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Efficacy of Some Botanical Powders as Grain Protectants Against Pulse Beetle (*Callosobruchus chinensis* L.) on Ricebean (*Vigna umbellata* Thunb.)

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ABSTRACT

An experiment was conducted during January–June of 2019 and 2020 in the laboratory of the Department of Entomology, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, Dimpaur district, Nagaland, India to evaluate the efficacy of some botanical powders as grain protectants against pulse beetle, *Callosobruchus chinensis* (L.) on ricebean, *Vigna umbellata* (Thunb.). The experiment was conducted in a Completely Randomized Design (CRD) with 3 replications. A total of 7 plant materials viz., *Azadirachta indica*, *Piper nigrum*, *Ocimum tenuiflorum*, *Eucalyptus globules*, *Allium sativum*, *Pongamia pinnata* and *Litsea citrata* were evaluated for their effect on oviposition reduction, adult emergence, infestation and weight loss by *C. chinensis*. All the plant products were mixed with susceptible ricebean seeds @ 5% w/w, Malathion 5% dust @ 1% w/w was used as standard check and untreated seed was used as control. Among the botanical powder treatments, the highest reduction in oviposition was found in *L. citrata* followed by *A. indica* and *P. nigrum*. The % adult emergence was also lowest in *L. citrata* treatment (55.23%) compared to the other botanical treatments. *L. citrata* seed powder also provided effective protection up to 2 months of storage with an infestation of 16.12% and weight loss of 2.40%, respectively followed by *P. nigrum* seed powder with an infestation of 31.67% and weight loss of 6.93%, respectively. The least effective was found in *P. pinnata* leaf powder. The findings revealed the potential of *L. citrata* and *P. nigrum* as grain protectants against pulse beetle in storage.

KEYWORDS: Botanical, grain protectants, infestation, pulse beetle, ricebean, storage

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1. INTRODUCTION

Pulses are important food crops that provides the nutritional needs of diverse human diets. They are rich source of protein, carbohydrates, minerals, vitamins and amino acids. In India, a variety of pulse crops are cultivated across a wide range of agro-climatic conditions which are utilized as a fodder crop and contribute to soil health, in addition to being consumed for their protein content. Among the various pulse crops, ricebean, *Vigna umbellata* (Thunb.) is an important pulse in Nagaland and is popularly known as '*Naga Dal*'. It is a traditional and native crop which has been cultivated for centuries and is grown predominantly under rainfed condition in mixed cropping system, shifting cultivation or in the kitchen garden. There are many landraces of ricebean under cultivation in Nagaland. Ricebean like other *Vigna* species is a versatile crop mostly grown as a dry pulse and also used as a fodder and green manure (Kumar et al., 2014, Chiphang et al., 2022). It is often considered a minor and underutilized crop cultivated mostly by farmers of South and Southeast Asia (Tian et al., 2013, Pattanayak et al., 2019). In the recent time ricebean has gained importance due to its adaptability in poor soil conditions as well as due to its nutritional quality (Bepary et al., 2017, Dhillon and Tanwar, 2018). The ricebean seeds are rich in protein, minerals, carbohydrates, amino acids and vitamins (Katoch, 2013). However, like any other pulse, ricebean seeds are also prone to attack by bruchids in storage. The pulse beetle, *Callosobruchus chinensis* L. is one of the major economically important pests of pulses causing considerable damage (Park et al., 2003, Duraimurugan et al., 2011, Neog, 2012, Gahukar and Reddy, 2018, Paikaray et al., 2022). The primary infestation starts from field where the infested seeds are harvested and carried to storage resulting in secondary infestation (Rana et al., 2013, Srivastava and Subramanian, 2016). *C. chinensis* feeds on the seeds and multiplies in storage which increases infestation causing up to 50% damage of seeds within 3-4 months of storage (Vijayalakshmi et al., 2021). The insect infestation not only damages the grains but also affects the nutritional quality rendering the seeds unsuitable for human consumption and also affects germinability of the seeds (Ponnusamy et al., 2014, Nisha, 2020, Pradhan et al., 2020). Generally, synthetic insecticides are used for the management of insect pests in storage. However, there are many limitations and undesirable side effects associated with the indiscriminate use of synthetic insecticides such as environment and health hazards, development of resistance, pest resurgence, toxic residues etc. (Zettler and Cuperus, 1990, Isman, 2006, Nayak et al., 2020, Rajmohan et al., 2020, Souto et al., 2021). Therefore, there has been an increased need to explore suitable alternative methods of pest management. The use of plant products is one such alternative as they are cheap, easy to use, readily available, biodegradable, specific mode of action, safe for the environment and human beings (Gahukar, 2012, Kedia et al., 2015, Mounika et al., 2021). Various plant products have been found to have insecticidal, oviposition deterrent and ovicidal properties against bruchids and other insect pests (Tripathi et al., 2002, Singh, 2003, Singh et al., 2006, Ahad et al., 2012, Suthar and Bharpoda, 2016, Swamy and Wesley, 2017).

Keeping the above aspects in view, the present study was carried out to evaluate some locally available botanicals for their effect on oviposition reduction, adult emergence, infestation and weight loss by pulse beetle, *C. chinensis* on ricebean, *V. umbellata* seeds.

2. MATERIALS AND METHODS

The experiment to study the efficacy of botanical powders against pulse beetle, *C. chinensis* on ricebean, *V. umbellata* was conducted during January–June of 2019 and 2020 in the laboratory of the Department of Entomology, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus. The experimental site is located at Medziphema (20°45'43" N latitude and 93°53'04" E longitude), Nagaland at an altitude of 304.8m above mean sea level. The experiment was conducted in a Completely Randomized Design (CRD) with 3 replications.

2.1. Culture of test insect

The test insect pulse beetle, *C. chinensis* was used for the experiment. The insects were reared in a plastic container on susceptible ricebean seeds. For a continuous supply of insects for the experiment, the population of pulse beetle was maintained at regular intervals by adding fresh seeds for egg laying. The containers were observed regularly for adult emergence and were collected for use in the experiment. The adults were differentiated as male and female using key described by Arora (1977).

2.2. Preparation of botanical powders

A total of 7 plant materials viz., leaves of *Azadirachta indica*, *Ocimum tenuiflorum*, *Eucalyptus globules*, *Allium sativum*, *Pongamia pinnata* and seeds of *Piper nigrum* and *Litsea citrata* were collected from Medziphema area and were washed and shade dried. The dried plant materials were ground by using an electric grinder, sieved and made into fine powders.

2.3. Effect of treatment on oviposition and adult emergence

For the evaluation of oviposition reduction effects of the plant powders, 25 seeds of ricebean was taken in a container and mixed with the plant powders @ 5% w/w, Malathion 5%

dust @ 1% w/w was used as standard check and untreated seeds were used as control (Table 1).

Table 1: Treatment details

Treatments	Plant parts used	Dosage (% w/w)
Azadirachta indica	Leaf	5 %
Piper nigrum	Seeds	5 %
Ocimum tenuiflorum	Leaf	5 %
Eucalyptus globules	Leaf	5 %
Allium sativum	Bulb	5 %
Pongamia pinnata	Leaf	5 %
Litsea citrata	Seeds	5 %
Malathion 5% Dust		1%
Untreated control		-

4 pairs of newly emerged *C. chinensis* male and female were introduced in each container. After 10 days, the number of eggs laid on treated and control seeds were recorded and the % reduction in oviposition was calculated by using the formula:

Reduction in oviposition (%)=(Number of eggs laid in control-Number of eggs laid in treated seeds)/Number of eggs laid in control×100……….....................................(1)

After the eggs were counted, the containers were kept undisturbed and regular observation was done for the emergence of adults. As adult emergence initiates, observations were recorded and adults were removed at a regular interval of 24 h until no further emergence occurred for 5 consecutive days. The adult emergence (%) was calculated by using the formula:

Adult emergence (%)=(Number of adults emerged)/(Number of eggs laid)× 100 ....……..(2)

2.4. Effect of treatment on infestation and weight loss

To study the effect of treatment on infestation and weight loss, 100g ricebean seeds were taken and mixed with the plant powders @ 5% w/w. Malathion 5% dust @ 1% w/w was used as standard check and untreated seed was used as control. The treated as well as untreated seeds were kept in container closed with a perforated lid. 4 pairs of freshly emerged male and female adults of *C. chinensis* were released into each container. The observations on infestation and weight loss were recorded after 2, 4 and 6 months of storage. The infestation and weight loss were calculated by using the formula:

Infestation (%)=(Number of holed seeds)/(Total Number of seeds)×100 …..………(3)

Weight loss (%)=(Initial weight of grains-Final weight of grains)/Final weight of grains×100 ..………………..(4)

2.5. Effect of treatment on seed germination

The treated, as well as untreated seeds (100 g) were kept in separate air-tight containers. After 6 months of storage, a germination test was conducted. 25 healthy seeds samples were taken at random from all the treatments and were placed in Petri dishes with moistened filter paper (Whatman No. 1). Healthy untreated seeds were used as control. After 7 days, the number of germinated seeds from each Petri dish were counted and recorded. The % germination was calculated by using the formula as follows:

Seed germination (%)=(No.of seeds germinated)/(Total no.of seeds in each petri dish)×100

2.6. Statistical analysis

The data obtained were transformed into suitable values and statistically analysed. Mean and standard error of mean were worked out using analysis of variance (ANOVA). The means were compared by Duncan Multiple Range Test (DMRT) at $p<0.05$ level of significance.

3. RESULTS AND DISCUSSION

3.1. Effect of treatment on oviposition

The plant powder treatments showed a significant reduction in oviposition ranging from 3.14–38.38%. The findings are presented in Table 2. The number of eggs laid on treated seeds varied from 137.00–215.33, whereas in untreated control it was 222.33. In the standard check (Malathion 5% dust) there was no oviposition. The highest number of eggs was laid in seeds treated with *P. pinnata*, while the minimum was in *L. citrata* treated seeds. Among all the plant powder treatments, the highest reduction in oviposition was found in *L. citrata* seed powder treatment with 38.38% followed by *A. indica* leaf powder with 24.73% and *P. nigrum* seed powder with 19.03%. The minimum reduction was found in *P. pinnata* leaf powder with 3.14%. Based on reduction of oviposition (%) the effectiveness of plant powders was *L. citrata*>*A. indica*>*P. nigrum*>*E. globules*>*A. sativum*>*O. tenuiflorum*>*P. pinnata.*

The results of the present study are in similarity with Neog and Singh (2013) who evaluated 9 plant powders against pulse beetle on ricebean seeds and reported *L. citrata* and *P. nigrum* to be the most effective in oviposition reduction with 63.14 and 50.49%, respectively.

3.2. Effect of treatment on adult emergence

The adult emergence varied from 55.23–73.37% in the plant powder treatments; whereas it was 0.00% in standard check and 77.96% in untreated control. The findings are presented in Table 2. The highest adult emergence was found in *P. pinnata* (73.37%) treated seeds followed by *E. globules* (69.43%), *A. sativum* (69.28%), *O. tenuiflorum* (68.53%), *A. indica* (65.53%), *P. nigrum* (61.11%) and minimum was found in *L. citrata* (55.23%). Among the plant powders, *L. citrata* was found to be the most effective with 55.23%

Table 2: Effect of plant powders on reduction of oviposition and adult emergence

Treatments	Dose (% w/w)	**No. of eggs laid on 25 seeds	*Reduction of oviposition (%)	*Adult emergence (%)
A. indica	5	167.33[b] (12.95)	24.73[c] (14.32)	65.53[cd] (40.94)
P. nigrum	5	180.00[b] (13.49)	19.03[c] (10.97)	61.11[de] (37.67)
O. tenuiflorum	5	214.00[a] (14.65)	3.74[d] (2.14)	68.53[bc] (43.26)
E. globules	5	205.00[a] (14.34)	7.79[d] (4.47)	69.43[bc] (43.97)
A. sativum	5	212.67[a] (14.60)	4.34[d] (2.49)	69.28[bc] (43.85)
P. pinnata	5	215.33[a] (14.69)	3.14[d] (1.80)	73.37[ab] (47.20)
L. citrata	5	137.00c (11.73)	38.38[b] (22.57)	55.23[e] (35.53)
Malathion 5% Dust	1	0.00d (0.71)	100.00[a] (90.00)	0.00[f] (0.00)
Untreated control	-	222.33[a] (14.93)	-	77.96[a] (51.22)
SEm±		1.81	1.05	0.71

Figures in the table are mean values; *Figures in the parentheses are angular transformed values; **Figures in the parentheses are square root transformed values; Within column values followed by different letter(s) are significantly different (p<0.05) by DMRT

adult emergence compared to untreated control (77.96%). *P. nigrum* and *A. indica* also reported effective result followed by *O. tenuiflorum*, *A. sativum* and *E. globules*. The least effective against adult emergence was found in *P. pinnata* leaf powder treatment.

Neog and Singh (2013) also reported 66.16% adult emergence from *L. citrata* and 59.50% from *P. nigrum* seed powder treatment. Suthar and Bharpoda (2016) studied the effect of neem leaf, garlic bulb and eucalyptus leaf powder @ 2% w/w against pulse beetle and reported a significant reduction in adult emergence in 6 months of storage. Parmar et al. (2018) also reported the effectiveness of neem leaf powder against adult emergence of pulse beetle in mung bean seeds. Similarly, Manju et al. (2019) studied 12 plant powders against pulse beetle, *C. maculatus* and reported minimum adult emergence (30.00%) from *P. nigrum* powder treatment.

3.3. *Effect of treatment on infestation*

The infestation after 2 months of storage varied from 16.12–67.82% among the treatments, while in the untreated control it was 69.23%.The details of the findings are presented in Table 3.

Table 3: Effect of plant powders on infestation

Treatments	Dose (% w/w)	*Infestation (%)		
		After 2 months	After 4 months	After 6 months
A. indica	5	51.54[d] (31.03)	72.63[d] (46.57)	100.00[a] (90.00)
P. nigrum	5	31.67[e] (18.47)	61.50[e] (37.95)	100.00[a] (90.00)
O. tenuiflorum	5	67.22[ab] (42.24)	92.11[b] (67.10)	100.00[a] (90.00)
E. globules	5	64.10[c] (39.87)	86.26[c] (59.59)	100.00[a] (90.00)
A. sativum	5	64.84[bc] (40.42)	88.69[c] (62.43)	100.00[a] (90.00)
P. pinnata	5	67.82[a] (42.71)	95.93[a] (73.59)	100.00[a] (90.00)
L. citrata	5	16.12[f] (9.28)	52.11[f] (31.41)	98.81[b] (81.17)
Malathion 5% Dust	1	0.00[g] (0.00)	0.00[g] (0.00)	0.00[c] (0.00)
Untreated control	-	69.23[a] (43.81)	97.92[a] (78.31)	100.00[a] (90.00)
SEm±		0.28	0.34	0.06

*Figures in the table are mean values; Figures in the parentheses are angular transformed values; Within column values followed by different letter(s) are significantly different (p<0.05) by DMRT

The minimum infestation was found in *L. citrata* treated seeds (16.12%) followed by *P. nigrum* (31.67%) and *A. indica* (51.54%). The highest infestation was found in *P. pinnata* treated seeds (67.83%) while in the standard check (Malathion dust) it was 0.00%. After 4 months of storage, the infestation increased significantly and varied from 52.11–95.93%, while in the untreated control it reached 97.92%. The infestation was highest in *P. pinnata* treated seeds (95.93%) followed by *O. tenuiflorum* (92.11%). The minimum infestation was found in *L. citrata* (52.11%) followed by *P. nigrum* (61.50%) and *A. indica* (72.63%). After 6 months of storage, 100% infestation was found in all the plant powder treatments and untreated control, while in the standard check no infestation was recorded. Among all the treatments, *L. citrata* and *P. nigrum* provided effective results in reducing infestation up to 4 months of storage. Swamy and Wesley (2017) reported that at 0.4% black pepper powder effectively minimized grain damage by pulse beetle up to 80 days of storage. Several authors (Jilani and

Saxena, 1990, Rajapakse et al., 1998) have reported neem to be effective as grain protectant; however, in the present study neem was not found effective which could be due to environmental factors, differences in the concentration used in the study and the plant parts used.

3.4. *Effect of treatment on weight loss*

The results showed a significant difference in the per cent weight loss due to infestation by *C. chinensis* on ricebean seeds treated by plant powders. The details of the findings are presented in Table 4.

Table 4: Effect of plant powders on weight loss

Treatments	Dose (% w/w)	*Weight loss (%)		
		After 2 months	After 4 months	After 6 months
A. indica	5	9.20[c] (5.28)	25.89[d] (15.01)	39.39[d] (23.20)
P. nigrum	5	6.93[d] (3.97)	14.44[e] (8.30)	32.53[e] (18.98)
O. tenuiflorum	5	14.23[b] (8.18)	32.34[b] (18.87)	40.47[d] (23.87)
E. globules	5	12.80[b] (7.35)	29.81[c] (17.34)	41.58[d] (24.57)
A. sativum	5	14.78[b] (8.50)	30.07[c] (17.50)	45.92[c] (27.33)
P. pinnata	5	21.87[a] (12.63)	32.62[b] (19.04)	52.04[b] (31.36)
L. citrata	5	2.40[e] (1.37)	10.49[f] (6.02)	29.33[f] (17.06)
Malathion 5% Dust	1	1.01[e] (0.58)	1.33[g] (0.76)	3.06[g] (1.75)
Untreated control	-	23.72[a] (13.72)	34.93[a] (20.45)	58.94[a] (36.11)
SEm±		0.23	0.20	0.25

*Figures in the table are mean values; Values in the parentheses are angular transformed values; Within column values followed by different letter(s) are significantly different (p<0.05) by DMRT

After 2 months of storage, the weight loss in seeds treated with plant powders varied from 2.40–21.87%, while it was 23.72% in the untreated control. The highest weight loss was found in seeds treated with *P. pinnata* leaf powder (21.87%) and the minimum weight loss was in *L. citrata* treated seeds (2.40%) followed by *P. nigrum* (6.93%) and *A. indica* (9.20%). In the remaining treatments, it ranged from 12.80–14.78% with no significant difference among them. After 4 months of storage, the per cent weight loss increased with an increase in the infestation. The weight loss varied from 10.49–32.62%. The minimum weight loss was found in *L. citrata* treatment (10.49%) followed by *P. nigrum* (14.44%) and *A. indica* (25.90%). The highest weight loss was found in *P. pinnata* treatment (32.62%) followed by *O. tenuiflorum* (32.34%). While in the standard check (Malathion dust) and untreated control, the weight loss was 1.33 and 34.93%, respectively. After 6 months of storage, the weight loss varied from 29.33–52.04% among the different plant powder treatments. The minimum weight loss was found in *L. citrata* treatment (29.33%) followed by *P. nigrum* (32.53%). The weight loss in *A. indica*, *O. tenuiflorum* and *E. globules* treatments were at par (39.39, 40.47 and 41.58%, respectively). The highest weight loss was found in *P. pinnata* treatment (52.04%) followed by *A. sativum* (45.92%).

L. citrata and *P. nigrum* were found to be effective with significant difference in per cent weight loss in comparison to untreated control. After 2 months of storage the weight loss in *L. citrata* seed powder treatment was 2.40% as against 23.72% in untreated control and it was at par with the standard check Malathion 5% dust. The findings are in conformity with Neog and Singh (2013). Shitiri et al. (2014) also reported the efficacy of *L. citrata* to be at par with monocrotophos. From the present study, it was observed that the infestation and weight loss increase with the increase in storage period which reveals that the botanical products are non-persistent in nature and their efficacy reduces over a period of time.

3.5. *Effect of treatment on seed germination*

After 6 months of storage, germination test was conducted with 25 healthy seeds samples taken at random from all the treatments. The results are presented in Table 5.

Table 5: Effect of plant powders treatment on seed germination

Treatments	Dose (% w/w)	*Germination (%)
A. indica	5	86.67[a] (60.07)
P. nigrum	5	88.00[a] (61.64)
O. tenuiflorum	5	85.33[a] (58.58)
E. globules	5	85.33[a] (58.58)
A. sativum	5	89.33[a] (63.30)
P. pinnata	5	86.67[a] (60.07)
L. citrata	5	82.67[a] (55.76)
Malathion 5% Dust	1	84.00[a] (57.14)
Untreated control	-	89.33a (63.30)
SEm±		0.90

*Figures in the table are mean values; Values in the parentheses are angular transformed values; Within column values followed by different letter(s) are significantly different (p<0.05) by DMRT

The germination of seeds ranged from 82.67–89.33% in the treatments and untreated control. The % germination did not show any significant difference among the different treatments and untreated control. The results revealed that the botanical treatments have no adverse effect on the germinability of the seeds. Similar findings were reported by various workers (Tandon et al., 2004, Rahman and Talukder, 2006, Neog and Singh, 2013).

4. CONCLUSION

Among the botanicals tested, the seed powders of *L. citrata* and *P. nigrum* showed effective results in reduction of oviposition, adult emergence, infestation and weight loss by pulse beetle. The study revealed the potential of *L. citrata* and *P. nigrum* as grain protectants against pulse beetle in storage. However, as per literature reviews very limited information on *L. citrata* are available. Therefore, more detailed research needs to be done to understand its potential in the management of storage pests.

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