LR-5283
[1-6]

RESEARCH ARTICLE | Legume Research- An International Journal

Carryover of *Callosobruchus maculatus* (Fab.) in Pigeon Pea Seeds from Field to Storage and its Management by Smearing Oil on Seeds

Dhruv Singh[1], D.V. Singh[1], Bhupendra Singh[1], Reetesh Pratap Singh[1], Chandra Kant[1]
10.18805/LR-5283

ABSTRACT

Background: Pigeonpea, *Cajanus cajan* (L.) is a vital pulse crop in South Asia, with India accounting for 90% of it's global production. Its protein content (21-25%) is essential for nutrition and plays significant role in improving food security and nutrition in regions with limited resources. The insect pest attacks in Pigeonpea cause significant amount of grain loss in field and storage, the research was carried out to investigate the carryover of pest from field to storehouses and to study the efficacy of oils on *C. maculatus* management in which literature available is scarce.

Methods: This study was carried out at Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut, U.P., India during the year 2020-2022. Pigeonpea seeds were collected from research farm threshing floor of ICAR-IIFSR, Meerut. Infestations of pulse beetle carried from field to storage was studied on basis of mean no. of eggs laid and mean seed damage caused by beetle. To study efficacy of oils, the seeds were subjected to linseed, mustard, soybean, rice bran, safflower, castor, mahua and neem oil each at concentrations of 0.20, 0.50 and 1.00 ml per 100 g of seeds and five pair of beetles of same age were released into each container and removed after 5 days to study the damage incurred.

Result: In the carryover study, maximum oviposition (16.88 eggs) was recorded on freshly harvested seeds that were kept open in storehouse for infestations which witnessed field as well as storage egg laying. Oils application on seeds showed 1ml oil per 100 g seed as most suitable dosage and neem oil, castor, mahua as most successful oil providing beetle control in terms of oviposition, damage and adult survival. Residual action of oil on seed surface after 3 months revealed different oil treatments showed significant reduction in the number of eggs laid, adult emergence and seed damage due to *C. maculatus* in pigeonpea seeds in comparison to control. Mean reductions in the number of eggs, adult emergence and seed damage were relatively higher in all the oil treatments.

Key words: *Callosobruchus maculatus,* Carryover, Management, Oils, Pigeonpea, Seed damage.

INTRODUCTION

Legumes, part of the Fabaceae family, are vital in Indian agriculture for nitrogen fixation, soil enrichment and nutrition. Pigeonpea (*Cajanus cajan*) holds a prominent position in Indian agriculture as a second most vital legume crop. Possessing drought tolerance and nitrogen-fixing ability, Pigeonpea plays a crucial role in sustainable farming practices (Sarkar *et al*., 2020). Pigeonpea (*Cajanus cajan*) cultivation in India is often challenged by various pest attacks, with *Callosobruchus maculatus* being a significant threat. *C. maculatus*, commonly known as the pulse beetle, is a notorious pest that inflicts severe damage to Pigeonpea seeds during storage. Female pulse beetles lay eggs on mature Pigeonpea pods or seeds and upon hatching, the larvae bore into the seeds, feeding on their contents (Khavilkar and Dalvi, 1984). To mitigate *C. maculatus* infestations, several integrated pest management strategies are employed. These include the use of chemical insecticides during storage, fumigation with carbon dioxide, Edible oils also play a crucial role in the management of *C. maculatus* infestations in pigeonpea seeds. The importance of edible oils in this context lies in their ability to deter and control *C. maculatus* infestations during storage, preserving the quality and nutritional value of Pigeonpea seeds (Khalequzaman *et al.,* 2007). This investigation aimed to focus on the status of carryover of pest from fields to storehouses causing infestations and pest management by application of edible and non edible oils on grain surface to confer if it is a viable option for future grain storage in storehouses.

[1]Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, Uttar Pradesh, India.

Corresponding Author: D.V. Singh, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, Uttar Pradesh, India.
Email: dvsingh20111@gmail.com

How to cite this article: Singh, D., Singh, D.V., Singh, B., Singh, R.P. and Kant, C. (2024). Carryover of *Callosobruchus maculatus* (Fab.) in Pigeon Pea Seeds from Field to Storage and its Management by Smearing Oil on Seeds. Legume Research. doi: 10.18805/LR-5283.

Submitted: 13-12-2023 **Accepted:** 13-02-2024 **Online:** 18-03-2024

MATERIALS AND METHODS

Rearing of *Callosobruchus maculatus*

The pulse beetle, *C. maculatus*, was cultured on cowpea in controlled lab conditions (27±1°C temperature, 70±1% RH).

adult beetles from infested grains were placed in open plastic containers with disinfested cowpea. After egg-laying, adults were removed and newly emerged ones were released onto fresh cowpea/moong bean for mating and oviposition. This cycle was repeated every 15 days to ensure a steady supply of insect stages for research.

Carryover of *C. maculatus* from fields to storage

The Pigeonpea grains were collected from farm threshing floors of ICAR- IIFSR, Modipuram Meerut and from those grains 100 g seed was divided equally into 4 treatments classifying the infestation carried from field, from storehouse, from field + storehouse and a control. Hundred grams of freshly harvested seeds of pigeonpea with pre-measured moisture content were taken in plastic containers (5×10cm). For checking field infestations, the container was covered with muslin cloth tightened with rubber band and kept in the laboratory. Another sample of hundred grams of Pigeonpea seed were taken and examined for bruchid infestation. Further it was fumigated for zero infestation carried from the field. It was kept without covering with muslin cloth in the University storehouse to know about the infestation occurring in storehouse. Further hundred grams of freshly harvested seeds were taken in a plastic container which was kept open in the storehouse to find out Field + storage combined infestation. In number four treatment which was control, egg free seeds (same as treatment number two) were taken in plastic container and covered with muslin cloth and tightened with rubber band to avoid oviposition in store house. Observations were recorded after a generation of the insect. The experiments were replicated five times. This experiment was repeated in the next year also the same season for confirmation. Following observations were recorded-

1. Seeds having eggs on per fifty randomly selected seeds from each treatment.
2. Total number of insect damaged seeds from per fifty randomly selected seeds in each treatment.

Control of *Callosobruchus maculatus* with some oils

The evaluation was conducted with linseed, mustard, soybean, rice bran, safflower, castor, mahua and neem oil each at concentrations of 0.20, 0.50 and 1.00 ml per 100 g of seeds. An untreated control was kept for comparison. The experiment was conducted under room temperature with an average temperature of 26°C and relative humidity of 83.5 per cent. The grain moisture was 10.50 per cent before the release of freshly emerged beetles. 100 g of seed of each treatment as weighed by electronic balance (400 g total for four replications of a treatment) was taken for each proportion of an oil in plastic containers separately. Required quantities of each oil for 400 g of seed (*i.e.* 0.20, 0.50 and 1.00 ml per 100 g of seed) were measured with a 1. 00 ml micropipette with graduation up to 0.01 ml. and mixed with the seeds of pigeonpea variety T-21 by shaking thoroughly to get uniform smearing of seeds. Five pairs of newly emerged beetles were then released in each container. The following nine treatments, including an untreated control, were used. The beetles were removed from the container after five days.

Treated seed samples of treatments (T-1 to T-9) were kept for 3 months to observe the residual efficacy of different oils smeared with pigeonpea against *C. maculatus* F. Five pairs of freshly emerged beetles were then released after 3 months. Following observations were recorded.

Mean oviposition

By counting total number of eggs laid on per 50 randomly selected seeds in each treatment replication.

Mean number of adult beetles emerged

By counting the total number of adult beetles that emerged after completion of one generation in each treatment replication.

Mean seed damage

By calculating the percentage of seed damage on 50 randomly selected seed in each treatment replication. Similar observations were recorded at 3 months after releasing five pair of adult beetles.

RESULTS AND DISCUSSION

Carry over of the *Callosobruchus maculatus* from the field to storage

Mean no. of eggs laid

During the year 2020-2021 and 2021-2022 after the harvesting and threshing of pigeonpea grains were collected observations were recorded on the different treatments on the following parameters.

Mean number of eggs laid on per 50 randomly selected seeds from each treatment were recorded after five days of infestation in store house. During second year's observations (2021-22), oviposition was recorded more than the first year's observations(2020-21), due to favourable weather conditions for biological activity of the pest during the period of investigation. Treatments differed significantly in the experiments of both years. Maximum oviposition was observed on freshly harvested seeds kept openly in store house (T3) (16.88 eggs/50 seeds) from field and store house followed by eggs laid in store house (T2) (10.00 eggs/50 seeds). Taking an average of both the years of experimentation eggs came from field with pigeonpea seeds (T1) were found 6.63 eggs/50 seeds which was less than other sources. Whereas, in control oviposition was recorded as zero (Table 1). Patnaik (1984), observed that the *C. maculatus*. infest pigeonpea seeds in the standing crop as well as store of pigeonpea. Dharne *et al*. (1984) recorded 1.33 to 3.61 eggs of *C. maculatus* after 25 days of harvest.

Extent of seed damage

In experiment of both years (2020-21,2021-22), mean per cent of seed damage was recorded after completion of one generation on different samples of Pigeonpea seeds. In second year's observations (2021-22), more seed damage was observed than the first year. Maximum seed damage (5.75%) was noticed in T3 which occupied infestation from both sources *i.e*, field and store. Treatment 2 (3.75%) was next in order. Infestation came from only field (T1) showed least seed damage (2.25%). Percentage of seed damage was nil in control. These observations were recorded on the basis of circular hole made by the bruchids to emerge out from seed (Table 2). Patnaik (1984), reported that pulse beetle is active in field as well as store. Dharne *et al.* (1984), recorded per cent seed damage ranged from 30 to 93 per cent on freshly harvested Pigeonpea seeds kept in laboratory. These findings support our present findings.

Control of *Callosobruchus maculatus* with edible and non-edible oils

Immediately after oil smearing of seed

Mean number of eggs laid by *C. maculatus* 5 days after oil smearing of seeds

All the oil treatments provided significant protection to the grain when compared to control. Rice bran oil conceded minimum protection to the grains compared to other oil treatments. Neem and mahua oils were highly effective and significantly better at protection than soyabean, safflower and linseed oil treatment (Table 3). Mustard and castor oil offered slightly lesser protection when compared to neem and mahua, the findings are corroborated by Krishnamurthy and Rao (1944), who also reported inhibition effect of vegetable oil treatments of seeds on egg laying due to the fact that eggs could not be properly adhered on oily surface of seeds. Complete inhibition of egg laying of the pest by seed, treatment with some oils was also reported by other workers.

Among three levels of oil treatment 1.00 ml oil applied per 100 g seed was found most effective and significantly better performing than both lower levels, among lower levels 0.20 ml per 100 g seed provided lesser protection than 0.50 ml per 100 g seed. Interaction of oils and their levels of application were not significant.

Number of adult beetles emerged after one generation

It was observed that with neem oil treatment least number of beetles emerged, which was significantly superior over rest of the oil treatments (Table 3). Mahua oil was superior over soybean, safflower, linseed and rice bran oils. Among all the oils, most beetle emergence was observed with rice-bran oil. However, all the oil treatments were significantly superior over control on the basis of the beetle emergence. Singh (1976), also reported that the population buildup of the pest was checked by treatment with neem and groundnut oils.

Similar observations were also made by Mummigatti and Ragunathan (1977), Schoonhoven (1978). Interaction between oils and their levels of application were also found to be significant 0.50 and 1.00 ml oil per 100 g seed levels of neem and mahua oils showed no emergence of beetles being best treatment. Also, mustard and soybean oils at 1.00 ml. level recorded nil emergence. Least effectiveness was observed with 0.20 ml level of rice-bran oil. Levels of oils were also found to be significant. Best effectiveness was observed with 1.00 ml, level, which was at par with 0.50 ml. level, both levels being significantly superior over 0.20 ml level.

Extent of seed damage after one generation

Effectiveness of different oils increased with their successive higher doses. With lower doses of 0.20 ml oil per 100 g

Table 1: Extent of oviposition by insect in field, field+ storage, Control.

Treatments	Source of infestation	Mean no of eggs laid per 50 seeds		
		First year	Second year	Mean
T1	Eggs laid on field	5.75 (2.48)	7.50 (2.79)	6.63 (2.64)
T2	Eggs laid in storage	9.25 (3.18)	10.75 (3.33)	10.00 (3.26)
T3	Eggs laid in storage + field	16.00 (4.05)	17.75 (4.27)	16.88 (4.16)
T4	Control	0 (0.71)	0 (0.71)	0 (0.71)
	S.E.	0.17	0.22	-
	C.D. at 5%	0.42	0.54	-

(Transformed figures into √n+0.5 are given in parenthesis).

Table 2: Extent of seed damage due to insect in field, Field+storage, Control.

Treatment	Source of infestation	Mean percentage of seed damage		
		First year	Second year	Mean
T1	In field	2.00 (7.99)	2.50 (8.83)	2.25 (8.41)
T2	In storage	3.50 (10.71)	4.00 (11.30)	3.75 (11.00)
T3	In storage + field	5.25 (13.11)	6.25 (14.32)	5.75 (13.71)
T4	Control	0(0)	0(0)	0
	S.E.	0.94	1.08	-
	C.D. at 5%	1.02	1.25	-

(Transformed figures in to angles are given in parenthesis).

seed. Castor, mahua and neem oil proved more desirable, neem oil providing best effectiveness (Table 3). However, at this level rice-bran oil offered least protection. At 0.50 and 1.00 ml levels all the oils were equally effective in controlling the pest except rice-bran oil at 0.50 ml per 100 g seed and 1.00 ml per 100 g seed.

The results are corroborated by (Sharma *et al*., 2018) who reported that Neem oil @ 10 ml/kg completely inhibited the oviposition, adult emergence and seed damage. All the oils and inert materials prevented egg laying, reduced population build-up of beetles and minimized the seed damage when compared to control.

Residual effect of different oil treatments three months after oil smearing of Pigeonpea seeds

Mean no of eggs laid

Neem oil was found most effective followed by mahua, mustard and linseed oil. Soybean oil treatment was, superior to rice-bran and safflower oils but inferior to all other oil treatments (Table 4). The interaction between type of oils and their levels of application were not registered as significant. The findings are confirmed by Raghvani *et al*. (2003) who concluded that neem, sesame and groundnut oils at 10 ml/kg seed and Karanja oil at 5 ml/kg seed provided more than 94% protection for up to four months of storage. Singh *et al.* (1996) reported neem oil @ 0.5 per cent to be the most effective to provide cent percent protection against *C. maculatus* in green gram for long term.

Number of adult beetles emerged

Neem oil treatment was most effective followed by mahua oil treatment. Linseed oil and mustard, were inferior to neem and mahua oils and superior to other oil treatments. Rice Bran oil was least effective and significantly inferior to rest of the oil treatments (Table 4). 1.00 ml oil per 100 g seed showed minimum emergence of adult beetles and was significantly superior to 0.20 ml 0.50 ml oil per 100 g seed level. 0.20 ml. level showed maximum emergence and was significantly inferior to both the levels the results are confirmed by Reddy *et al.* (1999). Stating that oils caused a significant reduction in oviposition and adult emergence. Neem oil at one per cent level gave the best protection, followed by palmolein, karanja and mahua oils. Fluctuations in untreated control observations in case of oil smearing may be the result of temperature changes as the experiment was carried out at room temperature and due to season change at the time of carrying out residual activity.

Lal and Raj (2012), in their studies revealed neem, eucalyptus, sunflower and castor oil at 0.1 and 0.3 per cent (v/w) as safest and most effective concentration of oils to minimize the incidence of *C. maculatus* on Pigeonpea based on its reduced fecundity, adult emergence and delayed development. However, their investigations registered no adverse effect on seed germination for up to 120 DAT (DAT= Days after treatment).

Table 3: Effects of immediate oil smearing on beetle control in pigeon pea seeds.

Treatments	Mean no of eggs laid 5 days after beetle release				No. of beetles emerged after one generation				Extent of seed damage after one generation			
	0.20 ml/ 100 g	0.50 ml/ 100 g	1.00 ml/ 100 g	Mean	0.20 ml/ 100 g	0.50 ml/ 100 g	1.00 ml/ 100 g	Mean	0.20 ml/ 100 g	0.50 ml/ 100 g	1.00 ml/ 100 g	Mean
T1: Linseed	10.75	3.25	1.00	5.00	8.75	0.75	0.25	3.25	2.50	1.00	0.00	1.16
T2: Mustard	4.50	1.50	0.75	2.25	4.00	0.25	0.00	1.42	0.50	0.00	0.00	0.17
T3: Soyabean	6.00	2.75	1.00	3.25	5.00	0.25	0.00	1.75	0.75	0.25	0.00	0.33
T4: Rice bran	16.00	4.25	2.50	7.58	15.50	0.75	0.50	5.58	3.50	1.75	0.50	1.91
T5: Safflower	6.75	3.00	1.25	3.66	6.00	0.75	0.25	2.34	1.25	0.00	0.00	0.41
T6: Castor	3.75	2.00	0.25	2.00	3.50	0.25	0.25	1.33	0.75	0.00	0.00	0.25
T7: Mahua	2.25	1.50	0.50	1.42	2.25	0.00	0.00	0.75	0.50	0.00	0.00	0.16
T8: Neem	2.50	1.00	0.00	1.17	0.25	0.00	0.00	0.08	0.00	0.00	0.00	0.00
T9: Untreated Control	-	-	-	130.58	-	-	-	108.17	-	-	-	74.75
mean	6.56	2.41	0.91	3.29	5.65	0.50	0.31	2.06	1.21	0.375	0.06	0.54
SE(m) (oil)	0.10	C.D. at 5%	0.40	SE (m) (oil)	0.15	C.D. at 5%	0.24	SE (m) (oil)	0.46	C.D. at 5%	2.35	-
SE (levels)	0.06	C.D. at 5%	0.24	SE (levels)	0.14	C.D. at 5%	0.15	SE (levels)	0.28	C.D. at 5%	1.44	-
Interaction (O×L)	0.18	C.D. at 5%	N.S.	Interaction (O×L)	0.15	C.D. at 5%	0.40	Interaction (O×L)	0.80	C.D. at 5%	2.30	-
S.E. (Control vs treatment)	0.16	C.D. at 5%	0.46	SE.M co vs tr	0.14	C.D. at 5%	0.41	SE.M co vs tr	0.58	C.D. at 5%	1.64	-

Table 4: Residual effects of oil smearing on beetle control in pigeon pea seeds.

Treatments	Mean no of eggs laid 5 days after beetle release				No. of beetles emerged after one generation				Extent of seed damage after one generation			
	0.20 ml/ 100 g	0.50 ml/ 100 g	1.00 ml/ 100 g	Mean	0.20 ml/ 100 g	0.50 ml/ 100 g	1.00 ml/ 100 g	Mean	0.20 ml/ 100 g	0.50 ml/ 100 g	1.00 ml/ 100 g	Mean
T1: Linseed	7.25	1.25	0.00	2.84	6.75	0.25	0.00	2.33	4.00	1.00	0.00	1.66
T2: Mustard	6.75	0.75	0.25	2.58	5.75	0.00	0.00	1.92	3.50	0.00	0.00	1.17
T3: Soyabean	35.75	4.00	3.00	14.25	34.00	3.25	2.75	13.33	21.00	2.50	2.00	8.50
T4: Rice bran	43.00	7.50	5.50	18.58	46.50	5.25	3.75	18.50	28.5	4.5	3.00	12.00
T5: Safflower	48.00	6.50	1.25	18.16	41.75	5.00	2.25	18.50	25.75	3.00	2.00	10.25
T6: Castor	26.00	1.25	0.25	9.16	24.00	0.25	0.00	8.08	14.75	0.00	0.00	4.91
T7: Mahua	2.75	0.50	0.25	1.16	2.50	0.00	0.00	0.83	2.00	0.00	0.00	0.66
T8: Neem	2.25	0.25	0.00	0.83	2.00	0.00	0.00	0.67	1.50	0.00	0.00	0.50
T9: Untreated control	-	-	-	102.08	-	-	-	90.08	-	-	-	59.5
mean	21.46	2.75	1.31	8.44	20.41	1.75	1.09	7.75	12.62	1.38	0.875	4.96
SE (m) (oil)	0.11	C.D. at 5%	1.28	SE (m) (oil)	0.07	C.D. at 5%	0.21	SE (m) (oil)	0.59	C.D. 5%	14.7	-
SE (levels)	0.07	C.D. at 5%	0.81	SE (levels)	0.05	C.D. at 5%	0.13	SE (levels)	0.36	C.D. 5%	1.02	-
Interaction (O×L)	0.18	C.D. at 5%	N.S.	Interaction (O×L)	0.13	C.D at 5%	0.40	Interaction (O×L)	1.02	C.D. 5%	2.90	-
S.E. (Control vs treatment)	0.17	C.D. at 5%	0.47	SE.M co vs tr	0.14	C.D at 5%	0.39	SE.M co vs tr	0.73	C.D. 5%	2.07	-

Extent of seed damage

Neem, mahua and mustard oil treatments were highly effective providing protection to grain against damage. Castor oil yielded results inferior than linseed, neem, mahua and mustard oils but superior to other oil treatments (Table 4). Rice-bran oil was least effective and inferior to other oil treatments. Fluctuations in untreated control observations in regard to observations taken 3 months before residual effect observation be resulted due to temperature changes as the experiment was carried out at room temperature and due to season change at the time of carrying out residual activity. Amongst the three levels of oil application seed damage was progressively less with increasing levels of oil application. 0.50 ml. level was superior to 0.20 ml. level but inferior to 1.00 ml. level. 1.00 ml. level was superior to both the lower levels. Singh (2017) reported that neem seed kernel powder at 2.0 per cent when admixed to the Pigeonpea and mung bean gave protection against *C. maculatus,* which corresponds to our findings.

CONCLUSION

Findings emphasize the critical role of storage conditions in managing *Callosobruchus maculatus* infestations in Pigeonpea seeds, ensuring their quality and marketability, this study highlights the significance of management of *Callosobruchus maculatus* infestations in stored pigeonpea seeds. This approach comes across as a promising, eco-friendly and sustainable strategy to manage *C. maculatus* infestations, ensuring the preservation of seed quality and marketability. All oil treatments were significantly better than the control. Neem, mahua and mustard oils showed the highest effectiveness with no seed damage. Castor and linseed oils were also effective. Findings suggest the potential of neem and mahua oils as promising alternatives for grain protection in agriculture at a dose of 1.00 ml/ 100 g seed, outperforming lower levels. Rice-bran oil performed least effectively, hence, rice bran oil is not ideal for grain protection.

Conflict of interest

All the authors declare that there is no conflict of interest.

REFERENCES

Dharne, P., Salunkhe, G. and Ajri, D. (1984). Studies on susceptibility of pigeon-pea, *Cajanus cajan* (Linn.) varieties to pulse beetle, *Callosobruchus chinensis* (Linn.). Bulletin of Grain Technology. 22(3): 262-264.

Khalequzzaman, M., Mahdi, S.H.A. and Goni, S.O. (2007). Efficacy of edible oils in the control of pulse beetle, *Callosobruchus chinensis* (Linn.) in stored pigeonpea. University Journal of Zoology, Rajshahi University. 26: 89-92.

Khanvilkar, S.V. and Dalvi, C.S. (1984). Carry over the pulse beetle *Callosobruchus maculatus* (F) infestation from field and its control. Bulletin of Grain Technology. 22: 54-61.

Krishnamurthy, B. and Rao, D.S. (1944). A brief review of the methods adopted in rural pests and the experiments and observations made in India in the matter of storage of food grains. Mysore Agriculture Journal. 22(3): 65-74.

Lal, D., Raj, D.V. (2012). Efficacy of application of four vegetable oils as grain protectant against the growth and development of *Callosobruchus maculatus* and on its damage. Advances in Bioresearch. 3: 55-59.

Mummigatti, S.C. and Ragunathan, A.N. (1977). Inhibition of the multiplication of *C.chinensis* by vegetable oils. Journal of Food Science and Technology. 14: 40-45.

Patnaik, H.P. (1984). Note on field infestation of pigeonpea by *Callosobruchus* spp. in Orissa. Bulletin of Grain Technology. 22(3): 259-261.

Raghvani, B.R. and Kapadia, M.N. (2003). Efficacy of different vegetable oils as seed protectants of Pigeonpea against *Callosobruchus maculatus* (Fab.). Indian Journal of Plant Protection. 31(1): 115-118.

Reddy, M.U., Bharati, S.R. and Reddy, D.D.R. (1999). Efficacy of some vegetable oils as protectants against the pulse beetle (*Callosobruchus chinensis*) in green gram (*Phaseolus aureus*) during storage. Indian Journal of Nutrition and Dietetics. 36(10): 436-442.

Sarkar, S., Panda, S., Yadav, K.K. and Kandasamy, P. (2020). Pigeonpea (*Cajanus cajan*) an important food legume in Indian scenario-A review. Legume Research-An International Journal. 43(5): 601-610. doi: 10.18805/LR-4021.

Schoonhoven, A.V. (1978). Use of vegetable oils to protect stored beans from bruchid attack. Journal of Economic Entomology. 71(2): 254-256.

Sharma, R., Devi, R., Yadav, S. and Godara, P. (2018). Biology of pulse beetle, *Callosobruchus maculatus* (Fab.) and its response to botanicals in stored Pigeonpea, *Cajanus cajan* (Linn.) grains. Legume Research-An International Journal. 41(6): 925-929. doi: 10.18805/LR-3807.

Singh, R.P., Saxena, P., Doharey, K.L. (1996). Evaluation of neem seed kernel and its derivatives against three important insect pests of stored products. Abstract presented at International Neem Conference, Gatton College, Queensland, Australia. 42.

Singh, S. (2017). Natural plant products-As protectant during grain storage: A review. Journal of Entomology and Zoology Studies. 5(3): 1873-1885.