Biology and Management of Pulse Beetle on Stored Greengram

Hk.Mkfjr ex ij nky Hkx dk thou pØ ,o ic/ku

Gurmel Singh

Thesis

Master of Science in Agriculture

(Entomology)

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MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
UDAIPUR (RAJASTHAN)

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Submitted to

Maharana Pratap University of Agriculture and Technology, Udaipur

in partial fulfillment of the requirements for the Degree of

Master of Science in Agriculture

(Entomology)

BY

Gurmel Singh

2017

Maharana Pratap University of Agriculture and Technology
Rajasthan College of Agriculture, Udaipur

CERTIFICATE-I

Dated: / / 2017

This is to certify that **Mr. Gurmel Singh** has successfully completed the comprehensive examination held on 22 /06 /2016 as required under the regulation for the degree of **Master of Science in Agriculture (Entomology)**.

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Dated: / / 2017

This is to certify that the thesis entitled **"Biology and Management of Pulse Beetle on Stored Greengram"** submitted for the degree of **Master of Science in Agriculture** in the subject of **Entomology**, embodies bonafide research work carried out by **Mr. Gurmel Singh** 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 approved by the advisory committee on / /201 .

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Dated: / / 2017

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This is to certify that **Mr. Gurmel Singh** student of **Master of Science in Agriculture, Department of Entomology**, Rajasthan College of Agriculture, Udaipur has made all corrections/ modifications in thesis entitled, **"Biology and management of pulse beetle on stored greengram"** that were suggested by the External Examiner and the Advisory Committee in the oral examination held on / / 201 . The final copies of the thesis duly bound and corrected submitted on / / 201 are enclosed herewith for approval.

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Biology and management of pulse beetle on stored greengram

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ABSTRACT

A laboratory experiment was conducted on "Biology and management of pulse beetle on stored greengram" at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2015-16. Biology of pulse beetle was studied on SML-668 variety of greengram. The study on the biology of pulse beetle showed that average growth index was 2.79 and total developmental period (egg to adult) was 33.7 days.

Out of the six varieties of greengram screened for their preference by the pulse beetle, RMG-62 was the least preferred host by *Callosobruchus chinensis* (L.) while SML-668 was most preferred host. RMG-62 and RMG-344 had lowest per cent grain damage (40.99% and 43.99%) with minimum loss in weight (10.49% and 11.49%).

The management practices comprising plant materials and inert dusts were evaluated against the pulse beetle. The treatment evaluated were custard apple leaf powder, custard apple seed powder, neem leaf powder, diatomaceous earth powder and cow dung ash at the rate of 5 and 10g/kg of seed. Both custard apple seed powder and diatomaceous earth (10g/kg) were found most effective resulted in lowest damage of grain being 3.20 per cent in both the treatments, followed by neem leaf powder (10g/kg) and custard apple leaf powder (10g/kg).

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1. INTRODUCTION

Pulses being is a vital source of protein form a major constituent of the vegetarian diet for a majority of the rural and urban population in India, where the consumption of animal protein except milk is still considered a religious and social taboo. Among the pulse crops, greengram [*Vigna radiata* (L) R. Wilczek] is important as it is widely used as a whole grain or as a split pulse on account of its easy digestibility. It contains 24 per cent protein, 56.7 per cent carbohydrates, 3.5 per cent fibre and 1.3 per cent fat.

The area under pulse crops is approximately 25.23 million hectares and the total production is 19.27 million tones in the world. The area under greengram in India is 96 thousand hectares with a production of 125.2 thousand tones (Anonymous, 2014). The productivity of pulse crops is hampered by abiotic and biotic stresses; among the biotic stresses, insects cause considerable damage to the crops in the field and storage. The pulse beetles (*Callosobruchus chinensis* and *C. maculatus*) are the key pests of stored pulses and are mainly responsible for causing significant damage. In severe cases, the entire quantity of stored grain gets reduced to a mass of empty shells and dust. It has been reported that *C. chinensis* also harbours certain pathogenic micro organisms that cause food poisoning and spoilage besides quantitative damage (Neelgund and Kumari, 1983).

In India, the present per capita availability of pulses is less than 40 g / day as against the recommendation of 80 g / day as per FAO and WHO standards (Asthana and Chaturvedi , 1999). The availability of pulses may go down considerably due to heavy losses caused by insects during storage. It is not enough to boost the pulse production, but a check on quantitative and qualitative losses caused by insect pests in the field and storage is equally necessary. The pulse beetle alone under storage conditions requires special attention, as in India about 8.5 per cent losses have been reported in post harvest handling of pulses (FAO, 1997; Agarwal *et al*., 1988). Post harvest losses of pulses other than gram are 5 per cent due to insects, 2.5 per cent due to rodents and 0.5 per cent due to transportation, bird damage and moisture loss (Anonymous, 1996). Apart from quantity, the quality and nutritional value of pulses get deteriorated during storage.

The life cycle of pulse beetle is reportedly completed in 25.2 days (Varma and Anandhi, 2010), 33.5 days (Patel *et al*, 2012) and 31 days (Thakur and Pathania, 2013). Use of insect resistant varieties is a safer and economic way of saving stored grains. Efforts should also be made to reduce the storage losses through eco-safe management techniques and proper utilization of the available natural resources in a compatible manner. Among the natural resources, plant materials and inert dusts possess some desirable qualities as a grain protectant and are easily available, cheaper, less persistent and leave less toxic residues on food grains. Various plant products and inert dusts have been reported to possess insecticidal activity against the bruchids. Considering the above facts the present study on,"Biology and management of pulse beetle on stored greengram" was proposed with the following objectives;

(i) To study the biology of *Callosobruchus chinensis* (L.) on greengram

(ii) To screen greengram varieties for their preference / tolerance to *C. chinensis*

(iii) To evaluate the efficacy of botanicals and inert dusts for its management

2 REVIEW OF LITERATURE

Various authors have conducted research on Biology and management of pulse beetle on stored greengram which have been reviewed as under.

2.1 Biology of the pulse beetle:

Singh and Borah (2001) reported the biology of pulse beetle, *C. chinensis* on *Cajanus cajan* pods, In the average pre-oviposition, oviposition, post-oviposition periods and longevity of adult female and male beetles were found to be 7.8+- 0.46 h,4.8+- 0.25 days 1.4 +- 0.11 days, 6.2+- 0.36 days and 6.8 +- 0.25 days, respectively. The incubation, larval, pupal, and total development periods of Pulse beetle was observed to be 6.8±0.13, 16.2 ± 0.16, 7.2 ±0.18, and 30.4± 0.62 days, respectively. Sadozai *et al*. (2003) recorded highest fecundity (51.2 eggs) on pea and the lowest (26.6 eggs) on lentil. However, the oviposition remained independent of growth and development. The shortest developmental period (19.2 days) was recorded on greengram and split gram, while the longest (23 days) was recorded on pea. Adult emergence, per cent damage and per cent weight loss were highest on greengram (28.6, 79.55 and 36.64%) and black gram (27.6, 98.15 and 26.03%); whereas lowest on pea (5.2, 11.54 and 5.32%). The sex ratio on all legumes remained as 50:50. The pest neither developed nor inflicted any damage or loss to lentil and kidney bean. Meghwal and Singh (2005) reported average ovipositional, incubation, developmental (larval and pupal) and total developmental period (egg to adult) of *C. chinensis* L, on moth bean as 5.20, 4.69, 20.79 and 25.49 days, respectively. Patel *et al.* (2005) studied the biology of pulse beetle (*C. chinensis*) on greengram, bengal gram (*Cicer arietinum*), red gram (*Lens esculenta* (*L. culinaris*), lentil, grass pea (*Lathyrus sativus*), pea and cowpea and found that the incubation period, larval-pupal period, total developmental period and adult longevity varied significantly among the host grain pulses. Greengram and cowpea were the most preferred hosts. The lowest incubation period (4.10 days) was recorded for lentil. The total developmental period and longevity were higher (23.49 and 14.83 days, respectively) on pea than greengram (17.19 and 11.75 days, respectively) and cowpea (18.12 days and 11.37 days, respectively). The duration of the life cycle was longer on pea (43.85 days) and shorter on greengram (33.51 days) and cowpea (34.02 days).

Ali and Rahaman (2006) reported that mung bean was the most common and suitable host for *C. maculatus* with regard to preference for oviposition, larval (58.21-76.31%), pupal (55.35-64.40%) development, adult emergence (33.18-46.62%) and infestation level (37.30-55.30%); whereas, lentil was unsuitable for this species with regard to larval (21.02-21.62%), pupal (9.99-11.84%) development, adult emergence (3.29-3.48%) and grain loss (2.19-2.27%). There was no significant influence of different pulses on egg hatching (82.97-91.90%); however, the developmental period of *C. maculatus* was influenced by the different pulses; the longest period (33-34 days) was required for three cultivars of blackgram and the shortest period (24.00 days) for four cultivars of mungbean. Suchitra and Amitava (2006) reported that the pest, *C. chinensis* completed eight generations within the period from April to October. Gatoria and Gill (2008) reported average developmental period of *C. chinensis* on different chickpea cultivars ranging from 26.33 to 27 days, respectively. Quazi (2007) evaluated eight locally available legumes and pulses *viz*., greengram (*V. radiata*), blackgram (*V. mungo*), lentil (*Lens culinaris*), white gram (*C. arietinum*), Bengal gram (*C. arietinum*), soybean (*Glycine max*), pea (*Pisum sativum*) 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 per cent the maximum (199) eggs were laid on soybean followed by pea (109), greengram (98.2), bengal gram (98.2), black gram (83.2), cow pea (71.6) and white gram (66.4). No eggs were recorded on lentil and in control. Bhargava *et al* (2008) observed that the fecundity, adult emergence and adult longevity of *C. chinensis* was the maximum on cowpea and the minimum on soybean; larval, pupal and developmental periods were shortest on cowpea and longest on soybean. Badoor *et al* (2009) reported that cowpea seeds were the most favorable for feeding the two tested bruchid beetles, followed by faba bean seeds, while bruchid infestation was not observed on common bean and soybean seeds. Results revealed that *C. maculatus* deposited more eggs on all tested leguminous seeds and gave more emerged adults with heavier weights than *C. chinensis*.

Johri *et al*. (2010) observed that the growth and developmental response of *C. chinensis* on different pulses, lentil was highly preferred and suitable host for the test insect. Kar *et al*. (2010) observed that split greengram (*V. radiata*) with seed coat was most preferred for adult orientation recording 3.5 adults, while lentil without seed

coat, *L. esculenta* was least preferred (0.2) by the adults of *C. maculatus* with regard to adult orientation. However, it was noticed during the studies that maximum number of insects showed non preference towards the split legumes without seed coat. Varma and Anandhi (2010) observed that the average incubation period, larval + pupal period, and adult longevity of male and female of the pulse beetle were 4.0, 16.4, 11.0 and 9.6 days, respectively. The total developmental period (egg to adult) was 25.2 days, and pre-oviposition, oviposition and post-oviposition period were 0.4, 8.0 and 2.2 days, respectively. The average fecundity of the females was 85.6 eggs and its viability was 94 per cent.

2.2 Varietal screening against pulse beetle

Dabi *et.al.* (1978) screened 10 blackgram varieties for their relative resistance to *C. maculatus* and found that varieties Krishna and PLS-364 were less susceptible having less than 20 per cent infestation, while varieties G-31 and K-5 proved to be highly susceptible with more than 60 per cent infestation. Vanninrajan *et al.* (1985) reported that ATD-3 and vamban -1 were resistant to attack of *C. maculatus* out of 13 varieties of blackgram screened.

Singh and Singh (1990) reported that varieties JU 78-3, RU-2, T-9, JU 78–27 remained free from *C. chinensis* infestation. However, in separate studies, Singh *et al.* (1991) studied the comparative susceptibility of 33 genotypes of pigeon pea to *C. chinensis* L. under laboratory conditions and reported that on the basis of per cent damaged grains, ICP 148 and ICPL 143 were least susceptible with 1.92 and 5.04 per cent grain damage, respectively. Haque *et al* (1992) studied 150 genotypes of *Vigna mungo* for susceptibility to *C. maculatus* at 30 degree centigrade and 70 per cent relative humidity. They observed that the genotypes SBG No-3and UH 83-2 were the least susceptible, while PU-26 and UHB-46 were the most susceptible. Zha *et al.* (1995) reported that cowpea line TVU-2027 was moderately resistant to the bruchid *C.maculatus*. Kumari and Singh (1996) reported CORG 11 variety of blackgram to be least susceptible for pulse beetle damage with 60.4 per cent damage; while MA 162 to be most susceptible with 99.1 per cent damage.

Singh and Sharma (2001) screened 13 chickpea varieties for ovipositional preference and larval development of *C. chinensis* and reported that the variety PG 5 was resistant, while GNG 663 remained susceptible to *C. chinensis.* Jha(2002) studied

the response of 14 chickpea cultivars for olfactory attraction to *C. chinensis* and found that cultivar BG 267 possessed the maximum attraction (11.8 per cent) and cultivar BG 257 had the minimum olfactory attraction for *C. chinensis* (2.5 per cent). Rani (2004) evaluated 9 chickpea cultivars to *C. chinensis* and observed that cultivars ICCL 86102 and ICCL 86104 were least susceptible to the beetle infestation. Muhammad and Maqbool (2005) screened 22 chickpea varieties for resistance against pulse beetle, (*C. analis*) and reported that genotypes CM 3142-2/92, CM 88, CM 3142-3/92, CM-72 and Pb-91 had significantly lower number of eggs and adult progeny development Muhammad *et al*. (2006) tested six varieties of chickpea for their resistance against *C. chinensis* and observed that the variety Bittle-98 was resistant and variety Parbat was susceptible; while Punjab-91 and Pb-2000 were partially resistant to the beetle. Srinivasan and Durairaj (2007) screened twenty-five promising genotypes of greengram to an intensive screening test against *C. maculatus* under no choice conditions. The genotypes PLS 308, LM 103, COGG 912 and IC 39412 were highly resistant to *C. maculatus* because on these genotypes the bruchid had prolonged developmental period and adult longevity coupled with lesser adult weight causing lower per cent seed loss.

Jha *et al* (2011) screened eight genotypes of greengram for their susceptibility to pulse beetles (*C. maculatus, C. chinensis and C. analis*) under free choice and no choice conditions of these, 'Pusa Baisakhi' was found least susceptible to *C. maculatus* under both conditions and *C. analis* under free choice conditions. Under no choice condition 'PS 10' variety was registered as least susceptible to *C. analis*; however, in case of *C. chinensis* 'Pusa 9531' was least susceptible followed by 'Pusa Ratna' in free choice condition, while 'PS 16' showed least susceptibility, followed by 'Pusa 9531' in no choice condition.

2.3 Efficacy of botanicals and inert dusts for pulse beetle management

Juneja and Patel (1994) conducted laboratory experiment to determine the relative bio-efficacy of various botanical products against *C. analis* infesting stored greengram (*V.radiata*). Among the various botanicals studied, the seed powders of custard apple (*Annona squamosa)* and black pepper, leaves of mint (*Mentha piperita*) and peel of orange all at the rate of 5 parts per 100 parts of greengram (w/w) resulted in 100 per cent adult mortality after 3 days of treatment and completely prevented the females from laying eggs until 60 days after treatment. Furthermore, no population

build-up and grain damage was observed until four months of storage; whereas, neem seed kernel powder gave protection for only three months. Shivanna *et al.*(1994) reported sweet flag powder applied at all 3 rates gave maximum protection against all 3 generations of *C. chinensis* on redgram, closely followed by custard apple, black pepper, turmeric and neem powders at the highest rate, but these gave only moderate protection at the lower rates. In contrast, tulsi at all rates gave minimum protection against all 3 generations of the beetle pest, which was at par with the untreated control. Singhal and Chauhan (1997) reported that neem seed oil and neem seed kernel powder individually prevented egg-laying of pulse beetle for up to 8 months of storage and a negligible adult population was developed after this period. Kumari and Kumar (1998) evaluated the effect of a mixture of tobacco and neem leaf powder on pulse beetle infesting pulse grains, both the products caused higher mortality of the beetle when applied at different doses.

Misra (2000) reported that, out of 10 botanicals and inert dusts tested, only the cow dung ash and mustard oil treatments completely inhibited oviposition. Al-Awati *et al.* (2002) tested eight plant extracts for their insecticidal and repellent properties against the pulse beetle, *C. chinensis*. The methanol and ethanol extracts from the seeds of *A. squamosa* recorded 100 per cent mortality of beetles within twenty four hours of their exposure. The other extracts that caused high mortality were from *A. nilotica*, *C. juncea*, *M. communis* and *S. aegyptiaca* in methanol and *B. sacra*, *J. dhofarica*, *S. aegyptiaca* and commercial neem in ethanol. The extracts of *M. communis* in methanol were highly repellent to the beetles compared to other extracts. Legume seeds treated with extracts of *A. squamosa* were not repellent; rather the beetles were attracted to them. Juneja and Patel (2002) examined greengram seeds treated with 1, 2, 3, 4 or 5 per cent (w/w) powdered custard apple (*A. squamosa*), black pepper (*P. nigrum*) seeds, mint (*M. piperita*) leaves, orange (*C. reticulata*) peels, and neem (*A. indica*) seed kernels to determine the persistence of these botanicals as protectants against the pulse beetle (*C. analis*). The number of eggs per 100 grains decreased with increased dosage of the botanicals used, although grain damage increased with the duration of the treatment. Seeds of greengram treated with 1 per cent of either powdered custard apple and black pepper seeds were totally protected from beetle for up to 5 and 4 months, respectively. Kotkar *et al.* (2002) evaluated foliar extracts of *A. squamosa* against pulse beetle, *C. chinensis* and found

that the flavonoids isolated from aqueous extracts of *A. squamosa* showed 80 per cent insecticidal activity against *C. chinensis* at a concentration of 0.07 mg/ml. Various physico-chemical tests, chromatographic and spectroscopic studies with partially purified aqueous extract indicated the presence of flavonol-type flavonoids. Singh (2003) reported that the seeds of greengram(*V. radiata*) can be effectively protected from the pulse beetle *C. chinensis* by treatment with the dried leaf powder of neem (*A. indica*) at the rate of 0.5-2.0 mg/100 g seed. Dwivedi and Venugopalan (2004) evaluated leaf extract of *Tabernaemontana divaricata* blended with that of *Quisqualis indica, Chenopodium album, Annona squamosa, Anethum sowa* and *Tamarindus indica* in a 1:1 ratio (v/v) and assessed their oviposition deterrence action against the pulse beetle, *C. chinensis*, on cowpea seeds. When mixed with *A. squamosa* and *C. album*, the mixture resulted in 97.15 and 94.70 per cent deterrence, respectively; while, with *Q. indica* it gave 75.15 per cent reduction in oviposition over the control. The other two combinations resulted in moderate reduction in oviposition varying from 51.83 to 57.74 per cent. Singh *et al.* (2004) evaluated eight botanicals against pulse beetle (*C. maculatus*) in greengram and found that Bidang seed powder recorded the lowest values for number of laid eggs (32.0) and number of emerged adults (4.7). kapoor, tulsi, bidang seed and doanaa leaf powder recorded the lowest per cent adult emergence (10.4, 15.2 and 18.0%). Bajya *et al.* (2007) evaluated the effect of. neem (*A. indica*), castor (*Ricinus communis*) and mustard (*Brassica juncea*) at 0.4, 0.8 and 1.2 ml/100 g seeds, and leaf and kernel powder of neem, karanj (*Pongamia glabra, P. pinnata*) and tulsi leaf powder (*Ocimum sanctum,O. tenuiflorum*) at 4.0, 8.0 and 12.0 g/100 g seeds on cowpea seeds and found that the neem oil was the most effective in giving the maximum adult mortality (96.0 %) after 3 days of treatment. The next best treatment was the castor oil at 1.2 ml/100 g seeds, causing 84.0 per cent mortality of the pest. All the plant protectants caused adult mortality of pulse beetle up to 3 days of treatment. The adult mortality increased subsequently with the increase in doses at increasing intervals. The maximum per centage mortality was recorded with neem kernel powder (65.0), followed by karanj kernel powder (59.0), neem leaf powder (51.0), karanj leaf powder (45.9%) and tulsi leaf powder (30.6) at 12.0 g/100 g seeds after 3 days of treatment.

Chander *et al.* (2007) reported that greengram seeds treated with grain protectants resulted in significantly lesser number of eggs laid by *C. chinensis*

compared to the control after 1, 35, 70 and 105 days of storage. The minimum number of eggs (0 egg/500 seeds) was observed when treated with neem oil (10 ml) while maximum number of eggs (67 eggs/500 seeds) was observed when treated with turmeric powder (3.5g) after 105 days of storage. All the grain protectants were effective in controlling adult emergence and seed damage compared to the untreated control after 35, 70, and 105 days of storage. There was no adult emergence and seed damage after 105 days of storage when treated with neem oil, sandy soil and dung cake ash (7 cm). Laxmi and Venugopal (2007) tested seed powders of *Vitex negundo*, *Acorus calamus* and *Curcuma longa* at 3 per cent; palmarosa (*Cymbopogon martini*) spike powder at 3 per cent; neem kernel dust at 3 per cent; activated clay at 1 per cent; Teepol at 0.1 per cent; and seed and leaf powders of *A. squamosa* at 3per cent against *C. maculates*. The seed powders of *A. squamosa* and rhizome powder of *Acorus calamus* resulted in minimum egg-hatching of *C. maculatus* and the larvae did not completed their development. The weight loss was also minimum in this treatment. However, seed treatment did not affect the germination of greengram seeds. Akhter and Rahaman (2008) evaluated three indigenous plant materials namely neem (*A. indica*), nishinda (*Vitex negundo*) and dholkolmi (*Ipomoea crassicaulis*) against the pulse beetle, *C. chinensis* on chickpea and found that all the plant materials were effective against pulse beetle. Leaf powder of dholkolmi was found more effective than neem and nishinda regarding grain protection and increased seed germination of chickpea. Per cent egg bearing seeds, number of eggs per 15 seeds and adult emergence were significantly higher in untreated seeds; whereas the lowest oviposition rate was recorded in seed treated with dholkolmi. Adult emergence per 50 g seeds was found to be significantly lower in dholkolmi treated seeds. Comparatively lower number of damaged seeds (6.33%), seed weight loss (10.83 g) and higher seed germination (60.33%) were obtained in seeds treated with dholkolmi leaf dust, over control treatment. Govindan and Nelson (2008) conducted laboratory studies to examine the effect of mixtures of plant powders on *C. maculatus*. To test the synergistic effect of botanicals, ten mixtures of plant powders were made and tested. Highest mortality (94.44%) was recorded in *A. squamosa* leaf powder 0.5 per cent + *A. cocculus* seed powder 0.5 per cent at 168 hr after the treatment Minimum number of eggs (70.00) were laid in *Helicteres isora* 0.5 per cent + *Nicotiana tabacum* 0.5 per cent when compared to 220.00 eggs in untreated control.

3. MATERIALS AND METHODS

The present study "Biology and management of the pulse beetle, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) on stored greengram" was conducted under laboratory conditions at the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2015-16 with the following objectives.

(iv) To study the biology of *Callosobruchus chinensis* (L.) on greengram

(v) To screen greengram varieties for their preference/ tolerance to *C. chinensis*

(vi) To evaluate the efficacy of botanicals and inert dusts for its management

Nucleus culture and maintenance:

The nucleus culture of pulse beetle, *C. chinensis* (L) was obtained from the laboratory of Post Harvest Technology, Collage of Technology and Agriculture Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur. This culture was maintained in the Department of Entomology, Bioagent laboratory at ambient conditions of temperature and relative humidity. Greengram was procured from the local market, cleaned, washed, shade-dried and sterilized in an oven at 50^0 C for 24 hours. The sterilized greengram seeds were used to maintain the culture for experimental needs. Ten pairs of one-day old adults were released into plastic containers (250 ml capacity) containing 100g greengram seeds on different dates and replicated thrice to obtain 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 3 days. Utmost care was taken to pick or transfer the seeds or test insects with the help of a forceps, camel hair brush and an aspirator.

Experimental details:

3.1 Study of biology of *C. chinesis*

The biology of pulse beetle, *C. chinensis* was studied on SML-668 variety of greengram, for which, three plastic containers (250 ml capacity) containing 100g seeds were taken wherein freshly emerged single pairs of *C. chinensis* were released in each container. Identification of the sexes was 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. The number of eggs laid by a single female on host grains was recorded taking a sample of 100 grains. Eggs laid on each day were kept in separate containers covered with muslin cloth and observations were recorded for incubation, development (larval and pupal), total developmental period and the growth index. The incubation 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.

3.2 Germplasm screening against pulse beetles

Freshly harvested seeds of greengram varities *viz*; of RMG-62, RMG-268, RMG-344, RMG-492, SML-668 and IPM-02-3 were collected from Rajasthan Agriculture Research Institute, Durgapura (Jaipur). Sound seeds of each genotype were kept in hot air oven for six hours at 50°C in order to eliminate insect pest infestation, if any. Seeds of each variety weighing 100g were kept in plastic containers of 250 ml capacity separately to evaluate the preference of variety by pulse beetle. Five pairs of healthy, one-day old emerged adult bruchids were introduced in each plastic jar and the top was covered with muslin cloth, tightened by rubber bands. Observation was taken from each plastic jar regularly for the following parameters:

1. Preference for egg laying based on numbers of eggs laid per grain at 3, 7 and 10 days after release
2. Adult emergence (%) at 30, 60 and 90 days of storage
3. Grain damage (%), weight loss (%) and germination (%) at 90 days of storage
4. Growth Index was computed as:

$$\frac{\text{Adult emergence (\%)}}{\text{Mean development period (days)}}$$

Experimental layout

Number of treatments : 6 varieties

Experimental design : Completely Randomized Design

No of replications : 4

3.3 Efficacy of botanicals and inert dusts for pulse beetle management

The plant materials were collected; shade dried and were powdered in a grinder mixer and sieved through a mesh of size 50 to remove the waste and coarse matter. The botanicals were mixed with pre-sterilized grains (50g) at application rates of 5 and 10 gram per kilo seeds and each treatment was replicated thrice. 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.

Observations from each replicate were taken for the average number of eggs laid on 100 randomly selected grains/seeds from each treatment after 3, 7 and 10 days of adult release; the numbers of adults that emerged from each treatment were counted and removed after 1, 2 and 3 months of storage; while, seed damage (%), weight loss (%) and seed germination (%) was recorded after 3 months of storage. The data thus obtained were analyzed statistically following completely randomized design.

Layout of experiment:

Number of treatments : 11

Experimental design : Completely Randomized Design

No of replications : 3

Mortality counts of pulse beetle

Twenty insects were released in each jar to assess the efficacy of the plant products/ inert dusts on bruchid mortality; the number of dead beetles in each replicate jar was counted after 7 days of treatment.

Analyses and computation of data after 3 months of storage:

a) Grain/ seed damage was computed as suggested by Adams and Schulten method (1978):

$$\text{Grain/ seed damage (\%)} = \frac{\text{No. of holed seeds}}{\text{Total seeds}} \times 100$$

b) Weight loss was calculated using the following equation:

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

Table -1 Treatment details of plant products, inert dusts and their doses

S. No.	Common name	Doses (g/kg seed)
1.	Custard apple leaf powder	5
2.	Custard apple leaf powder	10
3.	Custard apple seed powder	5
4.	Custard apple seed powder	10
5.	Neem leaf powder	5
6.	Neem leaf powder	10
7	Diatomaceous earth	5
8	Diatomaceous earth	10
9	Cow dung ash	5
10	Cow dung ash	10
11	Untreated control	----

4. RESULTS

Results of the present investigations on the biology of pulse beetle on stored greengram, screening of greengram verities and evaluation of botanicals and inert dusts for management of pulse beetle in stored greengram are elucidated in this chapter.

Table-2 Biology of pulse beetle on greengram variety SML-668

S.No.	Stage of the Insect	Average Days ± S.D.
1.	Egg	4.8±1.23
2.	Larval + Pupal	29.4±3.33
3.	Total developmental period	33.7±3.13
4.	Adult longevity	
	Male	6.2±0.79
	Female	8.6±1.07
5.	Pre-oviposition	5.8±1.62
6.	Oviposition	4.9±1.66
7.	Post- oviposition	3.6±0.97
8.	Fecundity	90±8.04

S.D. - Standard deviation

4.1 Development of bruchid

Number of eggs

The data indicate that on an average 90 eggs were laid by a single pulse beetle female on 100 randomly selected greengram seeds.

Larval pupal period

The data indicated that the average larval pupal period of pulse beetle was 29.4 days.

Total development period

The average total development period of pulse beetle was recorded 33.7 days.

Growth index

The growth index of pulse beetle on greengram was 2.79.

4.2 Screening of different greengram varieties against pulse beetle

Six varieties of greengram were screened to know their preference to pulse beetle up to 90 days of storage. The observations on preference for egg laying, adult emergence (%), grain damage (%), weight loss (%), total population build up (no.) and germination (%) were taken to decide the preference of greengram varieties against pulse beetle.

Preference of egg laying

The maximum mean number of eggs laid after 3, 7 and 10 days was on the variety SML-668 with the respective fecundity being 87.09, 89.12 and 89.12 (Table 3).

Adult emergence (%)

Emergence of adults began after 30 days. The maximum adults that emerged after 30, 60 and 90 days were 90.02, 93.36 and 94.14 on variety SML-668; whereas, the minimum number of adults that emerged after 30, 60 and 90 days were 50.99, 53.00 and 55.01 on variety RMG-62 (Table 4).

Growth index

The results table-(4) indicate that the growth index of the pulse beetle on the six genotypes ranged from 1.57 to 2.79. Variety RMG-62 recorded the minimum growth index (1.57); whereas, SML-668 recorded the maximum (2.79) growth index.

Grain damage (%)

A perusal of table-(5) showed that the lowest mean damage was caused in variety RMG-62 (40.99%); whereas, maximum mean damage (80.21%) was recorded on variety SML-668.

Weight loss (%)

The average weight loss due to the feeding of the insect was recorded as low as 10.49 per cent on variety RMG-62 and as high as 17.47 per cent on SML-668. The average net weight loss recorded in the varieties RMG-268, RMG-344, RMG-492 and IPM-02-3 were 13.46, 11.49, 14.51 and 16.48 per cent, respectively (Table-5).

Germination (%)

The results Table-(5) indicate that varieties RMG-62 and RMG-344 showed the average highest germination (85.37%), while variety SML-668 showed lowest germination (65.44%). The average germination recorded on the varieties RMG-268, RMG-492 and IPM-02-3 was 80.46, 75.34 and 70.39 per cent, respectively.

4.3 Bio-efficacy of botanicals and inert dusts

4.3.1 After 7 days of release

It is evident from table-(6) that the botanicals and inert dusts at all the application rates and time intervals caused significant pulse beetle mortality as compared to control. Custard apple seed powder showed the mean maximum of 43.69 per cent mortality. The mean minimum of 5.52 per cent mortality was observed in seeds treated with cow dung ash (5 g/kg). The application of powders at different rates exerted marked effect on the mortality, but at higher dose caused rapid mortality. However, more effective powders like custard apple seed powder and diatomaceous earth at their higher application rates (10 g/kg) provided higher mortalities as compared to the other treatments.

4.3.2 Fecundity of pulse beetle

All the plant powders and inert dusts after 3 ,7 and 10 days at their application rates of 5 and 10 g/kg reduced the number of eggs laid by pulse beetle when compared with that in control. The lowest average number of eggs laid after 3,7 and 10 days were 28.84, 22.90 and 27.54 respectively where the grain was treated with custard apple seed powder (10 g/kg) (Table 7). The cow dung ash treatment was least effective at the dose level of 10 g/kg. The table also indicates that powders of fruit parts (neem and custard apple) were more effective in reducing fecundity of pulse beetle as compared to those prepared from leaves.

4.3.3 Effect of botanicals and inert dusts on adult emergence

At 30 days after release

All the treatments at the lowest doses reduced the total per cent adult emergence when compared with control, where 41.31 per cent adults emerged. The average minimum adult emergence (7.00 and 7.32%) was recorded in seeds treated with custard apple seed powder (10g/kg) and diatomaceous earth (10g/kg)

respectively. The leaf powders of custard apple exhibited maximum per cent emergence (11.66%) of adult beetles when treated at the dose of with 10g/kg seeds. Fruit parts (custard apple) again showed better insecticidal potency than the leaf powders (Table-8).

At 60 days after release

All the botanicals and inert dusts even at their lowest doses reduced the total population build-up when compared with control, where the average maximum (57.01%) adults emerged in untreated control. The respective minimum adults (10.32 and 10.66%) emerged from seeds treated with custard apple seed powder (10g/kg) and diatomaceous earth (10g/kg). The leaf powders of custard apple (10g/kg) exhibited an average 13.33 per cent adult emergence.

At 90 days after release

The result as indicated in (Table-8) showed that all the botanicals and inert dusts even at their lowest doses reduced the per cent adult emergence when compared with control, where the average maximum adults emerged was 73.40 per cent. The average minimum adult emergence (11.00 and 11.66%) was recorded in seeds treated with custard apple seed powder and diatomaceous earth (10g/kg) respectively. Fruit parts (custard apple) again showed better insecticidal potency than the leaf powders. The cow dung ash treated seeds showed 51.33 and 48.67 per cent adult emergence after 90 days of storage at the treatment dose of 5g and 10g per kilogram of seeds, respectively.

4.3.4 Bio-efficacy of botanicals and inert dusts on per cent seed damage, weight loss and germination on pulse beetle up to 90 days after storage of pulse beetle

Seed damage (%)

As per (Table-9) all the plant powders and inert dusts even at their lowest application rate reduced the seed damage per cent when compared with control, where the average maximum seed damage (78.76%) was observed. The minimum seed damage of 3.20 and 3.20 per cent was observed in seeds treated with custard apple seed powder and diatomaceous earth (10g/kg) respectively. The leaf powders of custard apple (10g/kg) exhibited maximum (19%) seed damage.

Weight loss (%)

The average maximum weight loss (29.18%) was observed in untreated control; whereas, the minimum weight loss of 3.20 and 3.20 per cent was observed in seeds treated with custard apple seed powder and diatomaceous earth (10g/kg) respectively. The leaf powders of custard apple (10g/kg) exhibited 6.18 per cent weight loss.

Greengram germination (%)

A Perusal of table-(9) shows that the average maximum germination (85.18% in both) was recorded in greengram treated with custard apple seed powder and diatomaceous earth (10g/kg); whereas, in the control 25 per cent germination was recorded.

Table-3 Comparative preference for egg laying on greengram variety 2015

Variety	Number of eggs laid/100 grains		
	3 DAR	**7 DAR**	**10 DAR**
RMG-62	1.86 {72.44}	1.86 {72.44}	1.86 {72.44}
RMG-268	1.87 {74.13}	1.87 {74.13}	1.87 {74.13}

RMG-344	1.86 {72.44}	1.86 {72.44}	1.86 {72.44}
RMG-492	1.89 {77.62}	1.88 {75.85}	1.88 {75.85}
SML-668	1.94 {87.09}	1.95 {89.12}	1.95 {89.12}
IPM-02-3	1.93 {85.11}	1.93 {85.11}	1.93 {85.11}
S.Em ±	0.005	0.003	0.003
C.D. (p =0.05)	0.015	0.008	0.009

Figures in brackets { } are retransformed values

DAR= Days after release

Table-4 Comparative adult emergence and growth index of *Callosobruchus chinensis* (L.) on different greengram varieties

Variety	Adult emergence(%) days after release			Mean development Period (Days)	Growth Index
	30 DAR	60 DAR	90 DAR		
RMG-62	45.57 (50.99)	46.72 (53.00)	47.88 (55.01)	40.5	1.57
RMG-268	49.03 (57.01)	50.21 (59.04)	53.17 (64.06)	36.5	1.79
RMG-344	46.15 (52.00)	48.46 (56.02)	50.21 (59.04)	38.5	1.64
RMG-492	57.51 (71.14)	58.81 (73.18)	60.14 (75.21)	34.5	2.23
SML-668	71.68 (90.12)	75.07 (93.36)	76.00 (94.14)	31.5	2.79
IPM-02-3	69.55 (87.79)	70.56 (88.92)	73.85 (92.26)	32.5	2.77
S.Em ±	2.42	2.95	2.99	0.72	
C.D. (p =0.05)	7.20	8.77	8.88	2.17	

Figures in parentheses are retransformed per cent values

Table-5 Comparative damage to different greengram varieties 90 days after storage due to pulse beetle

Varieties	Grain Damage (%)	Weight Loss (%)	Germination (%)
RMG-62	39.81 (40.99)	3.24 [10.49]	9.24 [85.37]
RMG-268	47.88 (55.01)	3.67 [13.46]	8.97 [80.46]
RMG-344	41.55 (43.99)	3.39 [11.49]	9.24 [85.37]
RMG-492	53.78 (65.08)	3.81 [14.51]	8.68 [75.34]
SML-668	63.59 (80.21)	4.18 [17.47]	8.09 [65.44]
IPM-02-3	55 (67.10)	4.06 [16.48]	8.39 [70.39]
S.Em ±	3.84	0.08	0.19
C.D. (p =0.05)	11.42	0.23	0.55

Figures in parentheses are retransformed per cent values

Figures in square brackets are retransformed square values

Table-6 Bio-efficacy of plant powders and inert dusts on mortality of pulse beetle

Treatment	Doses(g/kg)	Cumulative mortaility (%) 7 days after release
Custard apple leaf powder	5	3.24 [10.49]
Custard apple leaf powder	10	4.53 [20.52]
Custard apple seed powder	5	5.52 [30.47]
Custard apple seed powder	10	6.61 [43.69]
Neem leaf powder	5	2.94 [8.64]
Neem leaf powder	10	4.53 [20.52]
Diatomaceous earth	5	4.86 [23.61]
Diatomaceous earth	10	6.33 [40.06]
Cow dung ash	5	2.35 [5.52]
Cow dung ash	10	2.94 [8.64]
Untreated control		2.35 [5.52]
S.Em ±		0.23
C.D. (p =0.05)		0.66

Figures in square brackets are retransformed square values

Table-7 Impact of leaf/seed powders and inert dusts on egg laying capacity

Treatment	Doses(g/kg)	Mean egg laid days after release		
		3	7	10
Custard apple leaf powder	5.00	1.54 {34.67}	1.55 {35.48}	1.56 {36.30}
Custard apple leaf powder	10.00	1.52 {33.11}	1.53 {33.88}	1.55 {35.48}
Custard apple seed powder	5.00	1.49 {30.90}	1.46 {28.84}	1.44 {27.54}
Custard apple seed powder	10.00	1.46 {28.84}	1.36 {22.90}	1.44 {27.54}
Neem leaf powder	5.00	1.54 {34.67}	1.56 {36.30}	1.56 {36.30}
Neem leaf powder	10.00	1.54 {34.67}	1.55 {35.48}	1.56 {36.30}
Diatomaceous earth	5.00	1.50 {31.62}	1.52 {33.11}	1.50 {31.62}
Diatomaceous earth	10.00	1.48 {30.19}	1.39 {25.54}	1.42 {26.30}
Cow dung ash	5.00	1.72 {52.48}	1.74 {54.95}	1.74 {54.95}
Cow dung ash	10.00	1.71 {51.28}	1.72 {52.48}	1.72 {52.48}
Untreated control		1.89 {77.62}	1.90 {79.43}	1.91 {81.28}
S.Em ±		0.007	0.014	0.017
C.D. (p =0.05)		0.021	0.041	0.049

Figures in brackets { } are retransformed values

Table-8 Effect of botanicals and inert dusts on adult emergence

Treatment	Doses (g/kg) seed	Adult emergence(%) days after release		
		30	60	90
Custard apple leaf powder	5.00	20.55 (12.32)	22.52 (14.66)	23.83 (16.32)
Custard apple leaf powder	10.00	19.97 (11.66)	21.41 (13.33)	21.97 (14.00)
Custard apple seed powder	5.00	8.00 (16.43)	19.37 (11.00)	21.41 (13.33)
Custard apple seed powder	10.00	7.00 (15.34)	18.74 (10.32)	19.37 (11.00)
Neem leaf powder	5.00	24.85 (17.66)	27.74 (21.67)	44.43 (49.01)
Neem leaf powder	10.00	23.83 (16.32)	27.04 (20.67)	43.47 (47.33)
Diatomaceous earth	5.00	16.77 (8.32)	19.67 (11.33)	21.69 (13.66)
Diatomaceous earth	10.00	15.70 (7.32)	19.06 (10.66)	19.97 (11.66)
Cow dung ash	5.00	24.60 (17.32)	28.43 (22.67)	45.76 (51.33)
Cow dung ash	10.00	23.83 (16.32)	26.56 (19.99)	44.24 (48.67)
Untreated control		40.00 (41.31)	49.03 (57.01)	58.95 (73.40)
S.Em ±		0.40	0.49	0.74
C.D. (p =0.05)		1.18	1.42	2.17

Figures in parentheses are retransformed per cent values

Table-9 Damage caused by *C. chinensis* to seed quality parameter on different varieties of greengram

Treatment	Doses(g/kg)	Seed damage (%)	Weight loss (%)	Germination (%)
Custard apple leaf powder	5	27.27 (20.99)	14.51 (6.27)	53.74 (65.01)
Custard apple leaf powder	10	25.84 (18.99)	14.40 (6.18)	56.82 (70.04)
Custard apple seed powder	5	10.45 (3.28)	10.45 (3.28)	67.36 (85.18)
Custard apple seed powder	10	10.32 (3.21)	10.32 (3.20)	67.36 (85.18)
Neem leaf powder	5	29.99 (24.98)	21.53 (13.46)	47.87 (55.00)
Neem leaf powder	10	28.65 (22.98)	19.97 (11.66)	50.78 (60.01)
Diatomaceous earth	5	10.45 (3.28)	10.45 (3.28)	63.52 (80.11)
Diatomaceous earth	10	10.32 (3.20)	10.32 (3.20)	67.36 (85.18)
Cow dung ash	5	32.58 (28.99)	21.69 (13.65)	45.00 (50.00)
Cow dung ash	10	31.30 (26.99)	20.24 (11.96)	47.87 (55.00)
Untreated control		62.56 (78.76)	32.69 (29.17)	30.00 (25.00)
S.Em ±		0.64	0.30	1.47
C.D. (p =0.05)		1.89	0.89	4.32

Figures in parentheses are retransformed per cent values

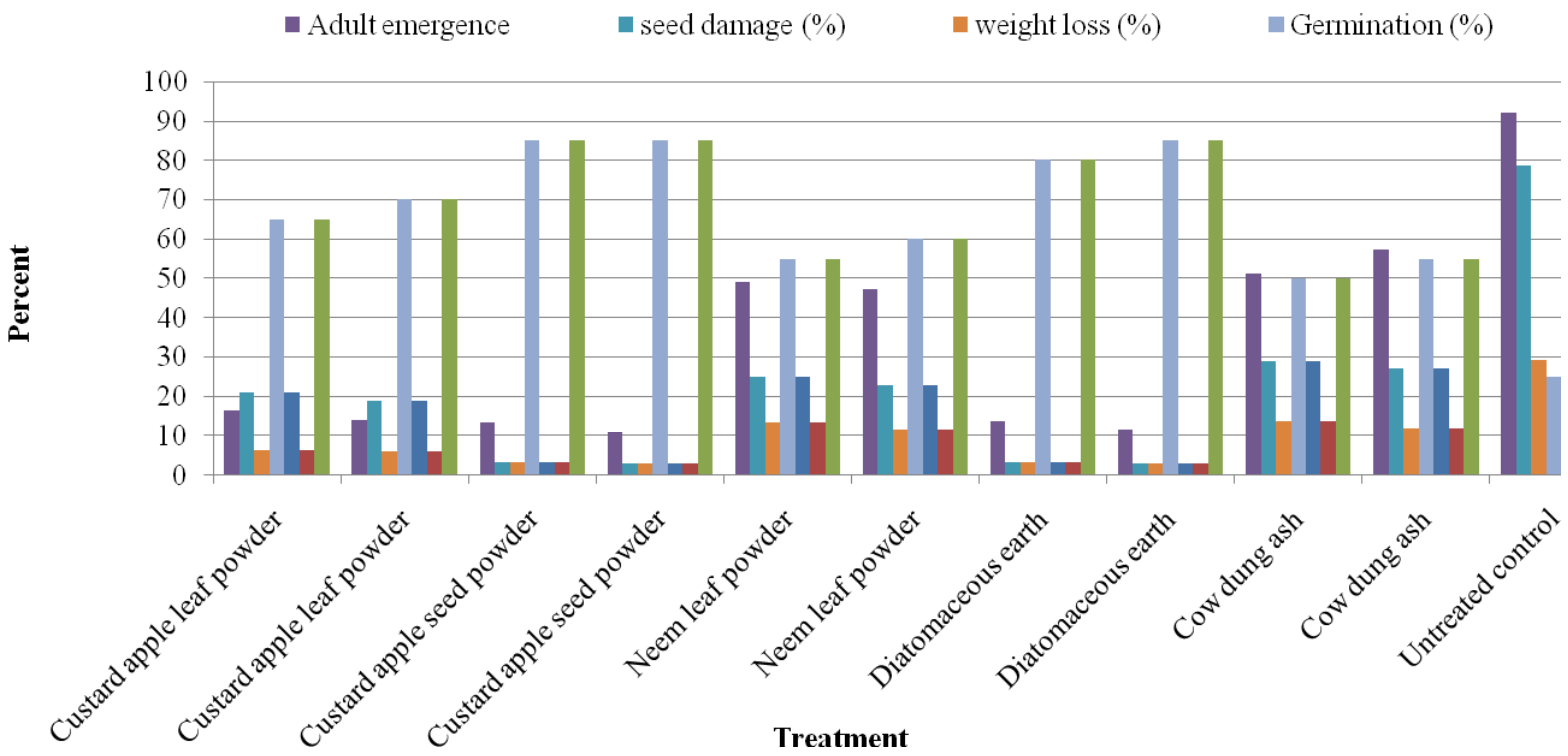

Fig.2 Influence of botanicals and inert dusts on bruchid adult emergence and seed quality parameter

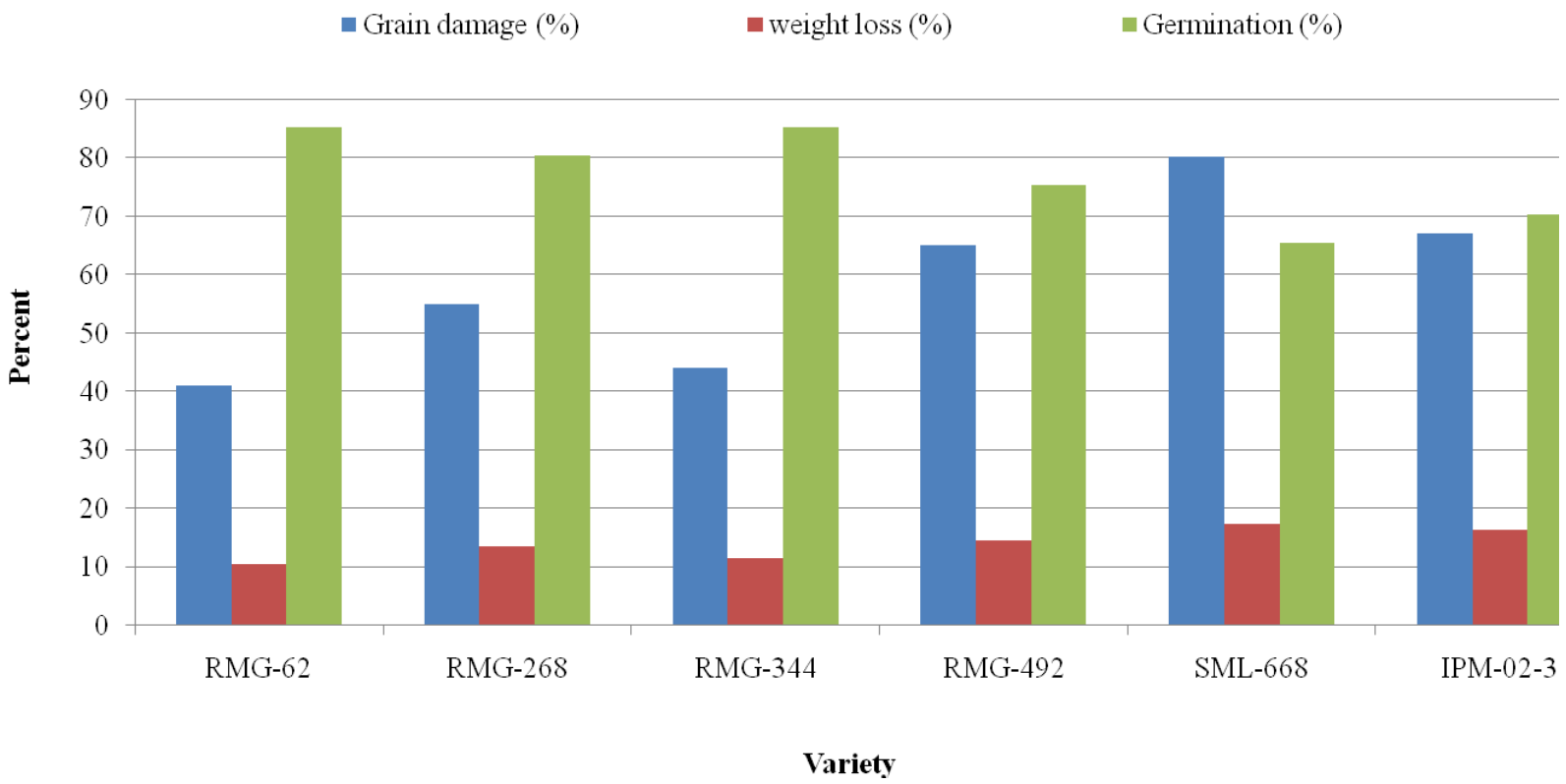

Fig.1 Comparative damage to different greengram varieties 90 days after storage due to pulse beetle

5. DISCUSSION

The results of the studies carried out on the "Biology and management of pulse beetle on stored greengram" are discussed in this chapter.

5.1 Biology of pulse beetle on SML-668 variety of greengram:

Biology of *C. chinensis* was studied on SML-668 variety of greengram under laboratory conditions during November 2015 to January 2016. It was observed that the average incubation period was 4.8 days which varied from 3 to 7 days in which could be due to the impact of temperature and humidity. Earlier, Singh (1962) reported the incubation period of *C. chinensis* ranging from 5-6 days at room temperature on different pulses. Kumari *et al*. (1991) observed average incubation period ranging from 9-13 days on blackgram. Incubation period of 4-5 days by *C. chinensis* was also reported by Singh and Kumari (2000) on greengram and cowpea seeds at 28±2ºC and 70±5 per cent RH. Variations in incubation period among different generations in different hosts have been reported by many workers, which were attributed to differences in temperature, relative humidity and host species.

The larval pupal period varied from 23 to 33 days with an average of 29.4 days during the present studies. Kumari *et al*. (1991) reported the larval period of 17-20 days in blackgram. While working the biology of *C. chinensis* on greengram and cowpea, Singh (1962) reported the combined larval and pupal period to vary from 18.9-38.3 days on different pulses at room temperature of 28±2ºC and 70±5 per cent RH; the pupal stage lasted 7.00 to 9.33 days during the six generations of *C. chinensis chinensis*, Siddiqi (1972) had reported a comparatively shorter pupal period (5.6 to 6.00 days) when compared to the present studies. Kumari *et al*. (1991) and Singal and Borah (2001) reported pupal periods of 7-9 days on blackgram and 7.2±0.18 days on pigeonpea, respectively.

The time taken by the beetle to complete total developmental period varied from 29 to 38 days (average: 33.7 days) during the present study. Earliar, Kumari *et al*. (1991) reported the total period of egg laying to adult emergence to be 36-39 days on blackgram and 28-40 days in greengram. 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.

The fecundity of pulse beetle female varied from 78 to 102 eggs with an average of 90 eggs in the present study. Pandey and Singh (1997) reported the average egg laying per female by *C. chinensis* to be 110 eggs.

The mean longevity of male was 6.2 days and 8.6 days for the female. 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.

5.2 Screening different greengram varieties against pulse beetle

The experiment was conducted to determine the preference of greengram varieties by the pulse beetle on the basis of preference for egg laying, adult emergence, growth index, grain damage, weight loss, germination and total population build up.

5.2.1 Preference for egg laying:-

The maximum average numbers of eggs were laid by the pulse beetle on SML-668 variety of greengram and minimum eggs were laid on variety RMG-62 after 3, 7 and 10 days of time intervals. The varieties SML-668, IPM-02-3, RMG- 492, and RMG-268 were more preferred for egg laying than RMG-62 and RMG-344.

Similar results were found by Chavan *et al.* (1997) for ovipositional preference of *C. chinensis* in cowpea lines. The beetle showed a definite varietal response for oviposition. The cowpea line with rough seed surface was less preferred for oviposition. Raina (1970) reported that *C. chinensis* female laid an average of 78 eggs, ranging from 63.90 over a period of 8 days and maximum number of eggs were laid on the first day of oviposition, Rajak and Pandey(1965) reported a range of 50-103 eggs and Takasugi (1924) between 70-80 eggs under natural conditions.

5.2.2 Adult emergence (%)

The result indicated that average maximum adult emergence was 87.09, 89.12 and 89.12 per cent on SML-668 variety of greengram after 30, 60 and 90 days, while minimum adult emergence was 72.44 (after 30, 60 and 90 days) per cent on RMG-62 and RMG-344. Gokhle (1973) reported that adult emergence of *C. chinensis* on cowpea was 96.62 per cent and on pea it was 73.35 per cent; whereas, Kumari *et al* (1991) reported 46.77 per cent adult emergence in blackgram.

5.2.3 Growth Index:

As per the growth index values RMG-62 was the least preferred host for pulse beetle with the least growth index (1.57), while SML-668 was most suitable host with a growth index of 2.79. Kumari et al. (1991) reported that the highest growth index for *C. chinensis* was on pigeonpea (2.37) and minimum on urd (1.07).

5.2.4 Grain damage, Weight loss and Germination (%)

The results of grain damage showed that the mean maximum damage to seed was recorded on SML-668 and minimum on RMG-62variety of greengram. Kalyan and Dadhich (1999) reported that the minimum per cent grain damage was recorded in the variety R-298 (27.51%) followed by K-851 (30.61%); whereas, the maximum was recorded in Pusa-105 (77.31%) and PS-16 (85.9%) by *C. maculatus*. Similar results of wide variation on grain damage was reported by Satyavir (1989), Singh and Dadhich (1992) and Singal (1987).

Choudhary *et al*. (1982) reported that greengram with larger seed size and thinner testa was preferred more as compared to small seed with thicker testa by *C. chinensis*, Kopergaon was the most susceptible variety, while J-45 was least susceptible and least preferred host for the development and survival of *C. chinensis*.

The results of weight loss showed that the average maximum weight loss was in SML-668 and minimum in RMG-62 and the results of germination per cent showed that the maximum germination was in RMG-62. Our observations are supported by those of Sadozai *et al*. (2003) who reported maximum weight loss in cowpea and greengram.

5.3 Efficacy of botanicals and inert dusts

The findings of the present study indicate the effects of some of the plant powders and inert dusts on mortality, egg laying, adult emergence, seed damage per cent, weight loss and germination of *C. chinensis*. Varying activity by different powders and inert dusts indicate that the pest controlling factors are not uniformly present in every aromatic plant and inert dusts.

5.3.1 Mortality of pulse beetle

In the present investigation custard apple seed powder (10g/kg) and the diatomaceous earth (10g/kg) showed the maximum average mortality of 43.69 per

cent and 40.06 per cent respectively after 7 days of exposure. The minimum mortality (5.00%) was observed in cow dung treatment. Juneja and Patel (1994) reported that the seed powders of custard apple at 5 parts per 100 parts of greengram (w/w) resulted in 100 per cent adult mortality.

5.3.2 Egg laying of pulse beetle:-

The average lowest number of eggs was recorded in grains treated with custard apple seed powder (10g/kg) and diatomaceous earth (10g/kg). The custard apple leaf powder and neem leaf powder showed the least effect but these were better as compared to the control. Juneja and Patel (1994) reported that pulse beetle laid no eggs on greengram treated with custard apple seed powder up to 60 days which justifies our results.

5.3.3 Adult emergence (%)

In the present investigation at was observed that the minimum average adults emerged from the seeds treated with custard apple seed powder(10g/kg) and diatomaceous earth (10 g/kg) of after 30,60 and 90 days. Fruit portion of neem and custard apple showed better insecticidal potency than their leaf powders. Similar results were also reported by Shivanna *et al.* (1994) that support the present findings.

5.3.4 Seed damage (%)

In the present investigation custard apple seed powder (10g/kg) and diatomaceous earth (10g/kg) treated seeds recorded average lowest (3.20 and 3.20%) seed damage and neem leaf powder, custard apple leaf powder also showed good result as compared to control.

The reduction in seed damage as observed by mixing various plant powders with blackgram @ 5 g per 100 g seed has been reported earlier by Gautam *et al.* (2000). The present findings also draw considerable support from the work of Misra (2000) who found neem leaf powder treatment ideal at 3 per cent dose in blackgram seeds resulting in less seed damage by *C. chinensis*. Aslam *et al.* (2002) however reported complete effectiveness of black pepper in preventing *C. chinensis* infestation of stored pulses when applied @ 25 g per kg of seed.

5.3.5 Weight loss (%)

The average minimum (3.20%) weight loss was recorded both in custard apple seed powder (10g/kg) and diatomaceous earth (10g/kg) treated seeds at 90 days of storage. The maximum weight loss (29.17%) was recorded in the untreated control. However, powders of custard apple leaf, neem leaf powder and cow dung were least effective in protecting grains from the damage of pulse beetle when applied at 10 g/kg of seeds. The present findings are in conformity with that of Misra (2000) and Juneja and Patel (2002) who reported negligible weight losses in seed weight treated with 1 per cent of either powdered custard apple or black pepper seed. Similarly, Laxmi and Venugopal (2007) also reported minimum weight loss in greengram treated with custard apple seed powder.

5.3.6 Germination (%)

The effect of five growth disrupting compounds *viz*., custard apple seed powder, custard apple leaf powder, neem leaf powder , diatomaceous earth powder and cow dung powder at 5 and 10 g/kg on germination of greengram seeds was studied. The average maximum germination (85.18%) was recorded in seeds treated with custard apple seed powder and diatomaceous earth and lowest (25%) in untreated control.

No adverse effect on seed viability of greengram by seed and leaf powders of custard apple at 3.0 per cent was reported by Saxena *et al.*, (1976), Yadav and Bhatnagar (1987), Gundannavar and Deshpande, (2006) and Lakshmi and Venugopal, (2007) and on pigeon pea by Sharma *et al.*, (2010) up to 180 days of treatments.

No harmful effect of neem leaf powder at dose level of 5.0 per cent on soybean (Gundannavar and Deshpande, 2006) and on mothbean (Yadav and Bhargava, 2005) was reported up to 90 days of treatment, support the present investigations.

6. SUMMARY

Investigation on “Biology and management of pulse beetle on stored greengram” was carried out at Department of Entomology, RCA, MPUAT, Udaipur during 2015-16. The present investigation an attempt was made to study the management of pulse beetle infesting stored greengram are summarized in this chapter.

The biology of pulse beetle was studied on SML-668 variety of greengram. Female beetles laid on an average 90.0 eggs with mean incubation period of 4.8 days, larval pupal period took on average of 29.4 days. Males lived for 6.2 days while females for 8.6 days. The mean developmental period was 33.7 days and the growth index recorded was 2.79 on SML-668 variety of greengram. The screening of greengram varieties against the pulse beetle *viz*.RMG-62, RMG-268, RMG-344, RMG-492, SML-668 and IPM-02-3 were studied against the pulse beetle. The varieties, SML-668 and IPM-02-3 was most preferred host for egg laying, while least preferred variety was RMG-62. The maximum mean adult emergence was in SML-668 and minimum in RMG-62. Variety RMG-62 was the least preferred food for the bruchid with the lowest growth index of 1.57. The maximum seed damage up to (80.21%) was observed in SML-668, while minimum (40.99%) damage occurred in RMG-62. The weight loss was highest in SML-668 with 17.47 per cent and was lowest in RMG-62 and RMG-344 with 10.49 and 11.49 per cent. Germination per cent was recorded highest in RMG-62 and RMG-344 with 85.37 per cent in both and was lowest in SML-668 with 65.44 per cent.

Custard apple seed powder (10g/kg) showed the maximum (43.69%) mortality of pulse beetle after 7 days. The minimum mortality (5.00%) was observed in grains treated with cow dung ash. All the plant powders and inert dusts at their application rates of 5g/kg and 10g/kg reduced the number of eggs laid by pulse beetle when compared with the control, which had the maximum (77.62, 79.43 and 81.28) eggs after 3, 7 and 10 days. The lowest (28.84, 22.90 and 27.54) number of eggs was recorded on grain treated with custard apple seed powder (10 g/kg). The cow dung dust was least effective at the dose level of 10 g/kg. The plant powders and inert dusts even at their lowest application rate reduced the emergence of adults when compared with control, where the maximum (41.31, 57.01 and 73.40%) adults emerged after 30,

60 and 90 days of intervals. The minimum (7.00, 10.32 and 11.00%) adults emerged in seeds treated with custard apple seed powder (10 g/kg). The minimum seed damage of 3.20 per cent was recorded in custard apple seed powder treated seeds, while maximum seed damage (78.76%) was recorded in the control. The minimum weight loss of 3.20 per cent was recorded in custard apple seed powder treated seeds, while maximum weight loss (29.17%) was recorded in the control. The maximum germination (85.18%) was recorded in custard apple seed powder and diatomaceous earth treated seeds of greengram, while and minimum germination (25%) was recorded in control.

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