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Botanical Pesticides for the Management of *Callosobruchus chinensis* Infesting Chickpea during Storage

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present research on efficacy of botanicals against pulse beetle in stored chickpea was conducted under laboratory conditions at Department of Entomology, SHUATS, Prayagraj, India during 2020-2021. The experiment was carried in the Completely Randomized Design with twelve treatments (Neem oil, Castor oil, Pungam oil and plant powders neem leaf powder, neem seed kernel powder, Vasambu rhizome powder, Turmeric powder, Custard apple leaf powder, Eucalyptus leaf powder, *Lantana camara* leaf powder, Notchi leaf powder, insecticide (Rynaxypyr) and untreated control. The results were evaluated on the basis of adult mortality, weight loss and Feeding Detterent Index. Vasambu rhizome powder, Neem oil, Castor oil, and Pungam oil were discovered to be the most successful treatments, demonstrating 100% adult mortality, negligible weight loss, and 100% Feeding Detterent Index.The effectiveness of the plant oils is due to their

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repellency and ovipositional detterent effects on stored products and the effeciency of vasambu rhizome powder was due to the presence of active principle, keta osarone which induces premature death of insects.

Keywords: Botanicals; feeding detterent index; pulse beetle; mortality; insecticides; weight loss.

ABBREVIATIONS

FDI = Feeding Detterent Index, HAT=Hours after Treatment, DAT= Days after Treatment.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an venerable crop that has been cultivated in the Middle East, parts of Africa, India and Pakistan for several years. In Southern European nations, West and South Asia it offers high-quality protein and is regarded as the ideal cuisine for the vegetarian population. Chickpea is used in a range of different preparations in cuisine and has a good source of energy i.e. 416 calories/100 gm chickpea along with protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins [1]. In India, a total of 98.5 Lha is used for chickpea cultivation, with an average annual production of 119.9 Lt; in Uttar Pradesh, however, only 6.1 Lha and 840 Lt are used[2]. In addition to production limitations, farmers' storage conditions result in a substantial post-harvest loss of chickpea. The major factor of the heavy loss of the grain legumes in the storage is pulse beetle (*C. chinensis* L.) [3,4]. The pulse beetle, *Callosobruchus chinensis* L. Fab. (Coleoptera: Bruchidae), is a major pest of economically important leguminous grains, such as chick pea, cowpeas, lentils, green gram, and black gram [5]. The larvae consume the pulse grain to the point where it is no longer suitable for human consumption, replanting, or sprouting. Under storage circumstances, they are significant pests of pulse crops in Asia and Africa. [6]. The grain damage was as high as 69.93% under storage condition [7]. Small farmers, village merchants, and typical houses with inadequate storage conditions are particularly affected by this insect.

Serious problems of genetic resistance by insect species, pest resurgence, residual toxicity, photo toxicity, vertebrate toxicity, widespread environmental hazards and increasing costs of application of the presently used synthetic pesticides have directed the need for effective, biodegradable pesticides [8]. This understanding has sparked interest in developing alternative tactics all around the world, including a reconsideration of the use of plant extracts against agriculturally significant insect pests. Materials made of plants, degrade more quickly. Some may function more selectively, be less poisonous to mammals, or delay the emergence of resistance. The primary benefit is that they are easily and reasonably produced by farmers and small-scale industries as unpurified or partially pure extracts. Over the past 20 years, a lot of effort has been made to screen plants in an effort to develop new botanical insecticides that can replace those currently in use. The emergence of adult bruchids is suppressed, the rate of seed damage and oviposition is decreased when leaf, bark, seed powder, or oil extracts of plants are combined with stored grains[6].

2. MATERIALS AND METHODS

The experiment was carried invitro at the Department of Entomology, SHUATS, Prayagraj, with ambient room temperature of 28±2°C and relative humidity of 65–70%. The culture of the test insect, pulse beetle was reared on whole chickpea. The plant materials were dried (leaves, rhizomes, and kernels) in the shade before being ground into a fine powder. The plant oils and insecticide (Rynaxypyr) were procured from the local market. The experiment was carried with 13 treatments including control. Plant powders such as Neem seed kernel powder, Neem leaf powder, Vasambu rhizome powder, Turmeric powder, Custard apple leaf powder, Eucalyptus leaf powder, *Lantana camara* leaf powder, Notchi leaf powder @2gm/100gm of seeds) and plant oils such as neem oil, castor oil, Pungam oil @2ml/100gm of seeds and insecticide (Rynaxypyr @ 0.01ml/1kg of seeds) were used and each treatment was replicated thrice.

2.1 Determination of Adult Mortality of Pulse Beetle

For the experiment of the pulse beetle's adult mortality, 100g of treated pulses were placed in plastic containers. Before being sealed, fifteen

pairs of adults ranging in age from 0 to 24 hours were placed inside each container. The total number of dead beetles was counted at 24, 48, 72, and 96 hours, respectively. It was presumed that the beetle had died when it did not respond to gentle pressure from a fingertip. Dead bruchids were taken out after each counting.

The following formula was used to calculate the adult mortality rate of *C. chinensis*.

Mortality (%) = No. of dead beetle / Total no. of released beetle [9] × 100

2.2 Determination of Percent Weight Loss of Seed and FDI

150g of seeds from different pulses that had been given treatmental concentrations were employed in the trials. Initial seed weights were recorded. 15 pairs of adults aged 0 to 24 were released. The weights of the seeds were once again recorded after 30, 60, and 90 days.

Percent weight loss was determined using the following formula:

Percent weight loss = w-f / w x 100 [10]

Where,

w = Initial weight of seeds,
f = Final weight of seeds.

2.2.1 Feeding detterent index

Feeding Detterent Index was calculated by using the formula

$$FDI = \frac{C - T}{C} \times 100 \quad [11]$$

C = Consumption in control seed (weight loss in control)
T = consumption in treated seed (weight loss in treated)

After the completion of the experiment, the data was statistically analysed using WASP 2.0 statistical software and results were evaluated after proper tabulation of the observations.

3. RESULTS

The data collected on the effect of different botanicals on the adult mortality of pulse beetle at 24, 48, 72 and 96 hours after application of treatments is presented in the Table 2.

Data (Table1) revealed that the mortality of released adults was highest in treatment, Vasamburhizome powder @2gm/100 gm of seeds (100.00%) followed by Turmeric powder@2gm/100gm of seeds (98.33%), *Lantana camera* leaf powder @2gm/100gm of seeds (95.00%),Custard apple leaf powder @2gm/100gm of seeds (91.67%), Neem leaf powder @2gm/100gm of seeds (85.00%), *Eucalyptus* leaf powder @2gm/100gm of seeds (83.33%), Notchi leaf powder @2gm/100gm of seeds (81.67%), Insecticide (Rynaxypyr) @0.01ml/1kg of seeds(65.00%) and Neem Seed kernel powder @2gm/100gm of seeds (56.67%).

All the plant oils namely, Neem oil @2ml/100gm of seeds, Castor oil @2ml/100gm of seeds and Pungam oil @2ml/100gm of seeds showed 100% mortality of released adults after 96 hours of treatment.

Neem Seed kernel powder @2gm/100gm of seeds was found to be the least effective treatment, with adult mortality (56.67%) that differed substantially from the untreated control (0.00%).

Treatments (T_3 and T_4), (T_2 and T_6), (T_1 and T_{12}) and (T_9, T_{10} and T_{11}) were found to be at par with each other.

Data pertaining to effectiveness of botanicals as seed protectants of chickpea on quality parameter of seed weight response against pulse beetle are presented in the Table 3.

Weight loss: The data regarding the weight loss of treated chickpea clearly showed the efficacy of Neem oil @2ml/150gm of seeds, Castor oil @2ml/150gm of seeds, Pungam oil @2ml/150gm of seeds, Insecticide (Rynaxypyr) @0.01ml/1kg of seeds and Vasambu rhizome powder oil @2mg/150gm of seeds which significantly recorded negligable weight loss. Where a weight loss was observed in the seeds treated with Turmeric powder@2gm/150 gm of seeds(7.30%) followed by *Eucalyptus* leaf powder @2gm/150gm of seeds(7.97%), Neem Seed kernel powder @2gm/150 gm of seeds (8.20%), Custard apple leaf powder @2gm/150 gm of seeds (8.63%), Neem leaf powder @2gm/150 gm of seeds (9.97%), *Lantana camera* leaf powder @2gm/150 gm of seeds (9.30%) and Notchi leaf powder @2gm/150 gm of seeds (11.50%) in comparision to maximum

weight loss in untreated pulses caused by the infestation of pulse beetle after 90 days of storage.

FDI: It has been observed that among all the treatments**,** Neem oil @2ml/150 gm of seeds, Castor oil @2ml/150gm of seeds, Pungam oil@2ml/150gm of seeds, Insecticide (Rynaxypyr) @0.01ml/1kg of seeds and Vasambu rhizome powder @2gm/150gm of seeds were most effective with highest FDI (100.00%) which differs significantly from all other treatments. This was followed by Turmeric powder @2gm/150gm of seeds(54.16%), *Eucalyptus* leaf powder @2gm/150gm of seeds(50.00%), Neem Seed kernelpowder @2gm/150gm of seeds (48.60%), Custard apple leaf powder @2gm/150gm of seeds (45.83%),

Table 1. Active ingredients and insecticidal activity of treatments

S.no	Treatments	Active ingredients	Insecticidal activity	Reference
1	Neem Seed Kernel	Tetranortriterpenoids (Azadirachtin, melantriol, salannin, nimbin, nimbidin, etc)	Antifeedent, Repellent,insect growth regulator	[12]
2	Neem Leaf Powder	Tetranortriterpenoids (Azadirachtin, melantriol, salannin, nimbin, nimbidin, etc)	Antifeedent ,Repellent,Anti inflammatory properties	[32]
3	Vasambu rhizome powder	keta asarone, Z – asarone	Repellent,Antifeedent	[13]
4	Turmeric Powder	Curcumin	Antifeedent,toxicant,Repellent,Growth regulator	[14]
5	Custard apple leaf powder	Squamocin and squamostatin Alkaloid,isomeric hydroxyl ketones	Repellent and anti ovipositional properties	[15]
6	*Eucalyptus* leaf powder	Globulol, Terpineol,Limonene,1,8 cineole,Mono and sesquiterpenes hydro carbons	Repellent,contact toxicity causes mortality	[16]
7	*Lantana camara* leaf powder	Lantic acid, Coumaran	Contact toxicity,Antifeedent,Repellent,Supress progeny production	[17]
8	Notchi leaf powder	casticin, isoorientin	Antifeedent,Insect growth regulator	[18]
9	Neem oil	Tetranortriterpenoids (Azadirachtin, melantriol, salannin, nimbin, nimbidin, etc)	Anti fertility agent,Antifeedent,Ovicidal,Larvicidal	[12]
10	Castor oil	Ricin and Ricinine.	Repellent, Antifeedent, causes suffocation inteferring with respiration	[19]
11	Pongam oil	Karanjin,pungamol,pongapin,glabrin	Oviposition deterrent	[20]
12	Coragen	Rynaxypyr® active	Act on insect ryanodine receptors. Affected insects rapidly cease eating , become paralysed, and usually die within one to three days.	[33]

Table 2. Effect of different botanicals on adult mortality of pulse beetle *C. chinensis* in chick pea at different Hours after Treatment (HAT)

S.No.	Treatments	Adult mortality after			
		24Hours	48Hours	72Hours	96Hours
1	Neem Seed kernel powder @2gm/100gm of seeds	6.67^{ef}	20.00^{d}	38.33^{f}	56.67^{d}
2	Neem leaf powder @2gm/100gm of seeds	18.33^{cde}	40.00^{c}	66.67^{cd}	85.00^{bc}
3	Vasamburhizome powder @2gm/100 gm of seeds	96.67^{a}	100.00^{a}	100.00^{a}	100.00^{a}
4	Turmeric powder@2gm/100gm of seeds	26.67^{bc}	65.00^{b}	75.00^{bc}	98.33^{a}
5	Custard apple leaf powder @2gm/100gm of seeds	31.67^{b}	60.00^{b}	80.00^{b}	91.67^{abc}
6	*Eucalyptus* leaf powder @2gm/100gm of seeds	11.67^{def}	51.67^{bc}	73.33^{bc}	83.33^{bc}
7	*Lantana camera* leaf powder@2gm/100gm of seeds	26.67^{bc}	51.67^{bc}	80.00^{b}	95.00^{ab}
8	Notchi leaf powder @2gm/100gm of seeds	20.00^{bcd}	36.67^{c}	58.33^{de}	81.67^{c}
9	Neem oil@2ml/100gm of seeds	98.33^{a}	100.00^{a}	100.00^{a}	100.00^{a}
10	Castor oil @2ml/100gm of seeds	96.67^{a}	100.00^{a}	100.00^{a}	100.00^{a}
11	Pungam oil@2ml/100gm of seeds	95.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
12	Insecticide(Rynaxypyr)@0.01ml/1kg of seeds	16.67^{cde}	38.33^{c}	51.67^{e}	65.00^{d}
13	Untreated Control	0.00^{f}	0.00^{e}	0.00^{g}	0.00^{e}
CD at 5%		11.94	15.32	12.89	12.89
SE (m)±		4.11	5.27	4.43	4.43

Neem leaf powder @2gm/150gm of seeds (37.50%), *Lantana camera* leaf powder @2gm/150gm of seeds(41.66%) and Notchi leaf powder @2gm/150gm of seeds (27.76%) which differs significantly from untreated control (0.00%).

4. DISCUSSION

Among the different treatments of botanicals used to evaluate the adult mortality of pulse beetle, *C.chinensis*, vasambu rhizome powder and neem oil showed the highest percent adult mortality, this might be as a result of the fact that essential oils from plants are extremely lipopholic and can therefore permeate insect cuticles. [21]. After ten days of treatment, Neem oil was discovered to result in 100% death of *Callasobruchus maculates*, according toRam and Gopal [22]. Rhizome powder was found to be lethal, resulting in 100% mortality and completely impeding F1 emergence by ovicidal action, according to Shuklaet al.[23]. The mortality was noticeably increased in oil-treated seeds compared to controls, according to Yadav et al. [24]. Maximum adult mortality of pulse beetle on cowpea seeds treated with neem oil and castor oil was reported byBajya et al. [25].

The beneficial effect of vasambu rhizome powder on maintenance of seed quality was focused to the presence of active principle, keta osarone, which prevent the bruchid infestation and preserved the genetic storage potential of seed [26]. The present data are correlated with the results of [27]. According to Homan and Yubak [28], chickpea treated with dust from the rhizome of *A. calamus* showed negligable weight loss. The low grain damage and less weight loss in oil treatment might be due to the decrease in number of adult emergence [29]. The results in respect of use of neem oil as seed protectant corroborated with those of [30] who observed no seed damage by *C. chinensis* in seeds of horse gram when treated with neem oil at 5 ml/kg seed. Pigeon pea seeds coated with neem and castor oil gave significant protection against pulse beetle compared to the untreated control [31] also supports the present findings [32,33].

Table 3.Effectiveness of botanicals on percent weight loss of stored chickpea caused by *Callosobruchus chinensis* at 30,60 and 90 Days After Treatment (DAT)

S.No.	Treatments	30 DAT		60 DAT		90 DAT	
		Weight loss(%)	FDI(%)	Weight loss(%)	FDI(%)	Weight loss(%)	FDI(%)
1	Neem Seed kernel powder @2gm/150gm of seeds	2.87^{cd}	47.22^{bcd}	5.73^{c}	48.15^{c}	8.20^{def}	48.61^{bc}
2	Neem leaf powder @2gm/150gm of seeds	3.30^{bc}	39.35^{cd}	7.97^{b}	28.24^{d}	9.97^{c}	37.50^{e}
3	Vasamburhizome powder @2gm/150 gm of seeds	0.00^{e}	100.00^{a}	0.00^{e}	100.00^{a}	0.00^{g}	100.00^{a}
4	Turmeric powder@2gm/150gm of seeds	2.20^{d}	59.72^{b}	4.20^{d}	61.80^{b}	7.30^{f}	54.16^{b}
5	Custard apple leaf powder @2gm/150gm of seeds	3.07^{bcd}	43.98^{bcd}	5.77^{c}	47.92^{c}	8.63^{de}	45.83^{cd}
6	*Eucalyptus* leaf powder @2gm/150gm of seeds	2.63^{cd}	51.85^{bc}	5.10^{cd}	54.17^{bc}	7.97^{ef}	50.00^{bc}
7	*Lantana camera* leaf powder@2gm/150gm of seeds	3.30^{bc}	39.35^{cd}	7.73^{b}	27.86^{d}	9.30^{cd}	41.66^{de}
8	Notchi leaf powder @2gm/150gm of seeds	3.77^{b}	31.48^{d}	8.63^{b}	21.53^{d}	11.50^{b}	27..76^{f}
9	Neem oil@2ml/150gm of seeds	0.00^{e}	100.00^{a}	0.00^{e}	100.00^{a}	0.00^{g}	100.00^{a}
10	Castor oil @2ml/150gm of seeds	0.00^{e}	100.00^{a}	0.00^{e}	100.00^{a}	0.00^{g}	100.00^{a}
11	Pungam oil@2ml/150gm of seeds	0.00^{e}	100.00^{a}	0.00^{e}	100.00^{a}	0.00^{g}	100.00^{a}
12	Insecticide(Rynaxypyr)@0.01 ml/1kg of seeds	0.00^{e}	100.00^{a}	0.00^{e}	100.00^{a}	0.00^{g}	100.00^{a}
13	Untreated Control	5.73^{a}	0.00^{e}	11.07^{a}	0.00^{e}	16.00^{a}	0.00^{g}
CD at 5%		0.86	16.90	1.12	9.08	1.11	6.91
SE (m)±		0.29	5.81	0.38	3.12	0.38	2.38

5. CONCLUSION

From the present study, it can be concluded that besides insecticide (Rynaxypyr) all the plant oils neem oil, castor oil and pungam oil and Vasambu rhizome powder were effective in causing the mortality of the pulse beetle and in giving negligible weight loss. They can therefore be used to successfully shield pulses from this pest while they are in storage. These results suggest that the plant oils and plant powders, which are affordable, environmentally benign can control pest infestation under storage conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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