grains that deposit eggs on the surface of the grains, agents that deter oviposition are highly desirable. The eggs of *C. maculatus* do not survive if they are not deposited on the grain surface. The hatching larvae require the seed material to complete their life cycle within the grains. If eggs are not deposited, the grains are saved from being used up. Oviposition deterrence values provide a good analysis for comparison of effects of various plant products that inhibit pest population growth. Oviposition deterrence values are interpreted as strongly deterrent (98 to 100%); fairly deterrent (80 to 97%); moderately deterrent (50 to 80%) and not deterrent (< 50%) [37]. Oviposition deterrence activity of aqueous extracts of *Cassia siamia* (Caesalpiniaceae) against *C. maculatus* was found to be high, recording a value of 84.66% [38]. Essential oil of *I. verum* possessed high degree of oviposition deterrent activity against *C. chinensis* [39]. The green inflorescence extracts of Artocarpus altillis (Parkinson) Fosberg (breadfruit) caused 50% oviposition deterrency for *C. maculatus* [40]. In the present study, except *A. vasica* all the plant products were moderately deterrent with mean oviposition deterrence values above 50%.

This study demonstrated the effectiveness of selected spice powders in greatly reducing the oviposition potential of *C. maculatus* and resulting in the failure of the hatched larvae to mature out. The eggs laid on the plant powder coated pulses may contain residues which might be taken in by the developing larvae thereby leading to their death within the pulse. *S.aromaticum* used in this study showed the highest oviposition inhibition at 0.8g concentration, where the mean total eggs laid for 5 days by 2 adult females in 30 g of *V. radiata* were only 10.8 (control: 77.2). The coated spice powder served as a deterrent and the beetles, withheld their eggs from being deposited on a treated unfriendly surface. *C. maculatus* females have the ability to hold back the eggs in their oviducts when the conditions for oviposition were not conducive.

The leaf extract of *Secamone afzelii* (Schult) K. Schum served as an effective oviposition deterrent for C .maculatus [41] where leaf extracts from *S. afzelii* were obtained through the Soxhlet extraction method using methanol and hexane as the solvents and their efficacies were tested on three replicates of five pairs of adult beetles in 20g cowpea by spraying with 0.5, 1.0, 1.5 and 2.0 ml of each extract, corresponding to 2.5, 5.0, 7.5 and 10.0% (v/w) in a Completely Randomized Design (CRD) exposure system. Control treatment was also set in triplicate. The results showed that oviposition and egg hatchability were significantly suppressed on seeds treated with higher concentration of the extracts ($P \leq 0.05$). Hexane leaf extract at 2 ml (10.0% v/w)/20g cowpea seeds was very effective in suppressing oviposition and egg hatchability

S. aromaticum powder at a concentration of 2.5g/20g of sorghum grains caused 100% mortality of adult *Sitophilus oryzae* Linn. within 48 h in a previous study [42]. The GC-MS analysis of *S. aromaticum* showed its primary constituent to be Eugenol (86.7%) which is considered to be the cause for its potent insecticidal activity [43]. In this study, the highest eclosion failure was noted for S. aromaticum at 0.8g with an eclosion failure of 22.06%. In the present study, the high oviposition deterrence and eclosion failure caused by *S. aromaticum*, are presumed to be due to the action of Eugenol. It not only inhibited *C. maculatus* from laying eggs but also hindered the development of larvae within the grains. The plant powder covers the grain surface as an ultrathin coating. The larvae hatching on these treated grains interact with a very small quantity of the plant powder which is sufficient to kill the developing larvae or disrupt normal larval development. Results from other studies suggests that plant extracts might interfere with the normal embryonic development of pests by modifying hormonal and biochemical processes [41,44,45].

The plant extract causes ovarian changes similar to those caused by chemosterilants by negating the female reproductive system. It was reported that *Jatropha curcas* L. seed oil applied at 0.2% (v/w) concentration significantly reduced the number of eggs laid by adult *C. maculatus* and prevented the development of hatched eggs and ultimately eclosion occured 33 days after the treatment [46]. The cowpea seeds treated with *J. curcas* seed oil reduced the number of eggs laid by *C. maculatus* and prevented the adult emergence at concentrations between 0.5 and 2% (v/w) [47]. It is suggested that the oviposition inhibition property of botanical powders on adult bruchids made them lay fewer eggs and killed the larvae hatching from eggs laid on grains [44,48].

Oviposition inhibitors have the advantage of attacking a pest at the start of its life cycle. The insect is deterred from laying its eggs on cereals/grains, thus preventing the pest population from increasing [49]. The egg mortality and the failure to hatch on seeds, treated with the extract, were probably attributed to the toxic component of the extracts and also to the physical properties, which caused changes in the surface tension and the oxygen tension within the eggs [50]. The ovicidal effect of the extract and its lethal effects on the larvae reduced adult emergence resulting in high eclosion failure.

Acetonic extract of *I. verum* was found to cause 100% mortality of young lesser mealworm, *Alphitobius diaperinus* Panzer (Coleoptera:Tenebrionidae) larvae. Anethole, a primary constituent of *I. verum* is considered to be the cause for its insecticidal effects [27]. Cinnamaldehyde, the primary constituent of *C. zeylanicum* when tested against *C. maculatus* and *S. oryzae* showed higher contact and fumigant toxicity [24]. Adult mortality of 97.8% was recorded in 72h when exposed to *S. aromaticum* essential oil at a concentration of 200mg/mL [51]. In the present study, at 0.8g concentration of both *I. verum* and *C. zeylanicum* showed decrease in eclosion with a percent eclosion failure of 13.95 and 18.83 respectively. Methanolic extracts of *A. vasica* showed ovicidal, nymphicidal and juvenomimetic effect on the cotton pest, Dysdercus cingulatus *Audinet-serville* (Hemiptera:Pyrrhocoridae) [(52)]. It also reduced the mean survival and adult emergence of *S. oryzae* [(23)].

Compared to the powders, the essential oils of *S. aromaticum, C. zeylanicum* and *I. verum* were very frequently used by many researchers to study their efficacy as insecticides and the oils are reported to cause adult mortality, oviposition inhibition, pupal mortality, reduced adult emergence and eclosion failure against many Coleopteran stored grain pests like *R. dominica, T.castaneum, C. maculatus* and *C. chinensis* [(25,53–56)].

As per the results of the present study, *S. aromaticum* was highly toxic to *C. maculatus* as an effective oviposition-deterrent and a promoter of significantly low developmental success, as inferred from the high eclosion failure observed in the treated grains. The efficacy of this plant product was followed by *C. zeylanicum*. Among the five plants, *A. vasica* was found to be the least potent with an eclosion failure level of 11.08% at 0. 8g [Table 1]. Except *A. vasica* recording gradual elevation in oviposition deterrence all the other four plant products showed linear drastic increase in oviposition deterrence with increasing concentrations, indicating a moderate toxicity effect of *A. vasica* with respect to *C. maculatus*. Based on the 'F' values calculated the five different plant products used, varied significantly in their impact on the oviposition of *C.maculatus* in all the individual concentrations (0.2, 0.4, 0.6 and 0.8) [Table 3].

Table 3. Concentration-wise one-way analysis of variance of oviposition deterrence in C. maculatus on V. radita protected by five plant products

Concentrationof plant products (g)	Source	Sum of Squares	Df	Mean Square	F	Critical P value
0.2	Between Groups	4744.527	4	1186.132	39.746	0.000
	Within Groups	596.853	20	29.843		
	Total	5341.380	24			
0.4	Between Groups	4767.736	4	1191.934	34.441	0.000
	Within Groups	692.152	20	34.608		
	Total	5459.888	24			
0.6	Between Groups	6437.372	4	1609.343	64.201	0.000
	Within Groups	501.346	20	25.067		
	Total	6938.719	24			
0.8	Between Groups	5175.695	4	1293.924	55.248	0 .000
	Within Groups	468.409	20	23.420		
	Total	5644.104	24			

At 0.05 level the oviposition deterrence of various plant products at each concentration are significantly different.

Further, Tukey analyses revealed the significance of the statistical deviations between the individual responses of the five different plant products on oviposition deterrence at each concentration level [Table 3]

Extended formulation time and high investment costs are some limitations associated with the use of botanical extracts in pest control [(57)]. Rather than using essential oils and plant extracts, the usage of plant powders would provide an easier and cheaper alternative for farmers and warehouse keepers to control stored grain pests like *C. maculatus*.

4 Conclusion

This study confirms the potent insecticidal property of *S. aromaticum* spice powder in causing inhibition of oviposition of female *C. maculatus* and also damaging the developing larva to cause eclosion failure. It was found to strike the pest at the initial phase of its life cycle and also the larval stage which is secure inside the seed and thereby causing greatly reduced progeny. To achieve higher effectiveness their application can be integrated with other pest management practices. Since preparation of plant powder is non-laborious and needs less investment it would be most comfortable for the farmers, pantry holders or house wives to use it with ease.

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