

Eco-friendly management of Pulse beetle infesting chickpea during storage

Abstract:

The present research on efficacy of botanicals against pulse beetle in stored chickpea was conducted under laboratory conditions. 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 Deterrent Index. Among all the treatments, Vasambu rhizome powder, Neem oil, Castor oil and Pungam oil were found to be the most effective treatments showing 100% adult mortality at 96hrs after treatment, negligible seed weight loss after 90 days of storage of treated chickpea with 100% Feeding Deterrent Index. The effectiveness of the plant oils is due to their repellency and ovipositional deterrent effects on stored products and the efficiency of vasambu rhizome powder was due to the presence of active principle, keta osarone which induces premature death of insects.

Keywords: *Botanicals, FDI, pulse beetle, mortality, insecticides, weight loss.*

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 our cuisine and has a good source of energy i.e. 416 calories/100 gm chickpea (Shrestha, 2001) along with protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins (Ali and Prasad, 2002). Chickpea is cultivated upon an area of 98.5 Lha with an average production of 119.9 Lt in India while the cultivated area and production in Uttar Pradesh is 6.1 Lha and 840 Lt. (Directorate of Economics and Statistics, DAC and FW, 2020). 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.) (Southgate, 1978; Talekar, 1988). 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 (Park *et al.* 2003). The larvae eat through the pulse grain, rendering it unfit for human nutrition, replanting viability, or sprout production. They are important pests of pulse crops in Asia and Africa under storage conditions (Tapondjou *et al.*, 2002). The grain damage was as high as 69.93% under storage condition (Singh *et al.*, 2001). 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 (Elhag, 2000). 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 advantage is that farmers and small-scale businesses can readily and inexpensively generate them as unpurified or only partially purified extracts. A lot of work has been put into screening plants over the past 20 years in attempt to create new botanical pesticides that can replace the present insecticides. It was reported that when mixed with stored-grains, leaf, bark, seed powder, or oil extracts of plants reduce oviposition rate and suppress adult emergence of bruchids, and also reduced seed damage rate (Tapondjou *et al.*, 2002).

2. Materials and methods:

The experiment was carried invitro at the Department of Entomology, SHUATS, Prayagraj, with ambient room temperature of $28\pm 2^{\circ}\text{C}$ and relative humidity of 65–70%. The culture of the test insect, pulse beetle was reared on whole chickpea. The plant powders were prepared by drying (kernals, leaves and rhizomes) under shade and then grinded to get fine powder. The plant oils and insecticide (Rynaxypyr) were procured from the local market. There were 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:

100gm of treated pulses were put in plastic containers for the investigation into adult mortality of the pulse beetle, *Callosobruchus chinensis* L. Each container was filled with fifteen pairs of adults aged 0 to 24 hours before being sealed. After 24, 48, 72, and 96 hours of treatment, respectively, the number of dead beetles was counted. When the beetle did not move in response to light pressure from a fingertip, death was assumed. After each counting, dead bruchids were removed. The following formula was used to calculate the adult mortality rate of *C. chinensis*.

$$\text{Mortality (\%)} = \frac{\text{No. of dead beetle}}{\text{Total no. of released beetle}} \times 100$$

(Vijayalakshmi *et al.*, 2021)

2.2.Determination of percentage 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. After 30, 60, and 90 days, the weights of the seeds were once again recorded.

2.2.1.Percent weight loss was determined using the following formula:

Percent weight loss = $\frac{w - f}{w} \times 100$ (Kobir *et al.* 2019)

w

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

2.2.2. Feeding deterrent index:

Feeding Deterrent Index was calculated by using the formula

$$FDI = \frac{C - T}{C} \times 100 \quad (\text{Isman } et al., 1990)$$

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.

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	Chaudhary <i>et al.</i> (2017)
2	Neem Leaf Powder	Tetranortriterpenoids (Azadirachtin, melantriol, salannin, nimbin, nimbidin, etc)	Antifeedent, Repellent, Anti inflammatory properties	Chaudhary <i>et al.</i> (2017)
3	Vasambu rhizome powder	keta asarone, Z – asarone	Repellent, Antifeedent	Shinthiya and Razak (2017)

4	Turmeric Powder	Curcumin	Antifeedent,toxicant,Repellent ,Growth regulator	Ali et al. (2014)
5	Custard apple leaf powder	Squamocin and squamostatin Alkaloid,isomeric hydroxyl ketones	Repellent and anti ovipositional properties	Khalequzaman and Sultana (2006)
6	<i>Eucalyptus</i> leaf powder	Globulol, Terpeneol,Limonene,1,8 cineole,Mono and sesquiterpenes hydro carbons	Repellent,contact toxicity causes mortality	Russo et al. (2015)
7	<i>Lantana camara</i> leaf powder	Lantic acid, Coumaran	Contact toxicity,Antifeedent,Repellent, Supress progeny production	Rajashekar, et al. (2014)
8	Notchi leaf powder	<u>casticin, isoorientin</u>	Antifeedent,Insect growth regulator	Haridasan et al. (2017)
9	Neem oil	Tetranortriterpenoids (Azadirachtin, melantriol, salannin, nimbin, nimbidin, etc)	Anti fertility agent,Antifeedent,Ovicidal,Larvicidal	Chaudhary et al.(2017)
10	Castor oil	Ricin and Ricinine.	Repellent, Antifeedent, causes suffocation interfering with respiration	Haghtalab et al. (2009)
11	Pongam oil	Karanjin,pungamol,pongapin ,glabrin	Oviposition deterrent	Reena et al. (2012)
12	Coragen	Rynaxypyr [®] active	Act on insect ryanodine receptors. Affected insects rapidly cease eating , become paralysed, and usually die within one to three days.	Yadav and Singh (2018)

3. RESULTS

3.1.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 (Table.1) revealed that the mortality of released adults was highest in treatment, Vasambu rhizome 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 used 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 (T₃ and T₄), (T₂ and T₆), (T₁ and T₁₂) and (T₉, T₁₀ and T₁₁) were found to be at par with each other.

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	Vasambu rhizome 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	<i>Eucalyptus</i> leaf powder @2gm/100gm of seeds	11.67 ^{def}	51.67 ^{bc}	73.33 ^{bc}	83.33 ^{bc}

7	<i>Lantana camera</i> 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

3.2. 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.

3.2.1. 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 negligible weight loss. Where as 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 comparison to maximum weight loss was

recorded in untreated pulses caused by the infestation of pulse beetle after 90 days of storage of treated chickpea.

3.2.2.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 per cent 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 kernel powder @2gm/150gm of seeds (48.60%), Custard apple leaf powder @2gm/150gm of seeds (45.83%), 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%).

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.N o.	Treatments	30 DAT		60 DAT		90 DAT	
		Weigh t loss(%)	FDI(%)	Weigh t loss(%)	FDI(%)	Weigh t loss(%)	FDI(%)
1	Neem Seed kernel powder @2gm/150gm of seeds	2.87 ^{cd}	47.22 ^{bc} d	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	Vasambu rhizome powder	0.00 ^e	100.00	0.00 ^e	100.00	0.00 ^g	100.00

	@2gm/150 gm of seeds		a		a		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 ^{bc} d	5.77 ^c	47.92 ^c	8.63 ^{de}	45.83 ^{cd}
6	<i>Eucalyptus</i> 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	<i>Lantana camera</i> 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)@0.01ml /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

4.DISCUSSION

4.1.Among the different treatments of botanicals used to evaluate the adult mortality of pulse beetle, *C.chinensis* at different hours after treatment, among all the botanicals vasambu rhizome powder and neem oil showed the highest percent adult mortality, this may be due to essential oils of plant origin are highly lipophilic and therefore have the ability to

penetrate the cuticle of insects (**Abdullahi et al., 2011**). (**Ram and Gopal, 2000**) observed that Neem oil was found to cause 100% mortality of *Callasobruchus maculatus* after ten days of treatment. (**Shukla et al., 2009**) also reported that rhizome powder proved fatal, causing 100% mortality and completely inhibiting F1 emergence by ovicidal activity. (**Yadav et al., 2004**) also recorded that the mortality was significantly higher in oil treated seeds compared to control. Maximum adult mortality of pulse beetle on cowpea seeds treated with neem oil and castor oil was reported by (**Bajya et al., 2007**).

4.2.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 (**Ananthi et al., 2017**). The present data are correlated with the results of **Chander et al., 2007**. **Regmi and Dhoj (2013)** reported that percent weight loss was very much low, almost no damage and no loss was observed in chickpea treated with *A. calamus* rhizome dust. The low grain damage in oil treatment might be due to the decrease in number of adult emergence that results in less weight and less grain damage (**Raja and Williams, 2008**). The results in respect of use of neem oil as seed protectant corroborated with those of **Ramangoudar et al. (2000)** who observed no seed damage by *C. chinensis* in seeds of horse gram when treated with neem oil at 5 ml/kg seed. **Singh (2003)** who reported that pigeon pea seeds coated with neem and castor oil gave significant protection against pulse beetle compared to the untreated control also supports the present findings.

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. So they can be used for successful protection of pulses from this pest in storage. These results indicate that the plant oils and plant powders, which are cheap, eco-friendly and household products help in control of pest infestation for small-scale farmers under storage conditions.

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