Biology and Management of Pulse Beetle, *Callosobruchus chinensis* (L.) Infesting Black Gram, *Vigna mungo* (L.)

mMn] ***Vigna mungo* (L.)** e nygu dh Hkx] ***Callosobruchus chinensis* (L.)** dk thou pØ ,o ibcU/ku

PAPPU LAL DALAL

Thesis

Master of Science in Agriculture

(Entomology)

2020

DEPARTMENT OF ENTOMOLOGY
RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
UDAIPUR-313001 (RAJASTHAN)

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Thesis

Submitted to the

Maharana Pratap University of Agriculture and Technology, Udaipur

In partial fulfilment of the requirement
for the degree of

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(Entomology)

By

PAPPU LAL DALAL

2020

RAJASTHAN COLLEGE OF AGRICULTURE

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, UDAIPUR

CERTIFICATE-I

CERTIFICATE OF ORIGINALITY

The research work embodied in the thesis titled "**Biology and Management of Pulse Beetle, *Callosobruchus chinensis* (L.) Infesting Black Gram, *Vigna mungo* (L.)**" submitted for the award of degree of **Master of Science in Agriculture** in the subject of **Entomology** to Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), is original and bonafide record of research work carried out by me under the supervision of **Dr. N. L. Dangi**, Assistant Professor, Department of Entomology, Rajasthan College of Agriculture, Udaipur. The contents of the thesis, either partially or fully, have not been submitted or will not be submitted to any other institute or university for the award of any degree or diploma.

The work embodied in the thesis represents my ideas in my own words and where others ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the university and can also evoke panel action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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CERTIFICATE-II

Date: 09/10/ 2020

This is to certify that the thesis entitled **"Biology and Management of Pulse Beetle, *Callosobruchus chinensis* (L.) infesting Black Gram, *Vigna mungo* (L.)"** submitted for the degree of Master of Science in Agriculture in the subject of Entomology, embodies bonafide research work carried out by **Mr. Pappa Lal Dalal** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of this thesis was also approved by the advisory committee on 20/08/2020.

The manuscript has been subjected to plagiarism check by software Urkund. It is certified that as per the check, the similarity index of the content is 9% and is within permissible limit as per the MPUAT guideline on checking plagiarism.

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This is to certify that the thesis entitled **"Biology and Management of Pulse Beetle, *Callosobruchus chinensis* (L.) infesting Black Gram, *Vigna mungo* (L.)"** submitted by **Mr. Pappu Lal Dalal** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfilment of the requirement for the degree of **Master of Science in Agriculture** in the subject of **Entomology** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination held on 08/10/2020 was found satisfactory, we therefore, recommend that the thesis be approved.

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This is to certify that **Mr. Pappu Lal Dalal,** student of Master of Science in Agriculture, **Department of Entomology** has made all the corrections/modifications in the thesis **"Biology and Management of Pulse Beetle, *Callosobruchus chinensis* (L.) infesting Black Gram, *Vigna mungo* (L.)"** which were suggested by the external examiner and the advisory committee in the oral examination held on 08/10/2020. The final copies of the thesis duly bound and corrected were submitted on 09/10/2020 are enclosed here with for approval.

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1. INTRODUCTION

Pulses, a vital constituent of Indian diet, play an important role in the agriculture economy. Although lacking in scientific knowledge, farmers include them in the cropping system realizing their values as a soil fertility improver. It is already understood that pulses have inherent capability to fix atmospheric nitrogen and there by enrich the soil, which place them as an important position in different cropping system. India is the largest producer and consumer of pulses in the world contributing 33 per cent and 22 per cent of area and production of pulses, respectively.

The area under pulse crops is approximately 29.99 m ha and the total production is 25.53 MT in the India (Anonymous, 2018). The important pulses are gram (*Cicrer arietinum*), urd (*Vigna mungo* L.), arhar (*Cajanus cajan* L.), lentil (*Lens culinaris* M.), mung (*Vigna radiata*) and cowpea (*Vigna unguiculata* L.) *etc.*

Among the pulse crops, black gram (*Vigna mungo* L.) is cultivated extensively all through different parts of African, American, European and Asian continent. India is the one of the important black gram growing countries in Asian continent (Thakur, 1975). In India, it is grown in many states, namely Madhya Pradesh, Andhra Pradesh, Rajasthan, Gujarat, Bihar, Uttar Pradesh, Haryana, Punjab, Karnataka, Maharashtra, Tamil Nadu, Kerala, West Bengal and Tripura (Singh *et al*., 1970). Black gram (*Vigna mungo* L.) also known as urdbean, black mapte, mash, mungobean, *etc*. It contains protein (25-26%), fats (1.64%). and carbohydrate (56.8%) *etc.*

Pulses are difficult to store than cereals as these suffer a great damage during storage due to the insect pests attack. Generally pulses are stored for food, seed and feed purpose. The availability of pulses may go down due to heavy losses caused by insect and pests during storage. Important pests that affect infesting stored pulses are *Callosobruchus chinensis* L., *Bruchus analis* Fab., *B. albocallosus* Pic, *B. phaseoli* Gyll., *Laria affinis* Frol., *Pachymerus quadrimaculatus* Fab., *Laria emarginatus* and *Laria pisorum* Linn. It causes serious damage to the grain during storage, not only in quantity but also in quality (Singh and Pandey, 2001). The damage is caused in the interior part of the grain and remains unseen till the beetle emerges out through the emergence holes. Grub, which is only feeding stage, destroys endospermic part of the seed completely leaving only seed coat. The pulse beetle, *Callosobruchus chinensis*

escape by cutting a circular hole (emergence hole) in the shell of the grains. The seed thus completely loose their viability as well as nutritive value and make it unfit for human consumption. In the hills, it is a serious pest of stored pulses with annual loss of almost 0.21 MT accounting to rupees 315 million (Rathore and Sharma, 2002). It was first reported from China in 1758 due to which the name chinensis was given to the species.

In India 117 species of bruchids belonging to 11 genera have been reported on infesting different pulses (Arora, 1970). The genus *Callosobruchus* attacks legumes grain during both field and storage stage all over the world, but in India, *C. chinensis* (L.), *C. analis* (Fab.) and *C. maculatus* (Fab.) are the major pest species of the genera (Dias, 1986). *C. chinensis* is most common pest of black gram. Generally the damage found severe during July to November (Sing, 1997 and Butani *et al.,* 2001). It is recorded that 55 to 60 and 45.50 to 66.30 per cent loss in grain and protein content of pulses is due to infestation caused by the pulse beetle, respectively (Faruk *et al.,* 2011).

Pesticides are the most powerful tool for pest controlling in world and are extremely effective, rapid in curative action, adaptable to all situations and ecological condition and relatively economical. The long and indiscriminate use of pesticides has been found ecologically, unsound, associated with disadvantage *viz.,* pest resistance, toxic residue in food grains, adverse effect on non-target organism, pollution of surrounding environment and direct hazards to the consumer. Although fumigation of storage grain with toxic gases is effective but not applicable at the farm level because the storage structure are not air tight. This situation dictates the farm need for safe, less costly and locally available material for pest control in storage. There are encouraging reports on the use of certain indigenous plant products as grain protectant during storage (Sharma and Singh, 1993; Bhargava and Meena, 2002; Sundria *et al.* 2001).

Among the existing natural resources plant material possess some desirable qualities as grain protectants which had been practiced in rural areas to protect stored grains from pests infestation. As the botanicals are more easily available, less persistent, cheaper as compare to existing synthetic chemicals, besides preventing quantitative and qualitative loss, they do not leave toxic residues on food grain.

Considering the above facts, the present study on **"Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)"** has been proposed with the following objectives:

1. To study the biology of pulse beetle, *Callosobruchus chinensis* (L.) on black gram.
2. To evaluate the bio-efficacy of different products against pulse beetle, *Callosobruchus chinensis* (L.).

2. REVIEW OF LITERATURE

Pertinent review on the present investigation **"Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)"** have been compiled and presented under the following sub heads:

2.1 Biology of Pulse Beetle, *Callosobruchus chinensis* (L.)

Borikar and Pawar (1996) observed that maximum duration of egg, larva and pupa were 5, 17 and 6 days, respectively on *C. chinensis* during development on moong bean control measures. Singh and Pandey (1997) reported that the average incubation and larval + pupal period of *C. chinensis* on urdbean (*Vigna mungo*) seeds was 4-5 and 20-28 days, respectively.

Singh and Kumari (2000) observed that the incubation period and larval + pupal period of *C. chinensis* was 4-5 and 20 days at 42.8°C temperature and 70-75 per cent relative humidity on cowpea and gram seeds. Singal and Borah (2001) observed that the biology of *C. chinesis* on *Cajanus cajan* pods, the average pre-oviposition, oviposition, post-oviposition period and longevity of adult male and female beetle were found to be 7.80 ± 0.46 h, 4.8 ± 0.25, 1.40±0.11, 6.80±0.25 and 6.20±0.36 days, respectively. The average incubation, larval, pupal periods and total development period of *C. chinensis* was reported to be 6.80±0.1, 16.20±0.16, 7.20±0.18 and 30.40±0.62 days, respectively.

Sadozai *et al.* (2003) observed the lowest fecundity (26.6 eggs) on lentil and highest (51.2 eggs) on pea. However, the ovipositions remain independent of growth and development. The shortest development period (19.20 days) was observed on green gram and split gram, while the longest (23.00 days) was observed on pea crops. Adult emergence, per cent damage and per cent weight loss were highest on green gram (28.60, 79.55 and 36.64%) and black gram (27.60, 98.15 and 26.04%), whereas lowest on pea (5.20, 11.54 and 5.33%). The sex ratio on all pulses remained as 50:50. *C. chinensis* neither developed nor infected any damage or loss to kidney bean and lentil.

Meghwal and Singh (2005) observed that the mean ovipositional, incubation, larva + pupa and total development period of *C. chinensis* on mothbean as 5.20, 4.69, 20.79 and 25.49 days, respectively. Patel *et al.* (2005) reported that biology of pulse

beetle on green gram, Bengal gram, lentil, pea, red gram and cowpea and observed that incubation, larval + pupal period, total development period and adult longevity varied significantly amongst the various host grain pulses. They found that green gram and cowpea were the most preferred host among the all host. The minimum incubation period (4.10 days) was recorded in lentil. The total developmental period and longevity of pulse beetle were higher (23.49 and 14.83 days, respectively) on pea than mung (17.19 and 11.75 days, respectively) and cowpea (18.13 days and 11.37 days, respectively). The duration of the life cycle was shortest on mung (33.51 days) and cowpea (34.02 days) and longest on pea (43.85 days).

Ali and Rahaman (2006) reported that the larval (58.21 to 76.31%), pupal (55.35 to 64.40%) development, adult emergence (33.18 to 46.62%) and infestation level (37.30 to 55.30%) on moongbean was the most common and suitable host for *C. maculatus* with regard to preference for oviposition, whereas, lentil (*Lens culinaris* M.) was unsuitable for this pest with regard to larval (21.02 to 21.62%), pupal (9.99 to 11.84%) development, adult emergence (3.29 to 3.48%) and grain loss (2.19 to 2.27%). There was no significant influence of different pulses on egg hatching (82.98 to 91.90%), however, the development period of pulse beetle, *C. maculatus* was influenced by the different pulses and the maximum period (33-34 days) was required for three cultivars of urdbean and the minimum period (24.00 days) for four cultivars of moongbean.

Mandal and Konar (2006) studied the biology of pulse beetle, *C. chinensis* in stored seeds of moongbean and observed that adult longevity of male and female were found to vary from 4.30 to 10.60 and 7.20 to 11.10 days, respectively. Adult longevity irrespective of sex was maximum (9.40 days) in during mid September to end of October, while it was minimum (7.70 days) in during mid April to mid May. The number of adult emerged from a single pair of bruchids ranged from 33.30 to 73.50 irrespective of generations studied. Sex ratio was more in favour of male than female. The more successful adult emergence was recorded from the eggs laid during first few days of oviposition *i.e.* within 5 days after release of the adult beetle.

Quazi (2007) evaluated eight different locally available legumes and pulses *viz.,* green gram (*V. radiata*), lentil (*L. culinaris*), black gram (*V. mungo*), gram (*C. arietinum*), pea (*P. sativum*), soybean (*Glycine max*) and cowpea (*V. unguiculata*) to determine fecundity on the basis of host preference to set measures of control for the

pest. The host preference was highly significant at 5.00 per cent the maximum (199.00) eggs were laid on *Glycine max* followed by pea (109.00), bengal gram (98.20), green gram (98.20), black gram (83.20), cowpea (71.60) and white gram (66.40). No egg laying was reported on lentil and thus, in control.

Bhargava *et al.* (2008) reported that average mean incubation, larval and pupal period of pulse beetle, *C. chinensis* were found in the range of 4.40 – 7.20, 14.80 – 26.20 days and 5.40 – 11.40 days, respectively on different host pulses. They were also reported that the development period of pulse beetle, *C. chinensis* varied from 24.6 – 44.8 days on different pulses including cowpea, mothbean, mungbean, gram, pigeonpea, pea and soybean. The fecundity, adult emergence and adult longevity of pulse beetle, *C. chinensis* was the maximum on cowpea and the minimum on soybean; larval, pupal and development periods were minimum on cowpea and maximum on soybean. The longevity of male and female of pulse beetle, *C. chinensis* varied from 6.2 – 8.8 days and 5.6 – 8.4 days, respectively being shortest in soybean and longest on cowpea in both the sexes. Gatoria and Gill (2008) reported that mean development period of pulse beetle, *C. chinensis* on different chickpea cultivars ranged from 26.33 to 27.00 days, respectively.

Badoor *et al.* (2009) reported that cowpea seeds were the most preferred for feeding the two tested bruchid beetles followed by faba bean seeds, while bruchid infestation was not observed on bean and soybean seeds. The results revealed that pulse beetle, *C. maculatus* deposited more eggs on all tested leguminous seeds and gave more emerged adults with heavier weights than *C. chinensis*. Kar *et al.* (2010) reported that split greengram, *V. radiata* with seed coat was most favoured for adult orientation recording 3.50 adults, while lentil without seed coat was least favoured (0.20) by the adults of pulse beetle, *C. maculatus* with regard to adult orientation. However, it was noticed that during the studies, the maximum number of insects showed non preference to split legumes without seed coat.

Verma and Anandhi (2010) reported that mean incubation, larval + pupal period, pre-ovipositon, oviposition and post-oviposition period and adult longevity of male and female of pulse beetle, *C. chinensis* were 4.0, 16.4, 0.40, 8.00, 2.20, 11.0 and 9.6 days, respectively and total development period was 25.20 days. The mean fecundity of the female was 85.60 eggs and its viability was 94.00 per cent. Pokharkar and Mehta (2011) reported that the mean adult longevity of the male of pulse beetle,

C. chinensis on gram was 7.07±0.84 and ranged from 5.00 to 9.00 days. The average adult longevity of the male of pulse beetle, *C. chinensis* on gram was 8.80±1.14 and ranged from 6.00 to 12.00 days. Such differences in adult longevity may be due to the differences in humidity and temperature. The average eggs laid by the female of pulse beetle, *C. chinensis* on gram were 80 - 89. The sex ratio of Pulse beetle, *C. chinensis* in case of gram consists of more males in comparison to females, being 1: 0.92.

Ramazeame *et al.* (2012) reported that the larval period of *C. chinensis* was highest in gram (21.66 days), whereas lowest in black gram (20.00 days). Thakur and Pathania (2013) observed that biology of pulse beetle, *C. chinensis* on the black gram discovered that total development period of bruchid was 31.00 and 38.30 days during July to August and April to May, respectively. On an average, the incubation period, larval period, pupal period and total development period was of 8.00, 18.39, 8.11 and 34.50 days, respectively.

Chakraborty and Mondal (2015) observed that the adult life span for a male pulse beetle, *C. chinensis* was 4.76 days and 6.01 days whereas for a female 8.36 and 9.13 days, respectively. Ahmad *et al.* (2016) studied that the growth and development of *C. chinensis* on eleven chickpea varieties and study reveal that the fecundity of the *C, chinensis* female varied significantly on various chickpea varieties, and highest on PKG-1 (81.00 eggs/100 seeds) and lowest being on PBG-1 (59.00 eggs/100 seeds). The development period of eggs (5.33 to 7.00 days), larva (17.00 to 18.67 days) and pupa (5.67 to 7.33 days) on various varieties was not significantly different. However, significant variation in the total development period (egg to adult) was 28.67 to 32.33 days in various varieties. Similarly, the growth index of the pulse beetle varied significantly on different varieties (0.52 to 0.71). The result of study showed that the chickpea variety PKG-1 was most favored host for growth and development of the pulse beetle, *C. chinensis.* Singh *et al.* (2017) reported that the mean incubation, larval + pupal period and adult longevity of male and female pulse beetle, *C. chinensis* were 4.17, 27.70, 7.07 and 8.80 days, respectively. The mean of the total development (egg to adult) period of pulse beetles was 34.62 days.

Hosamani *et al.* (2018) reported that the average incubation, larval + pupal and total life cycle period of pulse beetle were 4.00, 12.00 + 7.00 and 29.00 days, respectively. Jaiswal *et al.* (2018) studied the biology of pulse beetle, *C. chinensis* on the stored gram and reported that the incubation, larval and pupal period was

4.15±0.87, 22.30±3.06, and 8.65±0.87 days, respectively. The adult life span for male and female were 9.30±1.08 and 10.15±0.98 days, respectively. The pre-oviposition, oviposition, post-oviposition and total development period were 6.55±0.94, 8.10±1.25, 1.85±0.48, and 32.85±3.42 days, respectively. The mean egg laid by female was 84.15.

Kumar *et al.* (2018) reported that the mean incubation, larval + pupal period and adult longevity of male and female of pulse beetle were 4.00, 16.40, 11.00 and 9.60 days, respectively. The mean of total development period from egg to adult was 25.20 days and pre-oviposition, oviposition and post-oviposition period were 0.40, 8.00 and 2.20 days, respectively. The mean fecundity of the female was 85.60 eggs and viability 94 per cent during its life time. Sharma *et al.* (2018) studied the biology of pulse beetle, *C. maculatus* on pigeonpea, *Cajanus cajan* grains and study revealed that the adult beetle was oval in shape and reddish-brown in colour, with dark stripes on each side of dorsal abdomen with mean fecundity was 4.20+0.20 days with hatching per cent of 98.20±0.30. Mean larval-pupal period, ovipositon, post-ovipositon, total life cycle and adult life span were 21.30±0.3, 8.20±0.5, 2.80±0.5, 33.30±2.4 and 12.00±2.1 days, respectively. Augustine and Balikai (2019) reported that the total development period of 26.00 to 40.00 days with the average mean of 30.90±4.28 days.

2.2 Bio-efficacy of Different Products against Pulse Beetle, *Callosobruchus chinensis* (L.) on Stored Seed of Black Gram, *Vigna mungo* (L.)

Singh and Singh (1990) reported that seeds of moongbean showed only 0.50 per cent damage when treated with mustard oil at the rate of 0.1 and 0.2 ml/100 gm and rape seed oil at the rate of 5 ml/100 gm tested against pulse beetle, *Callosobruchus* spp. Sharma and Singh (1993) studied that the effect of 8 different vegetable oils against attack by Pulse beetles *C. chinensis* and showed that the oils of coconut, mustard, sesame and soybean oil at 0.1, 0.2 and 0.3 ml/100 gm of seed were found most effective for a period of 8 months. Lakhanpal *et al.* (1995) studied to evaluate effectiveness of edible oils (sesamum, mustard, groundnut, soybean, linseed, sunflower, safflower and coconut oil) as grain protectants against pulse beetle, *C. analis* infesting black gram, *Vigna mungo* seeds. They concluded that at 0.1, 0.2 and 0.3 ml/100 gm sunflower oil was found most effective, followed by sesame, groundnut and coconut oil, which resulted in minimum fecundity and prevented adult emergence for up to 150 days.

Juneja and Patel (1994) evaluated different botanical products against *C. analis* infesting moongbean, *V. radiata.* Among the different botanical products, the seed powder of custard apple, *Annona squamosa* and black pepper, mint, *Mentha piperita* (leaves) and peel of orange all at the rate of 5 parts/100 parts of moongbean (w/w) resulted in 100 per cent adult mortality after 3 days of treatment application and prevented the females from laying eggs until 60 days after treatment application. Besides, no population build-up and seed damage was recorded until 4 months of storage; whereas, neem seed kernel powder gave defense only for 3 months. Kumari and Kumar (1998) evaluated the effect of the mixture of tobacco and neem leaf powder against pulse beetle, *C. chinensis* infesting pulse grains, both products were found effective and caused maximum mortality of the pulse beetle when applied at various doses.

Misra (2000) observed that the cow dung ash and mustard oil treatment completely inhibited oviposition of pulse beetle. Al-Awati *et al.* (2002) evaluated eight plant products for their insecticidal and repellent properties against pulse beetle, *C. chinensis* and found that the methanol and ethanol extracts from the seeds of custard apple recorded highest mortality of 100 per cent of beetles within 24 hours of their exposure. The other extracts that caused maximum mortality were from *A. nilotica, M. Communis, C. juncea* and *S. aegyptiaca* in methanol and *B. sacra, S. aegyptiaca, J. dhofarica* and commercial neem in ethanol. The extracts of *M. communis* in methanol indicated highest repellent action by beetles compared to another extracts. Juneja and Patel (2002) reported that moongbean seeds treated with 1, 2, 3, 4 or 5 per cent (w/w) powder of custard apple (*A. squamosa*), black pepper (*P. nigrum*) seeds, mint (*M. piperita*) leaf, orange (*C. reticulate*) peels and neem (*A. indica*) seed kernel used to determine the persistence of these botanicals product as protectants against the pulse beetle, *C. analis.* The number of eggs per 100 grains was decreased with increased dosage of the botanicals, although grain damage increased with the duration of the various treatments. Seeds of moongbean treated with 1 per cent of either black pepper seed or powder custard were totally protected from beetle up to five and four months, respectively.

Kotkar *et al.* (2002) evaluated foliar extract of custard apple against Pulse beetle, *C. chinensis* and found that flavonoids isolated from aqueous extracts of custard apple showed 80 per cent insecticidal property against *C. chinensis* at a 0.07

mg/ml concentration. Singh (2003) reported that the seeds of moongbean (*V. radiata*) can be effectively protected from the pulse beetle, *C. chinensis* by dried neem leaf powder (*A. indica*) at the rate of 0.5 to 2.0 mg/100 gm seed.

Dwivedi and Venugopalan (2004) evaluated leaf extract of *Tabernaemontana divaricata* blended with that of *Quisqualis indica, Annona squamosa*, *Chenopodium album, Anethum sowa* in a 1:1 ratio (v/v) and assess their ovipositon deterrence action against pulse beetle, *C. chinensis* on cowpea seeds. When mixed with *A. squamosa* and *C. album,* this mixture resulted in 97.15 and 94.70 per cent deterrence, respectively. While *Q. indica* gave 75.15 per cent reduction in oviposition over control. The other two combinations resulted in moderate decreasing in ovipositon varying from 51.83 to 57.75 per cent.

Shaheen and Khaliq (2005) reported that fly ash, cow dung ash and terpine oil with the application rate of 1.0 gm/50 gm of grains take the minimum days (5.06 days) to 100 per cent mortality of released adults, lowest fecundity (0.86 eggs/grain), minimum holes (0.41%), lowest number (3.14 beetle) of emerged adults, maximum inhibition (78.62%) of adults, lowest weight loss of 9.63 per cent and the minimum of 2.86 days to 100 per cent mortality of adults. Bajya *et al.* (2007) studied to evaluate the effect of neem (*A. indica*), mustard (*B. juncea*) and castor (*R. communis*) at 0.4, 0.8 and 1.2 ml/100 gm seeds and leaf and kernel powder of neem, karanj (*Pongamia glabra, P. pinnata*) and tulsi leaf powder (*O. tenuiflorum*) at 4.0, 8.0 and 12.0 gm/100 gm seeds on cowpea seeds and found neem oil was the effective in giving the highest adult mortality (96.00%) after three days of treatment. All the plant product caused adult mortality of *C. chinensis* up to three days of treatment.

Laxshmi *et al*. (2007) evaluated that the effect of seed powder of *Vitex negundo, Curcuma longa* and *Acorus calamus* at 3.0 per cent; palmarosa, *Cymbopogon martini* spike powder at 3.0 per cent; neem kernel dust at 3.0 per cent; activated clay at 1.0 per cent; teepol at 0.1 per cent and seed and leaf powder of custard apple, *A. squamosa* at 3.0 per cent against pulse beelte, *C. maculates.* The seed powder of *Anonus squamosa* and rhizome powder of *A. calamus* found lowest egg hatching of *C. maculatus* and the larvae did not complete their development. The weight loss was also found lowest in this treatment.

Akhter and Rahaman (2008) studied to evaluate neem, *A. india*; dhokolmi, *Ipomoea crassicaulis,* nishinda, *Vitex negundo* against *C. chinensis* on gram and found that all the plant materials were effective against pulse beetle, *C. chinensis.* Leaf powder of dholkolmi was found highly effective than neem and nishinda regarding grain protection and increased seed germination of gram. Per cent egg bearing seeds, number of eggs on 15 seeds and adult emergence were found significantly highest in untreated dholkolmi seed. Adult emergence on 50 gm seeds was also found to be significantly lowest in dholkolmi treated seeds. Comparatively lowest number of damaged seeds (6.33%), seed weight loss (10.83 gm) and highest seed germination (60.33%) were obtained in seeds treated with dhoklomi leaf powder over the control. Govindan and Nelson (2008) evaluated the effect of plant powders on *C. maculatus.* To analysis the synergistic effect of botanicals, ten mixtures of plant powders were made and tested. Maximum mortality (94.44%) was recorded in *Annona squamosa* leaf powder 0.5 per cent + *A. cocculus* seed powder 0.5 per cent at 168 hour after the treatment. The minimum number of eggs (70.00) was laid in *Nicotiana tabacum* 0.5 per cent + *Helicteres isora* 0.5 per cent, whereas 220 eggs in control.

Verma and Anandhi (2010) evaluated the effect of seven botanicals on mortality of pulse beetle, *C. chinensis* and observed that the neem leaf (8.0 gm) was found more effective with 38.33 per cent adult mortality, whereas neem leaf (4.0 gm) was found less effective treatment with 5.70 per cent of adult mortality. Mahdi and Khalequzzaman (2012) studied the effectiveness of diatomaceous earth and other dusts likes kaolin powder, coal ash, paddy husk ash, china clay, alluvial soil and a dust formulations insecticide carbaryl were tested against pulse beetle, *C. chinensis* and *C. maculatus*.

Rajasri *et al.* (2012) observed that the neem formulations *viz.,* neemazal, econeem plus and neem cake were at par whereas deltamethrin found to be extremely effective against pulse beetle and enhanced the storability and quality of Black gram seed. Tabu *et al.* (2012) evaluated that botanicals, inert materials and edible seed oils had caused higher adult mortality, reduced egg laid, reduced F1 progeny emergence of pulse beetle, *C. chinensis,* low seed damage and lower weight loss of seed without affecting seed germination in stored gram grains. Seed powder of *Azardiractica indica* at 20 gm/kg of seed and the leaf powder of *C. ambrosioides* at 40 gm/kg of

seed caused higher adult mortality next to malathion 5 per cent dust at 0.5 gm/kg of seed, while other botanicals, inert materials and oils showed better performance than the control. *Brassica juncea, G. abyssinica*, *L. usitatissimum* seed oils applied @ 5.0 ml/kg of seed resulted in highest reduction in progeny emergence and sand, wood ash at all the levels tested, gave more effective inhibition in F1 progeny production. These results revealed that botanicals, inert materials and edible oils could be effective for the control of *C. chinensis* in stored gram.

Badii *et al.* (2013) reported the efficacy of the DEs, Diatomenerde, Damod-DI, Probe-A and Fossil shield against pulse beetle, *C. maculatus* in seeds of M. geocarpum. Each DE was applied at 0.50, 1.00, 1.50 and 2.00 gm/kg and each treatment infested with new emerged *C. maculatus* in petri dishes. The set up was maintained at 50 and 80 per cent relative humidity regimes at ambient temperature. Adult mortality increased gradually with the increasing dosage of DE and time of exposure. Seeds treated at 2.00 or 1.50 g/kg recorded significantly lowest number of eggs and F1 emergence compared with lower dosages in all DEs. Increased DE concentration constantly decreased seed weight loss due to low adult beetle infestation, but there was no significant effect on seed viability of *M. geocarpum.* Des were set up most effective at 50 per cent relative humidity instead of 80 per cent relative humidity. Probe-A or Damol-DI applied at 1.50 or 2.00 gm/kg at 50 per cent relative humidity is a viable alternative for preventing pulse beetle, *C. maculatus* infestation in stored Kersting's groundnut.

Lazar and Panickar (2013) reported that custard apple seed powder at 25 gm/kg seed, orange peel powder at 150 gm/kg seed, clove oil at 10 ml/kg seed and coconut oil at 10 ml/kg seed completely prevented ovipositon, adult emergence and grain damage on number and weight basis after four months of storage and found to be more effective grain protectants. Ramazeame (2014) reported that germination per cent of black gram, *Vigna mungo* L. was high in neem kernel powder. However, the decreasing trend in the germination per cent was observed both in botanicals and oils treated and untreated grains.

Thakur and Pathani (2017/2013) reported that black pepper powder and neem leaf powder at 5 gm/100 gm seed as well as mustard oil and neem oil at the rate of 5 and 7.5 ml/kg of seed were found most effective against *C. chinensis* and gave higher

adult mortality of 100 and 75.55 per cent in case of powders and 100 per cent in case of oils after 7 days of exposure of treatment and remained moderately capable of inhibiting oviposition and adult emergence of *C. chinensis.*

Ramyahr *et al*. (2017) reported that commercially available oils of neem, mustard, karanj, castor and sunflower at 3, 5, 7 ml/kg seed, respectively evaluated against pulse beetle, *C. chinensis*. The minimum per cent weight loss was recorded in neem oil treatments at all three dosages (3, 5, 7 ml/kg seed) of 2.36, 0.41 and 0.16 followed by karanj oil (2.73, 0.91 and 0.58%), castor oil (3.33, 1.83 and 1.33%), mustard oil (4.56, 2.66 and 1.53%) and sunflower oil (4.90, 2.93 and 2.36%). The neem oil was also found most effective with lowest per cent damage (10.66, 2.33 and 1.00%) on moongbean seed followed by karanj oil (13.00, 4.33 and 2.00%), castor oil (14.66, 5.66 and 3.50%), mustard oil (17.33, 12.00 and 6.00%) and sunflower oil (19.66, 13.62 and 10.66%). The highest germination per cent was reported in neem oil (89.99%) followed by karanj oil (88.88%), sunflower oil (88.88), castor oil (83.33%) and mustard oil (83.33%).

Singh *et al.* (2017) evaluated that eight seed protectants *viz*., neem leaf powder at 5 gm/kg seed, nimbecidine at 5 ml/kg seed, castor oil at 5 ml/kg seed, karanj oil at 5 ml/kg seed, eucalyptus oil at 5 ml/kg seed, custard apple powder at 5 gm/kg seed, gorakhmundi at 5 gm/kg seed and deltamethrin 2.8 EC at 0.04 ml/kg seed were evaluated against pulse beetle. Among different seed protectants, nimbecidine at 5 ml/kg seed followed by karanj oil at 5 ml/kg seed botanicals were found more effective in respect to less per cent infestation and per cent weight loss upto six months of storage. Sharma et al. (2018) reported that higher mortality of *C. maculatus* was observed in neem oil at 10 ml/kg seed (84 to 100 %) and lower (3.33%) in turmeric powder at 3.50 gm/kg seeds after 135 days of storage period. Neem oil at 10 ml/kg seeds had absolutely inhibited the ovipositon, adult emergence and seed damage by C. maculates.

Rathore *et al.* (2019) evaluated the efficacy of different botanicals against pulse beetle, *C. chinensis* in stored moongbean. There were eight treatments *viz.,* clove powder at 3 gm/kg grain, black pepper powder at 3 gm/kg seed, tulasi leaf powder at 3 gm/kg seed, *Acorus calamus* rhizome powder at 10 gm/kg seed, soybean oil at 5 ml/kg seed, sesame oil at 5 ml/kg seed, castor oil at 5 ml/kg seed were evaluated against pulse beetle, *C. chinensis* on moongbean seed. All botanicals

recorded found lower rate of ovipositoin and adult emergence than the control. Significantly lower number of egg laying was found in *Acorus calamus* rhizome powder (19.00 eggs/100 gm seed) and black pepper powder (27.00 eggs/100 seeds). Similar effect was shown by *A. calamus* rhizome powder and black pepper powder in minimum adult emergence. The minimum number of egg laying and adult emergence were recorded in clove powder, castor oil, sesame oil, soybean oil and tulsi leaf powder in first month and similar trend of efficacy of botanicals was found even after 6 months of storage.

3. MATERIALS AND METHODS

The experiment to Study "Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)" was conducted under laboratory conditions at the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during July-December, 2019. The materials used and methodology adopted in present investigation has been given as below.

3.1 GENERAL DETAILS OF THE EXPERIMENT

3.1.1 Nucleus Culture

The nucleus culture of pulse beetle, *C. chinensis* (L) was obtained from the laboratory of Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. This culture was maintained in the Department of Entomology, Bio-agent laboratory at ambient conditions of temperature and relative humidity. Black gram was purchase from the local market, washed, cleaned shade-dried and sterilized in an oven at 50° C for 24 hours. The sterilized black gram seeds were used to maintain the culture for experimental needs.

3.1.2 Maintenance of Culture

The culture was maintained in the laboratory at ambient conditions of temperature and humidity (Bio-control Lab, Department of Entomology). Ten pairs of one-day old adults were released into plastic containers (250 ml capacity) containing 100 gm black gram seeds on different dates and replicated thrice to get regular supply of the test insect of uniform age. The jars were covered with muslin cloth and fastened with rubber bands. The released adults were removed from the containers of the dated culture after three days. Utmost care was taken to pick and transfer the seeds or test insects with the help of a camel hair brush, forceps and an aspirator (direct touching was avoided).

3.2 BIOLOGY OF PULSE BEETLE, *C. chinesis*

The biology of pulse beetle, *Callosobruchus chinensis* was studied on black gram var. Nirali. For the experiment, three plastic containers (250 ml capacity)

containing 100 gm seeds were taken where in freshly emerged single pair of *C. chinensis* was released in each container. Identification of the sexes will be made by employing the method suggested by Pandey and Singh (1997).

Mouth of the containers were covered by muslin cloth and secured with rubber bands and later maintained at ambient conditions of temperature and relative humidity in the laboratory. Adults were removed from these containers after death.

3.2.1 Observations

i. **Incubation period:** The time taken by the eggs to hatch was recorded.

ii. **Larval and pupal period:** Larval and pupal period within the grain was recorded by gently splitting-open the whole grain with the help of the needle and forceps to observe the stage of insect under a stereo-zoom binocular.

iii. **Pre-oviposition period of female:** The number of days before laying eggs was recorded.

iv. **Oviposition period of female:** The number of days in which oviposition was carried out was recorded.

v. **Post-oviposition period:** The number of days after oviposition till the death of adults was recorded.

vi. **Adult longevity:** The longevity of male and female adults were recorded.

vii. **Life cycle completed (days):** Single generation time period was calculated.

viii. **Fecundity:** Eggs laid on each day were kept in separate containers covered with muslin cloth.

3.3 BIO-EFFICACY OF DIFFERENT PRODUCTS AGAINST PULSE BEETLE

The experiment was laid out in completely randomized design under laboratory condition in the Department of Entomology on black gram (Variety: Nirali) seeds with seven treatments replicated four times. The seeds of black gram were sterilized before used in the experiment. For bio-efficacy, the plant materials were collected; shade dried and were powdered in a grinder mixer and sieved through a mesh of size 50 (297 micron) to remove the waste matter. The botanicals and inert dust were mixed with pre-sterilized grains (50 gm) at application rates of 5 gm or ml

per kg seeds. The treated samples were kept in plastic containers, shaken vigorously in order to have an even coating of the test material on the grain surface. Five pairs of freshly emerged (0-24 hr) adults of *C. chinensis* were released into each container including that of control.

Layout of experiment

Experimental design : CRD (Completely Randomized Design)

Number of treatment : 7

Number of replication : 4

Table: 3.1: Treatment details of different plant products, inert dusts and their doses

S. No.	Common name	Scientific name	Doses (gm or ml/kg)
T_1	Custard apple leaf powder	*Annona squamosa* (L.)	5 gm
T_2	Mustard oil	*Brassica juncea* (L.)	5 ml
T_3	Neem leaf powder	*Azadirachta indica* (L.)	5 gm
T_4	Diatomaceous earth	-------	5 gm
T_5	Cow dung ash	-------	5 gm
T_6	Castor oil	*Ricinus communis* (L.)	5 ml
T_7	Untreated control	--------	----

3.3.1 Observations and analysis

i. Mortality counts of pulse beetle

Twenty insects were released in each jar to assess the bio-efficacy of the different products on pulse beetles mortality. The number of dead beetles in each replicate jar was counted after 1, 3, 5 and 7 days of treatment.

ii. Mean egg laid by pulse beetle

The average number of eggs laid on 100 randomly selected seeds/grains from each treatment after 3, 7 and 10 days of adult release was recorded.

iii. Adult emergence of pulse beetle

The numbers of adults that emerged from each treatment were counted and removed after 1, 2 and 3 months of storage.

iv. Grain/seed damage (%) by pulse beetle

The number of damaged seeds by pulse beetle was counted after 3 month of storage. Grain/ seed damage was computed as suggested by Adams and Schulten method (1978):

$$\text{Grain / seed damage}(\%) = \frac{\text{Number of holed seeds}}{\text{Total seeds}} \times 100$$

v. Weight loss (%) in grain/seeds of black gram due to pulse beetle infestation: Weight loss will be calculated using the following equation:

$$\text{Weight loss}(\%) = \frac{\text{Initial weight of seeds} - \text{final weight of seeds}}{\text{Initial weight of seeds}} \times 100$$

The count and weight method as explained by Dick (1987) as follow:

$$\text{Weight loss}(\%) = \frac{(\text{UNd}) - (\text{DNu})}{\text{U}(\text{Nd} + \text{Nu})} \times 100$$

Where: U = Weight of undamaged grains

D = Weight of damaged grains

Nu = Number of undamaged grains

Nd = Number of damaged grains

vi. Germination per cent of seeds/grain:

After the 3 month of treatment application, the seeds were sown for germination per cent. The germination per cent was calculated by following equation:

$$\text{Grain / seed germination}(\%) = \frac{\text{Number of germinated seeds}}{\text{Total seeds}} \times 100$$

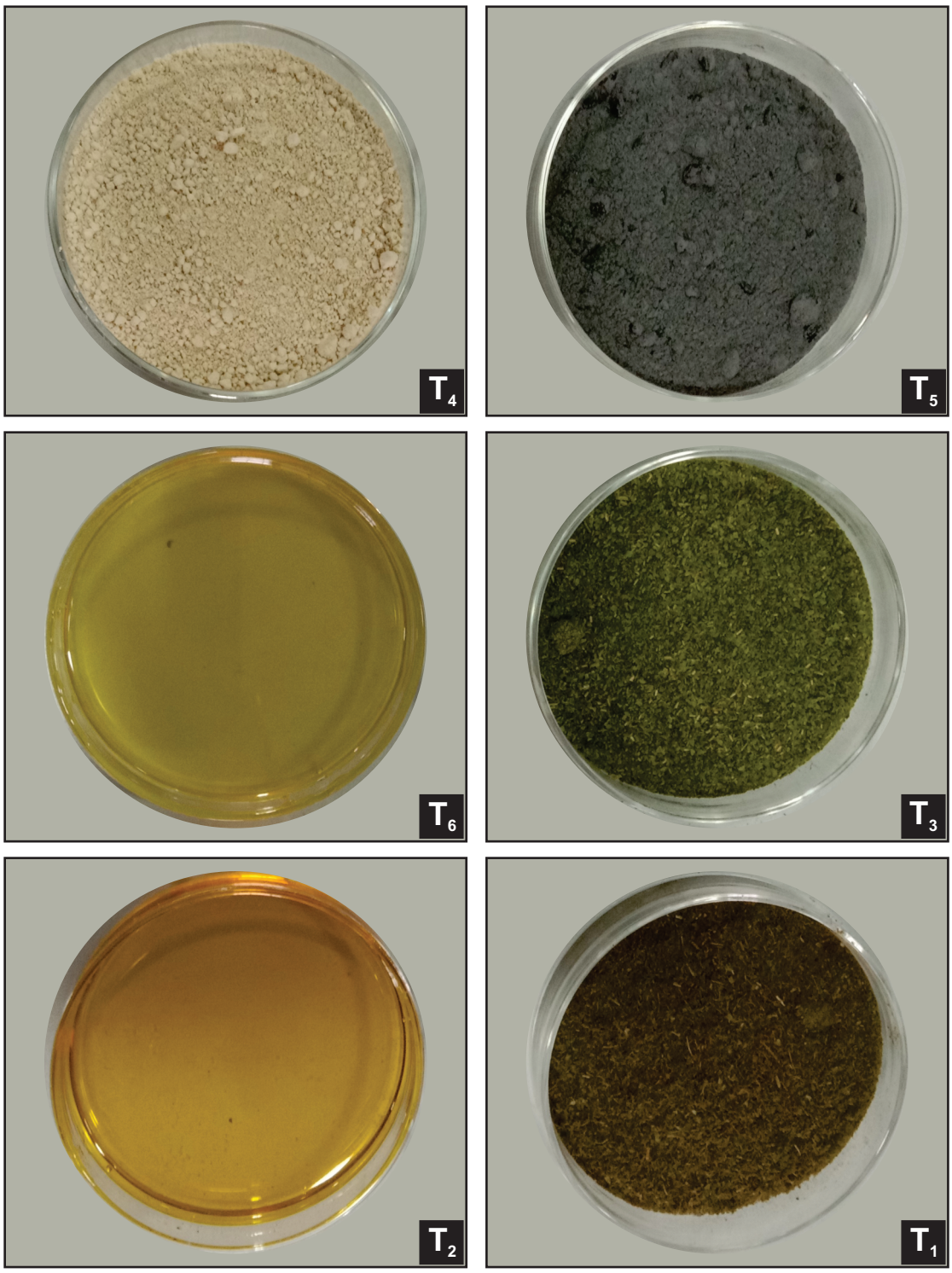

Plate 3.1: Plant Products and inert dusts as grain protectants

T_1 - Custard apple leaf powder

T_2 - Mustard oil

T_3 - Neem leaf powder

T_4 - Diatomaceous earth

T_5 - Cow dung ash

T_6 - Castor oil

4. RESULTS

The findings on different aspects of the investigation on **"Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)**" have been presented and described as follows:

4.1 BIOLOGY OF PULSE BEETLE, *C. chinensis*

The data on biology of pulsed beetle, *C. chinensis* was presented in table-4.1 The data revealed that mean fecundity was 89.30 eggs per female and ranged from 81-97 eggs. The hatching period of eggs was ranged from 4-5 days with the mean of 4.10 days. The larval and pupal period was ranged from 24-28 days with the mean of 26.57 days. The pre-oviposition, oviposition and post-oviposition period was ranged from 5-8, 4-6 and 1-3 days with the mean of 5.83, 4.77 and 1.77 days, respectively. The mean male and female longevity were 8.43 and 12.37 days, and ranged from 7-9 and 10-14 days, respectively. Total life cycle of male was completed in 39.03 days with range from 37-42 days, while female life cycle completed in 42.97 days with range from 40-47 days, respectively.

4.2 BIO-EFFICACY OF DIFFERENT PRODUCTS AGAINST PULSE BEETLE, *C. chinensis*

The bio-efficacy of different products *viz.,* custard apple leaf powder @ 5 gm/kg, mustard oil @ 5 ml/kg, neem leaf powder @ 5 gm/kg, diatomaceous earth @ 5 gm/kg, cow dung ash @ 5 gm/kg, castor oil @ 5 ml/kg against pulse beetle, *C. chinensis* on black gram, *Vigna mungo* L. seeds were evaluated under present study. The observation on pulse beetle mortality at 1, 3, 5 and 7 days after release, mean egg laid by pulse beetle at 3, 7 and 10 days after release, mean adult emergence at 1, 2 and 3 moth after release, grain/seed damage per cent, weight loss per cent and germination per cent of black gram seeds were observed and calculated. The data recorded are presented in table- 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 & 4.7 and analysed.

4.2.1 Mortality (%) of pulse beetle

At one day after release

It is evident from table- 4.2 and fig.-4.1 that the different products caused significant pulse beetle mortality on black gram as compared to control. Castor oil @ 5 ml/kgs showed maximum mortality of ulse beetle with 23.75 per cent followed by mustard oil @ 5 ml/kg, which caused 20.00 per cent mortality at one day after release of adult beetle. Application of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg caused 12.50, 7.50, 5.00 and 5.00 per cent adult pulse beetle mortality at one day after release, respectively.

At three day after release

The data presented in table-4.2 and fig.-4.1 revealed that castor oil @ 5 ml/kg had maximum mortality of pulse beetle (45.82 %). Next effective treatment was mustard oil @ 5 ml/kg, which caused 42.18 per cent mortality at three days after release of adult beetle. Application of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg caused 29.90, 25.66, 21.05 and 18.42 per cent adult pulse beetle mortality at three days after release, respectively.

At five day after release

The data (table- 4.2 & fig.-4.1) revealed that different products caused significant pulse beetle mortality on black gram, as compared to control. Castor oil @ 5 ml/kg showed maximum mortality of pulse beetle which was 63.54 per cent followed by mustard oil @ 5 ml/kg (62.29%) at five days after release of adult beetle. Seed treatment with diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg caused 55.14, 52.62, 39.87 and 35.49 per cent adult pulse beetle mortality at five days after release.

At seven day after release

Seed treatment with castor oil @ 5 ml/kg was showed maximum mortality (66.67%) of pulse beetle on black gram at seven days after release (table-4.2 & fig.-4.1). Seed treatment with mustard oil @ 5 ml/kg caused 64.58 per cent mortality. Application of diatomaceous earth @ 5 gm/kg and custard apple leaf powder @ 5 gm/kg caused 62.86 and 53.27 per cent adult pulse beetle mortality, respectively. The

Table 4.1: Biology of Pulse beetle, *C. chinensis* on Black gram var. Nirali (n=30)

Insect stages	Mean ± SD	Range (days)
Incubation period	4.10 ± 0.31	4.00 – 5.00
Larval + Pupal period	26.57 ± 1.07	24.00 – 28.00
Pre oviposition period of female	5.83 ± 0.99	5.00 – 8.00
Oviposition period of female	4.77 ± 0.73	4.00 – 6.00
Post oviposition period of female	1.77 ± 0.63	1.00 – 3.00
Adult longevity:		
i. Male	8.43 ± 0.68	7.00 – 9.00
ii. Female	12.37 ± 1.30	10.00 – 14.00
Total life cycle (egg to adult):		
i. Male	39.03 ± 1.43	37.00 – 42.00
ii. Female	42.97 ± 1.96	40.00 – 47.00
Fecundity/female (number of eggs)	89.30 ± 5.15	81.00 – 97.00

SD = Standard deviation

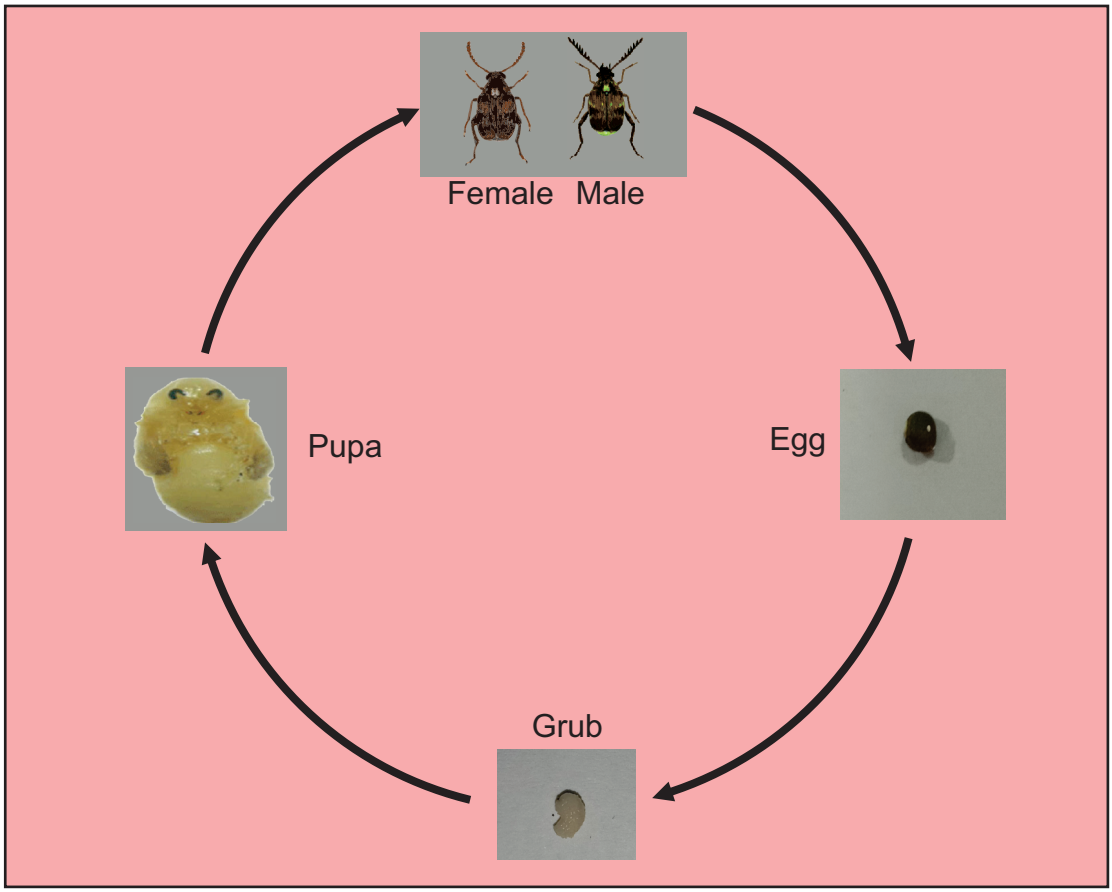

Plate 4.1: Life cycle of pulse beetle

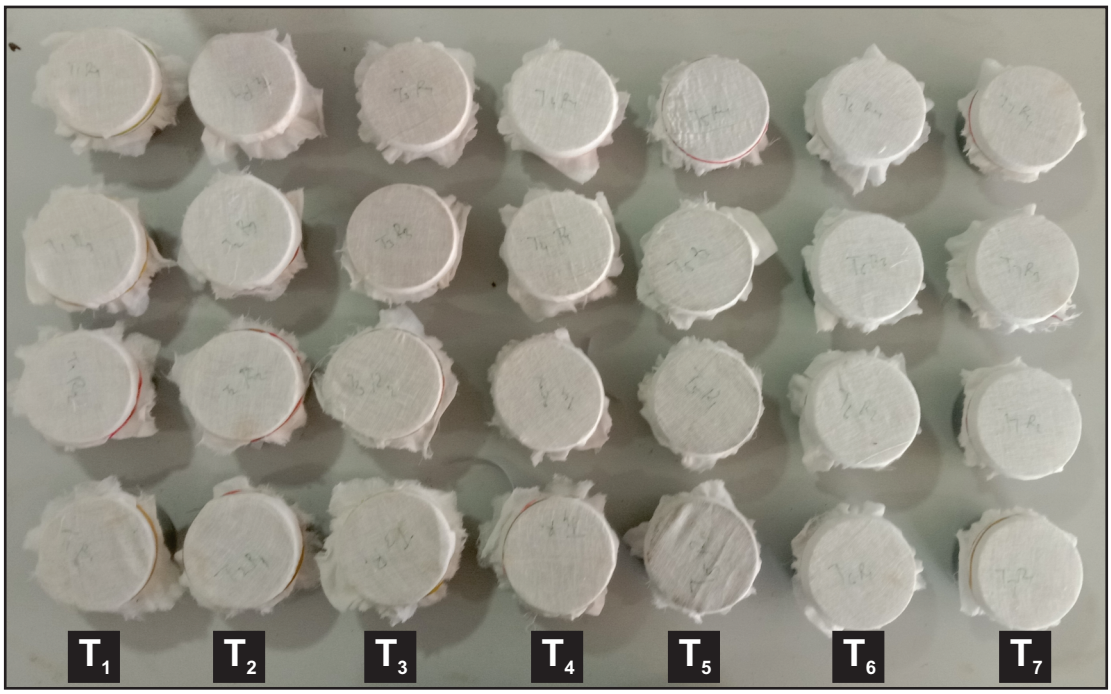

Plate 4.2: Plastic containers containing treated blackgram seeds with different products against pulse beetle

T_1 - Custard apple leaf powder

T_2 - Mustard oil

T_3 - Neem leaf powder

T_4 - Diatomaceous earth

T_5 - Cow dung ash

T_6 - Castor oil

T_7 - Control

Table: 4.2: Effect of different products on mortality of pulse beetle, *C. chinensis* on black gram var. Nirali during July-December, 2019

S. No.	Treatment	Mortality % of pulse beetle				
		1 DAR**	**3 DAR**	**5 DAR**	**7 DAR**	**Pooled Mean**
T_1	Custard apple leaf powder @ 5 gm/kg	7.50 (15.68)*	25.66 (30.27)	52.62 (46.50)	53.27 (47.05)	34.76 (34.87)
T_2	Mustard oil @ 5 ml/kg	20.00 (26.48)	42.18 (40.48)	62.29 (52.13)	64.58 (53.62)	47.26 (43.17)
T_3	Neem leaf powder @ 5 gm/kg	5.00 (12.92)	21.05 (27.22)	39.87 (39.14)	47.22 (43.41)	28.28 (30.67)
T_4	Diatomaceous earth @ 5 gm/kg	12.50 (20.61)	29.90 (33.06)	55.14 (47.97)	62.86 (52.50)	40.10 (38.53)
T_5	Cow dung ash @ 5 gm/kg	5.00 (12.92)	18.42 (25.28)	35.49 (36.55)	39.70 (39.03)	24.65 (28.44)
T_6	Castor oil @ 5 ml/kg	23.75 (29.09)	45.82 (42.60)	63.54 (52.86)	66.67 (54.74)	49.94 (44.82)
T_7	Control	1.25 (3.23)	0.00 (0.00)	1.25 (3.23)	0.00 (0.00)	0.62 (1.60)
	S.Em ±	1.659	1.624	1.605	1.642	1.632
	C.D. (p =0.05)	4.879	4.777	4.721	4.828	4.801

* Figures in parentheses are retransformed per cent values; ** DAR: Days after release

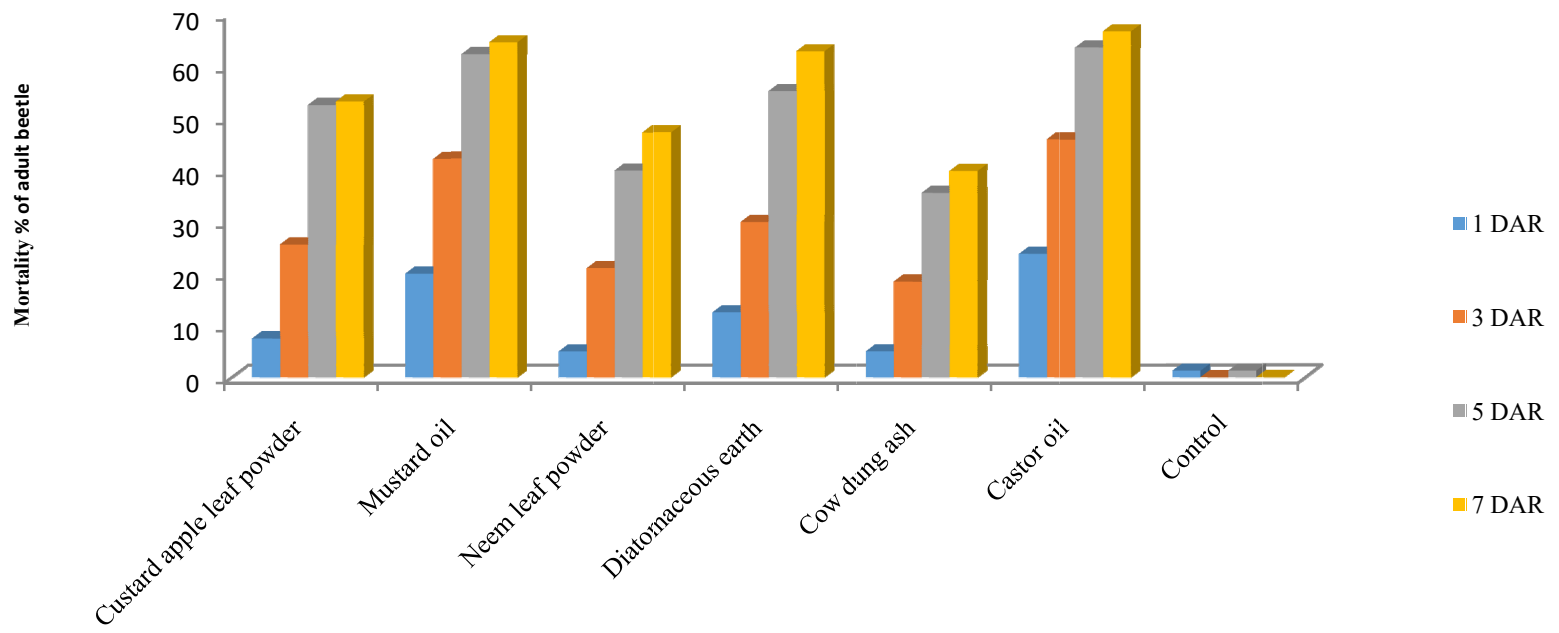

Fig.4.1: Effect of different products on mortality of pulse beetle, *C. chinensis* on black gram var. Nirali during 2019

minimum pulse beetle mortality was observed in treatments of neem leaf powder @ 5 gm/kg (47.22%) and cow dung ash @ 5 gm/kg (39.70%).

4.2.2 Mean egg laid by pulse beetle

At three day after release

The data (table-4.3 & fig.-4.2) revealed that all the treatments were found significantly superior over control. The lowest number of mean egg laid (23.50 eggs) by pulse beetle on castor oil @ 5 ml/kg treated black gram seeds/grains. The mean egg laid on seed treated with mustard oil @ 5 ml/kg was 25.25 eggs. The mean egg laid in case of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg treated seeds were 31.75, 36.00, 43.50 and 49.75 eggs at three days after release of adult, respectively. Cow dung ash @ 5 gm/kg was found least effective treatment against pulse beetle and maximum egg laying was found.

At seven day after release

The data presented in table-4.3 and fig.-4.2 showed that lowest number of mean egg laid by pulse beetle on castor oil @ 5 ml/kg treated black gram seeds/grains (25.75 eggs) at seven days after release. The mean egg laid at seven days after release of beetle on mustard oil @ 5 ml/kg, diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg and neem leaf powder @ 5 gm/kg seed treated grains were 28.50, 35.25, 42.50 and 50.00 eggs, respectively. The maximum egg laying (53.50 eggs) was observed on cow dung ash @ 5 gm/kg treated seeds, which was found least effective treatment against pulse beetle.

At ten day after release

The data (table-4.3 & fig.-4.2) revealed that all the treatments were found significantly superior over control on black gram. The lowest number of mean egg laid (24.25 eggs) by pulse beetle on castor oil @ 5 ml/kg treated black gram seeds/grains, which was found most effective treatment against pulse beetle. The mean egg laid at ten days after release of beetle on mustard oil @ 5 ml/kg seed treated grains was 26.75 eggs. The mean egg laid in case of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg treated seeds were 32.75, 43.25, 51.50 and 55.25 eggs, respectively. Cow dung ash @ 5 gm/kg was found least effective treatment against pulse beetle and had maximum egg laid.

4.2.3 Adult emergence

At one month after release

A significant variation was observed among different treatments in terms of number of adult beetles emerged at one month after release during the management of pulse beetle on black gram (table-4.4 & fig.-4.3). Seed treatment with castor oil @ 5 ml/kg was found to be most effective, whereas cow dung ash @ 5 gm/kg was found to be very less effective against the pulse beetle. The minimum number of adult emergence was recorded in castor oil @ 5 ml/kg seed (11.00 adults/100 seeds). Seed treatment with mustard oil @ 5 ml/kg seed was found next effective treatment and adult emergence at one month after release was 14.75 adults/100 seeds. It is followed by seed treatment with diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg and neem leaf powder @ 5 gm/kg which showed adult emergence of 17.00, 20.50 and 22.50 adutls/100 seeds, respectively. The maximum number of adult emergence was found in seed treatment with cow dung ash @ 5 gm/kg (22.75 adults/100 seeds).

At two month after release

The minimum number of adult emergence (14.25 adults/100 seeds) was recorded in castor oil @ 5 ml/kg seed at two month after release (table-4.4 & fig.-4.3). Seed treatment with mustard oil @ 5 ml/kg seed was found next effective treatment and adult emergence was 16.25 adults/100 seeds. It is followed by seed treatment with diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg and neem leaf powder @ 5 gm/kg which showed adult emergence of 20.50, 26.00 and 31.25 adults/100 seeds at two month after release, respectively. The maximum number of adult emergence (33.25 adults/100 seeds) was found in seed treatment with cow dung ash @ 5 gm/kg, which was found least effective treatment against pulse beetle.

At three month after release

The data presented in table-4.4 and fig.-4.3 revealed that seed treatment with castor oil @ 5 ml/kg was found to be most effective throughout the storage period of three month (90 days), whereas cow dung ash @ 5 gm/kg was found to be very less effective against the pulse beetle. The minimum number of adult emergence was recorded in castor oil @ 5 ml/kg seed (16.25 adults/100 seeds). Seed treatment with mustard oil @ 5 ml/kg seed, diatomaceous earth @ 5 gm/kg, custard apple leaf

Table 4.3: Effect of different products on mean egg laid by pulse beetle, *C. chinensis* on black gram var. Nirali during July - December, 2019

S. No.	Treatment	Mean egg laid/100 seeds			
		3 DAR**	**7 DAR**	**10 DAR**	**Pooled Mean**
T_1	Custard apple leaf powder @ 5 gm/kg	36.00 (6.04)*	42.50 (6.56)	43.25 (6.61)	40.58 (6.40)
T_2	Mustard oil @ 5 ml/kg	25.25 (5.07)	28.50 (5.38)	26.75 (5.22)	26.83 (5.22)
T_3	Neem leaf powder @ 5 gm/kg	43.50 (6.63)	50.00 (7.11)	51.50 (7.21)	48.33 (6.98)
T_4	Diatomaceous earth @ 5 gm/kg	31.75 (5.67)	35.25 (5.97)	32.75 (5.76)	33.25 (5.80)
T_5	Cow dung ash @ 5 gm/kg	49.75 (7.09)	53.50 (7.35)	55.25 (7.46)	52.83 (7.30)
T_6	Castor oil @ 5 ml/kg	23.50 (4.89)	25.75 (5.12)	24.25 (4.97)	24.50 (4.99)
T_7	Control	74.25 (8.64)	80.25 (8.98)	85.50 (9.27)	80.00 (8.96)
	S.Em ±	0.114	0.106	0.108	0.109
	C.D. (p =0.05)	0.335	0.309	0.319	0.321

* Figures in parentheses are square root transformed values; ** DAR: Days after release

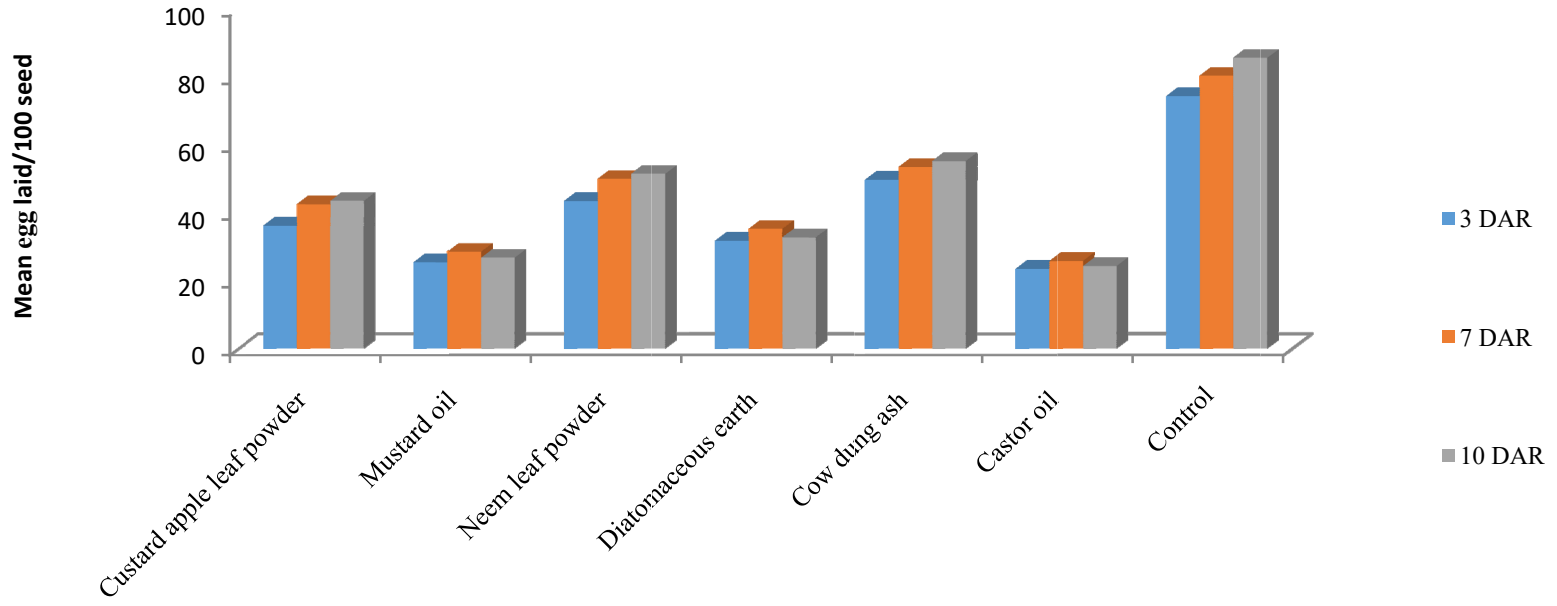

Fig.4.2: Effect of different products on mean egg laid by pulse beetle, *C. chinensis* on blackgram var. Nirali during July-December, 2019

Table 4.4: Effect of different products on adult emergence of pulse beetle, *C. chinensis* on black gram var. Nirali during July – December, 2019

S. No.	Treatment	Adult emergence/100 seeds			
		1 MAR**	2 MAR	3 MAR	Pooled Mean
T_1	Custard apple leaf powder @ 5 gm/kg	20.50 (4.58)*	26.00 (5.14)	29.00 (5.43)	25.17 (5.05)
T_2	Mustard oil @ 5 ml/kg	14.75 (3.90)	16.25 (4.09)	20.00 (4.53)	17.00 (4.17)
T_3	Neem leaf powder @ 5 gm/kg	22.50 (4.79)	31.25 (5.63)	33.50 (5.83)	29.08 (5.42)
T_4	Diatomaceous earth @ 5 gm/kg	17.00 (4.18)	20.50 (4.58)	24.50 (5.00)	20.67 (4.59)
T_5	Cow dung ash @ 5 gm/kg	22.75 (4.82)	33.25 (5.81)	36.00 (6.04)	30.67 (5.56)
T_6	Castor oil @ 5 ml/kg	11.00 (3.38)	14.25 (3.83)	16.25 (4.09)	13.83 (3.77)
T_7	Control	42.00 (6.52)	52.00 (7.24)	70.75 (8.43)	54.25 (7.40)
	S.Em ±	0.092	0.111	0.113	0.105
	C.D. (p =0.05)	0.271	0.325	0.332	0.309

* Figures in parentheses are square root transformed values; ** MAR: Month after release

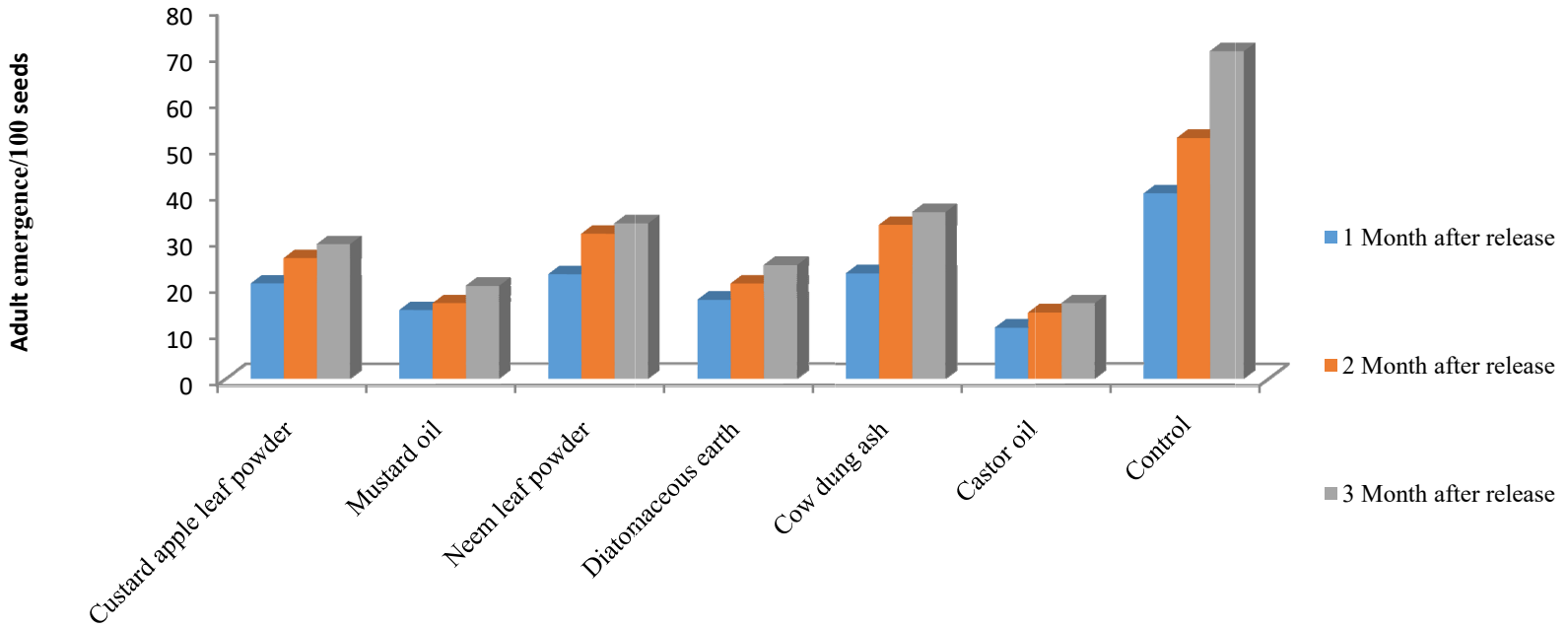

Fig. 4.3: Effect of different products on adult emergence of pulse beetle, *C. chinensis* on black gram var. Nirali during July-December, 2019

powder @ 5 gm/kg and neem leaf powder @ 5 gm/kg were found next effective treatment and adult emergence were 20.00, 24.50, 29.00 and 33.50 adults/100 seeds, respectively. The maximum number of adult emergence (36.00 adult emergence/100 seeds) was found in seed treatment with cow dung ash @ 5 gm/kg.

4.2.4 Grain/seed damage (%)

The data presented in table-4.5 and fig.-4.4 indicate that all the treatments with different seed protectants resulted in reduced per cent seed damage caused by *C. chinensis* on blach gram,*Vigna mungo* as compared to untreated control. Significant variations were also observed among different treatments in terms of per cent seed damage throughout the storage period of 90 days (three month). The minimum seed/grain infestation by *C. chinensis* was recorded in castor oil @ 5 ml/kg seed (5.25%) followed by mustard oil @ 5 ml/kg seed (5.75%), diatomaceous earth @ 5 gm/kg seed (11.50%), custard apple leaf powder @ 5 gm/kg (13.75%) and neem leaf powder @ 5 gm/kg (24.25%). However, the maximum seed damage (26.25%) was recorded in cow dung ash @ 5 gm/kg as compared to untreated control (78.25%).

4.2.5 Weight loss (%)

The data (table-4.6 & fig.-4.4) revealed that all the treatments with different seed protectants resulted in reduced per cent weight loss caused by *C. chinensis* on black gram, *Vigna mungo* as compared to untreated control. The minimum seed/grain weight loss was recorded in castor oil @ 5 ml/kg seed (1.75%) followed by mustard oil @ 5 ml/kg seed (3.25%), diatomaceous earth @ 5 gm/kg seed (5.75%), custard apple leaf powder @ 5 gm/kg (6.25%) and neem leaf powder @ 5 gm/kg (12.25%). However, the maximum weight loss (14.50%) was recorded in cow dung ash @ 5 gm/kg as compared to untreated control (30.47%).

4.2.6 Germination (%)

The data presented in table-4.7 and fig.-4.5 showed that the average maximum germination (84.50%) was recorded in black gram treated with castor oil @ 5 ml/kg seed followed by mustard oil @ 5 ml/kg seed (82.50%), diatomaceous earth @ 5 gm/kg seed (81.50%), custard apple leaf powder @ 5 gm/kg (76.25%) and neem leaf powder @ 5 gm/kg (70.75%). However, the minimum germination (61.50%) was recorded in cow dung ash @ 5 gm/kg as compared to untreated control (25.50%).

Table 4.5: Effect of different products on grain/seed damage (%) by pulse beetle, *C. chinensis* on black gram var. Nirali during July – December, 2019

S. No.	Treatment	Dose	Grain/seed damage (%) at 90 days after release
T_1	Custard apple leaf powder	5 gm/kg	13.75 (21.74)*
T_2	Mustard oil	5 ml/kg	5.75 (13.71)
T_3	Neem leaf powder	5 gm/kg	24.25 (29.42)
T_4	Diatomaceous earth	5 gm/kg	11.50 (19.73)
T_5	Cow dung ash	5 gm/kg	26.25 (30.77)
T_6	Castor oil	5 ml/kg	5.25 (12.97)
T_7	Control	-	78.25 (62.25)
	S.Em ±		1.306
	C.D. (p =0.05)		3.841

* Figures in parentheses are retransformed per cent values

Table 4.6: Effect of different products on weight loss (%) by pulse beetle, *C. chinensis* on black gram var. Nirali during 2019

S. No.	Treatment	Dose	Weight loss (%) at 90 days after release
T_1	Custard apple leaf powder	5 gm/kg	6.25 (14.37)*
T_2	Mustard oil	5 ml/kg	3.25 (10.36)
T_3	Neem leaf powder	5 gm/kg	12.25 (20.45)
T_4	Diatomaceous earth	5 gm/kg	5.75 (13.84)
T_5	Cow dung ash	5 gm/kg	14.50 (22.32)
T_6	Castor oil	5 ml/kg	1.75 (7.40)
T_7	Control	-	25.75 (30.47)
	S.Em ±		0.882
	C.D. (p =0.05)		2.594

* Figures in parentheses are retransformed per cent values

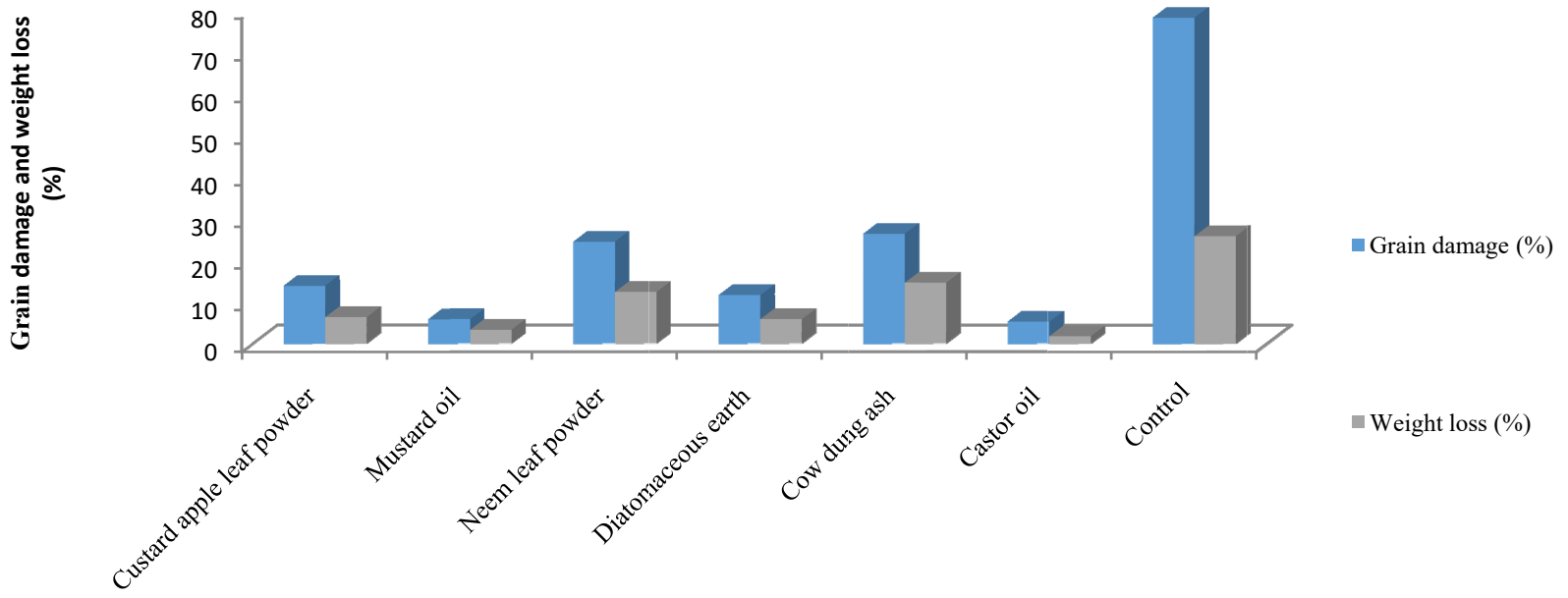

Fig.4.4: Effect of different products on grain damage (%) and weight loss (%) by pulse beetle, *C. chinensis* on black gram var. Nirali during July-Dec., 2019

Table 4.7: Effect of different products on germination (%) of black gram var. Nirali infested with pulse beetle, *C. chinensis* during 2019

S. No.	Treatment	Dose	Germination (%) at 90 days after release
T_1	Custard apple leaf powder	5 gm/kg	76.25 (60.86)*
T_2	Mustard oil	5 ml/kg	82.50 (65.34)
T_3	Neem leaf powder	5 gm/kg	70.75 (57.31)
T_4	Diatomaceous earth	5 gm/kg	81.50 (64.64)
T_5	Cow dung ash	5 gm/kg	61.50 (51.66)
T_6	Castor oil	5 ml/kg	84.50 (66.84)
T_7	Control	-	25.50 (30.29)
	S.Em ±		1.163
	C.D. (p =0.05)		3.420

* Figures in parentheses are retransformed per cent values

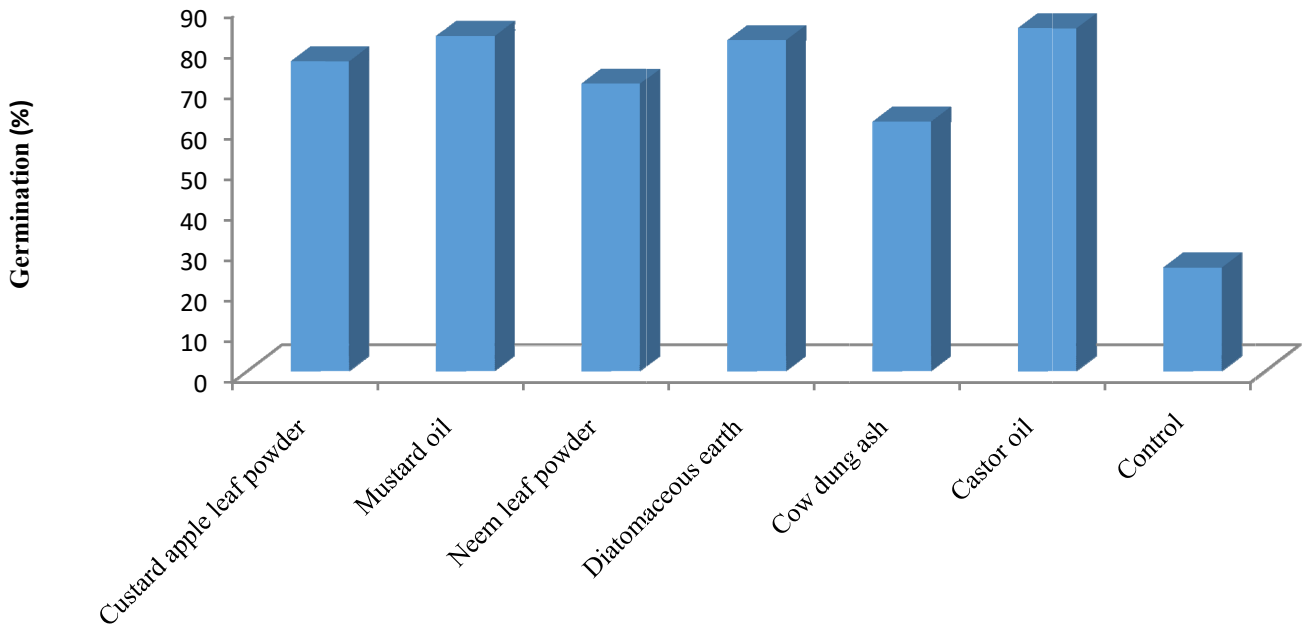

Fig. 4.5: Effect of different products on germination (%) of blackgram var. Nirali infested with pulse beetle, *C. chinensis* during July-December, 2019

5. DISCUSSION

The results of the studies carried out on the **"Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)"** are discussed as under:

5.1 BIOLOGY OF PULSE BEETLE, *C. chinensis*

The hatching period of eggs of pulse beetle on black gram var. Nirali was ranged from 4-5 days with the mean of 4.10 days. Similarly, Kumari *et. al*. (1991) observed Average incubation period ranging from 9-13 days on blach gram, *Vigna Mungo* (L.). Average incubation period of 4-5 days by *C. chinensis* was also reported by Singh and Kumari (2000) on cowpea and greengram seeds at 28±2ºC and 70±5 per cent relative humidity. Bhargava *et. al.* (2008) observed the mean incubation period was varied from 4.40-7.20 days on different pulses. Singh (2017) reported that the average mean incubation period was 4.17 days which varied from 3 to 7 days, which could be due to the impact of temperature and humidity. Hosamani *et al.* (2018) reported that incubation period of pulse beetle on blackgram ranged from 4-5 days with the mean of 4 days. Augustine and Balikai (2019) reported that the incubation period of the eggs under laboratory conditions ranged from 4 to 6 days with a mean of 4.6 ± 0.70 days.

The larval and pupal period of *C. chinensis* on black gram seeds was ranged from 24-28 days with the mean of 26.57 days. Similarly, Kumari *et al*. (1991) reported the larval period of 17-20 days in black gram, *Vigna Mungo* (L.). Singal and Borah (2001) reported pupal periods of *C chinensis* was ranged from 7-9 days on blach gram, *Vigna mungo* and 7.2±0.18 days on Arhar, *Cajanus cajans,* respectively. Bhargava *et. al.* (2008) reported the mean larval and pupal period of pulse beetles was varied from14.80-26.20 and 5.40-11.40 days, respectively. Average larval and pupal period of *C. chinensis* was 18.39 and 8.11 days on blach gram reported by Thakur and Pathania (2013). Singh (2017) reported that the larval-pupal period varied from 23 to 33 days with an average of 29.4 days on moongbean. Singh *et al.* (2017) reported that larval + pupal period of pulse beetle completed in 27.7 days on gram. Hosamani *et al.* (2018) reported that mean larval and pupal period of pulse beetle on black gram were 12.0 and 6.0 days, respectively. Sharma *et al.* (2018) reported that mean larval and pupal period of pulse beetle was 21.3+0.3 days.

The pre-oviposition, oviposition and post-oviposition period of female pulse beetle on black gram seeds ranged from 5-8, 4-6 and 1-3 days with the mean of 5.83, 4.77 and 1.77 days, respectively. Similarly, Singh and Borah (2001) reported the pre-oviposition, oviposition and post-oviposition period of *C. chinensis* on *Cajanus cajans* were 7.8+0.46 h, 4.8+0.25 and 1.4+0.11 days, respectively. Singh (2017) reported that pre-oviposition, oviposition and post-oviposition period of female pulse beetle on greengram were 5.8 ± 1.62 days, 4.9 ± 1.66 days and 3.6 ± 0.97 days, respectively. Jaiswal *et al.* (2018) reported that the pre-oviposition, oviposition and post-oviposition periods on chickpea were 6.55 ± 0.94 hours, 8.10 ± 1.25 days and 1.85 ± 0.48 days, respectively.

The mean male and female longevity were 8.43 and 12.37 days, which were ranged from 7-9 and 10-14 days, respectively on black gram. Similarly, Patel *et al*. (2005) reported the adult longevity of *C. chinensis* to vary between 11.37 to 14.83 days on different pulses. Singal and Borah (2001) reported lower mean longevity of female and male beetle as 6.2±0.36 and 6.8±0.25 days. Singh (2017) reported that the mean longevity of male was 7.07 days and 8.8 days for the female on greengram. Hosamani *et al.* (2018) reported that adult longevity of pulse beetle ranged from 7-14 days with the mean of 8 days on black gram. Augustine and Balikai (2019) reported that the females lived for a period of 8-12 days with a mean of 9.50 ± 1.58 days whereas the males lived for 7 to 11 days with a mean of 8.30 ± 1.25 days.

Total life cycle of male pulse beetle on black gram var. Nirali was completed in 39.03 days with range from 37-42 days, while female life cycle completed in 42.97 days with range from 40-47 days, respectively. Similarly, Singh and Borah (2001) observed that total development period of egg to adult to be 30.04+0.62 days. Meghwal and Singh (2005) also observed the average period for development from egg laying to adult emergence to be 25.49 days on moth bean. Bhargava *et. al*. (2008) reported that total development period was varied from 24.60 to 44.80 days on various pulses. Thakur and Pathania (2013) reported that total developmental period (egg to adult) of pulse beetle on black gram was 34.5 days. Singh (2017) reported that total developmental period of pulse beetle to be 34.62 days. Hosamani *et al.* (2018) reported that total life cycle completed in 30 days on black gram. Augustine and Balikai (2019) reported that the total development period occupied 26 to 40 days with a mean of 30.90 ± 4.28 days.

The mean fecundity of female on black gram var. Nirali seeds was 89.30 eggs and ranged from 81 to 97 eggs. Similar findings were reported by Pandey and Singh (1997) reported the average egg laying per female by *C. chinensis* to be 110 eggs. Pokharkar and Mehta (2011) reported the average egg laying per female by *C. chinensis* to be 80-89 eggs on chickpea. Singh (2017) observed that fecundity of pulse beetle female on greengram varied from 78 to 102 eggs with an average of 90 eggs. Kumar *et al*. (2018) observed average fecundity of the female pulse beetle was 85.6 eggs.

5.2 BIO-EFFICACY OF DIFFERENT PRODUCTS AGAINST PULSE BEETLE, *C. chinensis*

The bio-efficacy of different products *viz.,* custard apple leaf powder @ 5 gm/kg, mustard oil @ 5 ml/kg, neem leaf powder @ 5 gm/kg, diatomaceous earth @ 5 gm/kg, cow dung ash @ 5 gm/kg, castor oil @ 5 ml/kg against pulse beetle, *C. chinensis* on black gram seeds were evaluated under present investigation. The results of efficacy of different products against pulse beetle are discussed as below:

5.2.1 Mortality (%) of pulse beelte

Seed treatment with castor oil @ 5 ml/kg showed maximum mortality of pulse beetle at 1, 3, 5 and 7 days after release which were 23.75, 45.82, 63.54 and 66.67 per cent, respectively. Next effective treatment was mustard oil @ 5 ml/kg, which caused 20.00, 42.18, 62.29 and 64.58 per cent mortality at 1, 3, 5 and 7 days after release of adult beetle, respectively. Application of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg caused 12.50, 29.90, 55.14 and 62.86; 7.50, 25.66, 52.62 and 53.27; 5.00, 21.05, 39.87 and 47.22; 5.00, 18.42, 35.49 and 39.70 per cent adult pulse beetle mortality at 1, 3, 5 and 7 days after release, respectively. The findings confirmed the results obtained by Paneru and Shivakoti (2001), who reported that mustard oil @ 0.5% caused 13.3, 28.0, 62.7 and 74.7 per cent pulse beetle mortality at 2, 4, 6 and 8 days after release, respectively. Bajya *et al.* (2007), who reported that castor oil @ 1.2 ml/100 gm seed caused 84 per cent mortality of pulse beetle. Singh (2017) reported that custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg, diatomaceous earth @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed treated greengram seeds showed pulse beetle mortality of 10.49, 8.64, 23.61 and 5.52 per cent at 7 days after release.

5.2.2 Mean egg laid by pulse beetle

The lowest number of mean egg laid by pulse beetle on castor oil @ 5 ml/kg treated black gram seeds/grains, which were 23.50, 25.75 and 24.25 eggs at 3, 7 and 10 days after release, respectively. The mean egg laid at 3, 7 and 10 days after release of beetle on mustard oil @ 5 ml/kg seed treated grains were 25.25, 28.50 and 26.75 eggs, respectively. The mean egg laid in case of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg, neem leaf powder @ 5 gm/kg and cow dung ash @ 5 gm/kg treated seeds were 31.75, 35.25 and 32.75; 36.00, 42.50 and 43.25; 43.50, 50.00 and 51.50; 49.75, 53.50 and 55.25 eggs at 3, 7 and 10 days after release of adult, respectively. Cow dung ash @ 5 gm/kg was found least effective treatment. The results of present investigation are in acquiescence with the findings of Singh (2017), who reported that mean egg laid at 3, 7 and 10 days after release of adult pulse beetle on the seeds treated with diatomaceous earth @ 5 gm/kg seed, custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed were 31.62, 33.11 and 31.62; 34.67, 35.48 and 36.30; 34.67, 36.30 and 36.30; 52.48, 54.95 and 54.95 eggs, respectively. Ramyahr *et al*. (2017) reported that the mean egg laid by *C. Chinensi*s on castor oil and mustard oil @ 5 ml/kg dose , which were 22.00 and 26.00 eggs, respectively. Rathod *et al.* (2019) reported that 33.33 eggs/100 gm seed treated with castor oil @ 5 ml/kg seed in first month.

5.2.3 Adult emergence

A significant difference was observed among different treatments in terms of number of adult beetles emerged at different storage periods starting from 1 to 3 MAR (Month after release) considering 1 month interval during the management of pulse beetle on black gram, *Vigna mungo* L. Seed treatment with castor oil @ 5 ml/kg was found to be most effective throughout the storage period of 3 month (90 days), whereas cow dung ash @ 5 gm/kg was found to be very less effective against the pulse beetle. The minimum number of adult emergence was observed in castor oil @ 5 ml/kg seed at 1, 2 and 3 month after release was 11.00, 14.25 and 16.25 adults/100 seeds, respectively. Seed treatment with mustard oil @ 5 ml/kg seed was found next effective treatment and adult emergence at 1, 2 and 3 month after release was 14.75, 16.25 and 20.00 adults/100 seeds, respectively. It is followed by seed treatment with diatomaceous earth @ 5 gm/kg and adult emergence reported that 17.00, 20.50 and

24.50 adults/100 seeds at 1, 2 and 3 month after release, respectively. Seed treatment with custard apple leaf powder @ 5 gm/kg and neem leaf powder @ 5 gm/kg were showed adult emergence of 20.50, 26.00 and 29.00; 22.50, 31.25 and 33.50 adults/100 seeds at 1, 2 and 3 month after release, respectively. The maximum number of adult emergence was found in seed treatment with cow dung ash @ 5 gm/kg, 22.75, 33.25 and 36.00 adult emergence/100 seeds at 1, 2 and 3 month after release, respectively. Similar results were obtained by Ramyahr *et al*. (2017) who reported that the mean adult emergence in castor oil and mustard oil at 5 ml/kg seed were 7.00 and 11.67 adult/ 100 seed. Singh (2017) observed that average mean adult emergence at 30, 60 and 90 DAR of adult pulse beetle on the seeds treated with diatomaceous earth @ 5 gm/kg seed, custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed were 8.32, 11.33 and 13.66; 12.32, 14.66 and 16.32; 17.66, 21.67 and 49.01; 17.32, 22.67 and 51.33 adults, respectively.

5.2.4 Grain/seed damage (%)

The minimum seed/grain infestation by *C. chinensis* was recorded in castor oil @ 5 ml/kg seed (5.25%) followed by mustard oil @ 5 ml/kg seed (5.75%), diatomaceous earth @ 5 gm/kg seed (11.50%), custard apple leaf powder @ 5 gm/kg (13.75%) and neem leaf powder @ 5 gm/kg (24.25%). However, the maximum seed damage (26.25%) was recorded in cow dung ash @ 5 gm/kg as compared to untreated control (78.25%). Similarity of result findings of Gautam *et al*. (2000) also reported that the decrease in seed damage as observed by mixing different plant powders with Urd, *Vigna mungo* @ 5 g per 100 g seed. Similarty, Ramazeame *et al.* (2014), reported 9.20 per cent grain damage in case of castor oil @ 5 ml/kg seed. Singh (2017) also reported that moongbean seed/grain damage in case of treatments comprising diatomaceous earth at 5 gm/kg seed, custard apple leaf powder at 5 gm/kg seed, neem leaf powder at 5 gm/kg seed and cow dung ash at 5 gm/kg seed were 3.28, 20.99, 24.98 and 28.99 per cent, respectively.

5.2.5 Weight loss (%)

The minimum seed/grain weight loss was recorded in castor oil @ 5 ml/kg seed (1.75%) followed by mustard oil @ 5 ml/kg seed (3.25%), diatomaceous earth @ 5 gm/kg seed (5.75%), custard apple leaf powder @ 5 gm/kg (6.25%) and neem leaf powder @ 5 gm/kg (12.25%). However, the maximum weight loss (14.50%) was

recorded in cow dung ash @ 5 gm/kg as compared to untreated control (30.47%). Similarly, Laxmi and Venugopal (2007) also reported lowest weight loss in moongbean treated with custard apple seed powder. The present result corroborate the finding of Singh (2017) who reported that weight loss of moongbean seeds due to pulse beetle infestation in case of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed treated seeds were 3.28, 6.27, 13.46 and 13.65 per cent, respectively. Similarly, Ramyahr *et al*. (2017) reported that lowest per cent weight loss was recorded in neem oil treatments in all three dosages (3, 5, 7 ml/kg seed) was 2.36, 0.41 and 0.16 followed by karanj oil (2.73, 0.91 and 0.58%), castor oil (3.33, 1.83 and 1.33%), mustard oil (4.56, 2.66 and 1.53%) and sunflower oil (4.90, 2.93 and 2.36%) respectively.

5.2.6 Germination (%)

The maximum germination (84.50%) was recorded in black gram, *Vigna mungo* L. treated with castor oil @ 5 ml/kg seed followed by mustard oil @ 5 ml/kg seed (82.50%), diatomaceous earth @ 5 gm/kg seed (81.50%), custard apple leaf powder @ 5 gm/kg (76.25%) and neem leaf powder @ 5 gm/kg (70.75%). However, the minimum germination (61.50%) was recorded in cow dung ash @ 5 gm/kg as compared to untreated control (25.50%). No adverse effect of neem leaf powder at dose level of 5.0 per cent on *Soyabean* (Gundannavar and Deshpande, 2006) and on cowpea (Yadav and Bhargava, 2005) was reported up to 90 days of treatment. Similarly, Ramyahr *et al*. (2017) reported that the highest germination per cent was observed in neem oil (89.99%) followed by karanj oil (88.88%), sunflower oil (88.88), castor oil (83.33%) and mustard oil (83.33%). Singh (2017) reported that germination per cent of pulse beetle infested moongbean seeds in case of diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg seed, neem leaf powder @ 5 gm/kg seed and cow dung ash @ 5 gm/kg seed treated seeds were 80.11, 65.01, 55.0 and 50.0 per cent, respectively.

6. SUMMARY

The present investigation on **"Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)"** was carried out under laboratory conditions at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during July-December, 2019.

The study on biology of pulse beetle, *C. chinensis* revealed that mean fecundity of female was 89.30 eggs and ranged from 81 to 97 eggs. The hatching period of eggs was ranged from 4-5 days with the mean of 4.10 days. The larval and pupal period was ranged from 24-28 days with the mean of 26.57 days. The pre-oviposition, oviposition and post-oviposition period of female pulse beetle ranged from 5-8, 4-6 and 1-3 days with the mean of 5.83, 4.77 and 1.77 days, respectively. The mean male and female longevity were 8.43 and 12.37 days, which were ranged from 7-9 and 10-14 days, respectively. Total life cycle of male pulse beetle was completed in 39.03 days with range from 37-42 days, while female life cycle completed in 42.97 days with range from 40-47 days, respectively.

The bio-efficacy of different products *viz.,* custard apple leaf powder @ 5 gm/kg, mustard oil @ 5 ml/kg, neem leaf powder @ 5 gm/kg, diatomaceous earth @ 5 gm/kg, cow dung ash @ 5 gm/kg, castor oil @ 5 ml/kg against pulse beetle, *C. chinensis* on black gram seeds were evaluated under present investigation. Among different products, seed treatment with castor oil @ 5 ml/kg showed maximum mortality of pulse beetle at 1, 3, 5 and 7 days after release which were 23.75, 45.82, 63.54 and 66.67 per cent, respectively. It was followed by mustard oil @ 5 ml/kg, which caused 20.00, 42.18, 62.29 and 64.58 per cent mortality at 1, 3, 5 and 7 days after release of adult beetle, respectively. The lowest number of mean egg laid by pulse beetle on castor oil @ 5 ml/kg treated black gram seeds/grains, which were 23.50, 25.75 and 24.25 eggs at 3, 7 and 10 days after release, respectively. The minimum number of adult emergence was recorded in castor oil @ 5 ml/kg seed at 1, 2 and 3 month after release was 11.00, 14.25 and 16.25 adults/100 seeds, respectively. Seed treatment with mustard oil @ 5 ml/kg seed was found next effective treatment and adult emergence at 1, 2 and 3 month after release was 14.75, 16.25 and 20.00 adults/100 seeds, respectively. The minimum seed/grain infestation and weight loss were recorded in castor oil @ 5 ml/kg seed (5.25 and 1.75%, respectively) followed

by mustard oil @ 5 ml/kg seed (5.75 and 3.25%, respectively), diatomaceous earth @ 5 gm/kg seed (11.50 and 5.75%, respectively), custard apple leaf powder @ 5 gm/kg (13.75 and 6.25%, respectively) and neem leaf powder @ 5 gm/kg (24.25 and 12.25%, respectively). However, the maximum seed damage (26.25%) and weight loss (14.50%) was recorded in cow dung ash @ 5 gm/kg. The maximum germination (84.50%) was recorded in black gram treated with castor oil @ 5 ml/kg seed followed by mustard oil @ 5 ml/kg seed (82.50%), diatomaceous earth @ 5 gm/kg seed (81.50%), custard apple leaf powder @ 5 gm/kg (76.25%) and neem leaf powder @ 5 gm/kg (70.75%). However, the minimum germination (61.50%) was recorded in cow dung ash @ 5 gm/kg, which was found least effective treatment against pulse beetle, *C. chinensis.*

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Biology and Management of Pulse Beetle, *Callosobruchus chinensis* (L.) Infesting Black Gram, *Vigna mungo* (L.)

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ABSTRACT

The present investigation on "Biology and management of pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram, *Vigna mungo* (L.)" was carried out under laboratory conditions at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during July-December, 2019.

The study revealed that the mean hatching period of pulse beetle eggs was 4.10 days. The mean larval and pupal period was 26.57 days. The mean pre-oviposition, oviposition and post-oviposition period of female pulse beetle were 5.83, 4.77 and 1.77 days, respectively. The mean male and female longevity were 8.43 and 12.37 days, respectively. Total life cycle of male and female pulse beetle were completed in 39.03 and 42.97 days, respectively. The mean fecundity of female was 89.30 eggs and ranged from 81 to 97 eggs.

The different products evaluated against pulse beetle showed that seed treatment with castor oil @ 5 ml/kg seed was found most effective treatment with highest adult mortality (mean: 49.94%), lowest mean egg laid (24.50 eggs), lowest adult emergence (13.83 adults), lowest grain damage (5.25%), lowest weight loss (1.75%) and highest germination per cent (84.50%) of seeds. It was followed by mustard oil @ 5 ml/kg seed, diatomaceous earth @ 5 gm/kg, custard apple leaf powder @ 5 gm/kg and neem leaf powder @ 5 gm/kg. Whereas, cow dung ash @ 5 gm/kg was found least effective treatment with lowest adult mortality (24.65%), highest mean egg laid (52.83 eggs), highest adult emergence (30.67 adults), highest grain damage (26.25%), highest weight loss (14.50%) and lowest (61.50%) germination of seeds.

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mMn] *Vigna mungo* (L.) e nygu dh Hkx] *Callosobruchus chinensis* (L.) dk thou pØ ,o icU/ku

ili yky nyky*
स्नातकोत्तर छात्र

Mk- ,u- ,y- Mkxh**
मुख्य सलाहकार

vuqi.k

^^mMn] *Vigna mungo* (L.) e nygu dh Hkx] *Callosobruchus chinensis* (L.) dk thou pØ ,o icU/ku** के लिए जुलाई से दिसम्बर 2019 में राजस्थान कृषि महाविद्यालय, उदयपुर के कीट विज्ञान विभाग की प्रयोगशाला में अन्वेषण किया गया।

अध्ययन के परिणाम के अनुसार दलहन की भृंग के अण्डों का औसत ऊष्मायन काल 4.10 दिन होता है। औसत लार्वा एवं कोशित अवधि 26.57 दिन की होती है। दलहन की मादा भृंग का औसत पूर्व–अण्डरोपण, अण्डरोपण एवं पश्च–अण्डरोपण अवधि क्रमशः 5.83, 4.77 एवं 1.77 दिन होती है। औसत नर एवं मादा भृंग का जीवन क्रमशः 8.43 एवं 12.37 दिन का होता है। नर एवं मादा भृंग का सम्पूर्ण जीवन क्रमशः 39.03 एवं 42.97 दिन में पूर्ण होता है। मादा की औसत 89.30 अण्डे एवं 81 से 97 अण्डे देती है।

दलहन भृंग के प्रति विभिन्न उत्पादों की दक्षता दर्शाती है कि अरण्डी का तेल 5 मिली./किलो बीज, सबसे अधिक प्रभावी पाया गया जिसमें अधिकतम वयस्क भृंग मृत्यु दर (49.94 प्रतिशत), न्यूनतम औसत अण्डे देना (24.50 अण्डे/100 बीज), न्यूनतम वयस्क उद्भव (13.83 वयस्क/100 बीज), न्यूनतम ग्रसित दाना (5.25 प्रतिशत), न्यूनतम वजन ह्रास (1.75 प्रतिशत) एवं बीजों का अधिकतम अकुंरण प्रतिशत (84.50 प्रतिशत) रहा। इसके बाद सरसों का तेल 5 मिली./किलो बीज, डायटोमेसियस मृदा 5 ग्राम/किलो बीज, सीताफल पत्ती चूर्ण 5 ग्राम/किलो बीज एवं नीम पत्ती चूर्ण 5 ग्राम/किलो बीज प्रभावी पाये गये। जबकि गाय गोबर राख सबसे कम प्रभावी पायी गई, जिसमे न्यूनतम वयस्क भृंग मृत्यु दर (24.65 प्रतिशत), अधिकतम औसत अण्डे देना (52.83 अण्डे/100 बीज), अधिकतम वयस्क उद्भव (30.67 वयस्क/100 बीज), अधिकतम ग्रसित दाना (26.25 प्रतिशत), अधिकतम वजन ह्रास (14.50 प्रतिशत) एवं बीजों का न्यूनतम अकुंरण प्रतिशत (61.50 प्रतिशत) रहा।

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APPENDIX

APPENDIX I

Analysis of variance for effect of different products on mortality of pulse beetle, *C. chinensis* on black gram at 1 day after application

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	1892.186	315.364	28.650	2.573	1.659	4.879
Error	21	231.161	11.008	-	-	-	-

APPENDIX II

Analysis of variance for effect of different products on mortality of pulse beetle, *C. chinensis* on black gram at 3 days after application

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	4761.877	793.646	75.220	2.573	1.624	4.777
Error	21	221.572	10.551	-	-	-	-

APPENDIX III

Analysis of variance for effect of different products on mortality of pulse beetle, *C. chinensis* on black gram at 5 days after application

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	7130.381	1188.397	115.290	2.573	1.605	4.721
Error	21	216.465	10.308	-	-	-	-

APPENDIX IV

Analysis of variance for effect of different products on mortality of pulse beetle, *C. chinensis* on black gram at 7 days after application

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	8823.223	1470.537	136.423	2.573	1.642	4.828
Error	21	226.363	10.779	-	-	-	-

APPENDIX V

Analysis of variance for effect of different products on mean egg laid by pulse beetle, *C. chinensis* on black gram at 3 days after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	40.719	6.786	131.014	2.573	0.114	0.335
Error	21	1.088	0.052	-	-	-	-

APPENDIX VI

Analysis of variance for effect of different products on mean egg laid by pulse beetle, *C. chinensis* on black gram at 7 days after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	42.257	7.043	159.838	2.573	0.105	0.309
Error	21	0.925	0.044	-	-	-	-

APPENDIX VII

Analysis of variance for effect of different products on mean egg laid by pulse beetle, *C. chinensis* on black gram at 10 days after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	54.161	9.027	191.921	2.573	0.108	0.319
Error	21	0.988	0.047	-	-	-	-

APPENDIX VIII

Analysis of variance for effect of different products on adult emergence of pulse beetle, *C. chinensis* on black gram at 1 month after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	23.674	3.946	115.906	2.573	0.092	0.271
Error	21	0.715	0.034	-	-	-	-

APPENDIX IX

Analysis of variance for effect of different products on adult emergence of pulse beetle, *C. chinensis* on black gram at 2 month after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	32.943	5.490	112.150	2.573	0.111	0.325
Error	21	1.028	0.049	-	-	-	-

APPENDIX X

Analysis of variance for effect of different products on adult emergence of pulse beetle, *C. chinensis* on black gram at 3 month after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	48.404	8.067	158.498	2.573	0.113	0.332
Error	21	1.069	0.051	-	-	-	-

APPENDIX XI

Analysis of variance for effect of different products on grain/ seed damage (%) by pulse beetle, *C. chinensis* on black gram at 90 days after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	6863.930	1143.988	167.689	2.573	1.306	3.841
Error	21	143.264	6.822	-	-	-	-

APPENDIX XII

Analysis of variance for effect of different products on weight loss (%) by pulse beetle, *C. chinensis* on black gram at 90 days after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	1498.697	249.783	80.243	2.573	0.882	2.594
Error	21	65.369	3.113	-	-	-	-

APPENDIX XIII

Analysis of variance for effect of different products on germination (%) of pulse beetle, *C. chinensis* on black gram at 90 days after release

Source of Variation	D.F.	SS	MSS	F (cal)	F(tab) 5%	SEm+	CD 5%
Treatment	6	3924.092	654.015	120.920	2.573	1.163	3.420
Error	21	113.582	5.409	-	-	-	-

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