GAVIN PUBLISHERS

OPEN ACCESS

Current Trends in Entomology and Zoological Studies

Miah MA. Curr Trends Entomol Zool Stds 3: 112.

Research Article

DOI: 10.29011/2690-0114.100012

Host Preference of Pulse Beetles (*Callosobruchus chinensis* and *C. maculatus*) on Different Mungbean (*Vigna radiata*) Varieties

Mohammad Asaduzzaman Miah*

Department of Entomology, Patuakhal Science and Technology University, Bangladesh

***Corresponding author**: Mohammad Asaduzzaman Miah, Department of Entomology, Patuakhali Science and Technology University, Bangladesh

Citation: Miah MA (2020) Host Preference of Pulse Beetles (*Callosobruchus chinensis* and *C. maculatus*) on Different Mungbean (*Vigna radiata*) Varieties. Curr Trends Entomol Zool Stds 3: 112. DOI: 10.29011/2690-0114.100012

Received Date: 13 November 2020; **Accepted Date:** 26 November 2020; **Published Date:** 30 November 2020

Abstract

The host preferences of pulse beetles, *C. chinensis* and *C. maculatus* on different Mungbean (*Vigna radiata*) varieties were assessed under laboratory conditions. For this test, 9 varieties of mung bean were evaluated for their preference against two species of pulse beetle by studying their biology (oviposition, growth and development of larvae and pupae, adult emergence) and food consumption. Among the mungbean varieties, BARI Mug-6 was the most suitable host for *C. chinensis* and Barisal local for *C. maculatus*, whereas BARI Mug-4, BARI Mug-5, BARI Mug-6 appeared to be most common and suitable host for both the species. There was no significant influence of mungbean varieties on egg hatching for both the species. The developmental period of *C. chinensis* and *C. maculatus* were not so influenced by different mungbean varieties.

Keywords: Host preferences; Mungbean (*Vigna radiata*); Pulse beetles (*C. chinensis* and *C. maculatus*)

Introduction

Mungbean, *Vigna radiata* (L.) is one of the most important pulse crops in the tropical and subtropical countries in the world and playing important role in the global economics. In Bangladesh, it ranks fifth in both acreage and production, contributes 6.5% of the total pulse production [1]. It is considered as a poor man's meat because it is a good source of protein contains 51% carbohydrate, 26% protein, 4% minerals and 3% vitamins [2]. In storage, mungbean suffer enormous losses due to pulse beetles attack and the infestation starts in the field on the maturing pod and is carried to the stores with the harvested crops or it originates in the storage itself [3]. Three species viz. *Callosobruchus chinensis*, *C. maculatus* and *C. analis* have been reported as the pest of stored pulses. In 1971, Alam [4] reported that *C. chinensis* causes enormous losses to almost all kind of pulses in storage condition. In warehouses, about 12.5% losses was reported due to pulse beetle infestation in pulses. Ali, et al. [5] reported that mungbean appeared to be the most common and suitable host for *C. chinensis* in respect of oviposition, egg deposition, adult emergence (66.11-70.29%) and grain content loss (50.37 - 57.58%). In India, Gujar and Yadav [6] reported that 55-60% loss by seed weight and 45-66% loss in protein content of mungbean by the pulse beetles. It was also reported that the extent of damage might be up to 100% in mungbean seed during a period of one year in storage. In Bangladesh, Muhammad, et al. [7] reported that among different strains/varieties of mungbean MB-46 and Kanti were found to be highly susceptible, with 13.6% and 13.0% loss in weight of seeds, respectively; strains MB-87, MB-66 were susceptible and strains MB-63 and MB-55 were moderately susceptible to *C. chinensis*.

Among the pulse beetles, *C. chinensis* and *C. maculatus* are major pests causing serious damage and are cosmopolitan in distribution. They are known to breed on different pulses including mungbean. But there is no bruchid resistant mungbean variety/genotype available for cultivation. Knowledge of the host range and biology of the pest species are essential to minimize the incidence. Considering the seriousness of this pest on mungbean, this study was carried out to assess the host preference of *C. chinensis* and *C. maculatus* on different mungbean (*Vigna radiata*) varieties.

Materials and Methods

Healthy seeds of mungbean varieties i.e. BU Mug-1, BU Mug-2, BARI Mug-2, BARI Mug-3, BARI Mug-4, BARI Mug-5, BARI Mug-6, BINA Mug-1 and Barisal local (local variety) were collected from Bangladesh Agricultural Research Institute (BARI), Bangabandhu Sheikh Mujibur Rahman Agricultural

University (BSMRAU) and Bangladesh Institute of Nuclear Agriculture (BINA). The seed characteristics of these varieties are presented in Table 1.

Varieties	1000-seed weight (g)	Colouration
BU Mung-1	50.2 g	Dull and greenish.
BU Mung-2	50.2 g	Deep green
BARI Mug-2	25.33 g	Green-smooth
BARI Mug-3	29.40 g	Greenish brown. smooth
BARI Mug-4	31.90 g	Light green- smooth.
BARI Mug-5	42 g	Deep green - shiny
BARI Mug-6	45.50g	Deep green
BINA Mug-1	32.50 g	Golden in colour, shiny
Barisal local	20.00 g	Dull and light green

Table 1: Specifications of different mungbean varieties used in the study.

The adult beetles of *C. chinensis* and *C. maculatus* were studied separately. Male and female beetles were sorted out under simple microscope by their antennal characteristics, size and body shape. The rearing of the pulse beetles was maintained on mungbean seeds in plastic jars covered with cotton cloth in the laboratory. One hundred gram (100 g) of each mungbean varieties were considered for host preference test that was allowed to pulse beetle attack. Each test was performed with three replications. Fresh and healthy seeds of each mungbean variety were taken in individual plastic pot (6 cm dia. x 9 cm height). The seed containing pots were placed randomly at equal distances around a central circle in the mosquito netted topped tin cage (70 cm dia. x 15 cm height). Then 100 pairs of one-day-old healthy adults of pulse beetles from the stock culture were taken in a petridish and placed it in the centre of the cage. The lids of all plastic pots containing mungbean seeds were removed. The cage was covered tightly with mosquito net. The beetles were allowed to remain there for the purpose of oviposition, growth and development of larvae and pupae, adult emergence and food consumption. The developmental stages were observed, and the data were recorded. The number of emerged adults and the weight of the grains were recorded about 30 days later (complete emergence of adult from the laid eggs). For recording data, 20 seeds for each variety of mungbean were randomly collected from each variety/pot.

In the study, data were calculated on different parameters using the following formula:

a) $$\text{Total no. of eggs/pot} = \frac{\text{No. of eggs per collected sample} \times \text{Total no. of seeds/pot}}{\text{Number of seeds per collected sample}}$$

b) $$\%\ \text{egg hatching} = \frac{\text{No. of eggs hatched in collected sample}}{\text{Total no. of eggs laid in collected sample}} \times 100$$

c) $$\%\ \text{larvae/ pupae developed} = \frac{\text{No. of alive larvae/ pupae in collected sample}}{\text{Total no. of eggs laid in collected sample}} \times 100$$

d) $$\%\ \text{adult emergence} = \frac{\text{No. of adult emerged per pot}}{\text{Total no. of eggs laid per pot}} \times 100$$

e) $$\%\ \text{seed damage} = \frac{\text{Weight loss per pot}}{\text{Initial wt. of grains per pot}} \times 100$$

Weight loss per pot = (Initial wt. – final weight) of grains per pot.

Statistical Analysis

The experimental data were analyzed by ANOVA-1 in Completely Randomized Design (CRD) with three replications and the means were separated by Duncan's Multiple Range Test (DMRT).

Results and Discussion

The results of host preference of pulse beetles (*C. chinensis and C. maculatus*) are presented in Table 2 and Table 3. The criteria for the host preference studies were ovipositional preference, egg hatching, development of larvae and pupae, adult emergence, and seed damage.

Mungbean Varieties	Egg Deposition (No.)	Egg Hatching (%)	Larvae Developed (%)	Pupae Developed (%)	Adult Emergence (No.)	Seed Damage (%)
BU Mug-1	756.7 f	80.17 a	6.7 d	7.17 d	9.33 e	2.00 e
BU Mug-2	696.7 g	81.67 a	5.92 d	6.86 d	4.67 f	1.50 e
BARI Mug-2	890.0 d	83.67 a	13.33 c	15.67 c	13.33 e	7.67 d
BARI Mug-3	936.7 c	88.42 a	56.83 a	50.00 b	191.7 b	19.17 b
BARI Mug-4	923.3 c	86.53 a	50.00 ab	50.00 b	201.7 b	20.00 ab
BARI Mug-5	970.0 b	87.73 a	46.33 b	51.67 b	133.3 c	16.67 c
BARI Mug-6	1027a	88.67 a	56.85 a	62.67 a	238.3 a	22.23 a
BINA Mug-1	830.0 e	81.67 a	43.33 b	46.67b	96.67 d	10.00 d
Barisal local	726.7 fg	80.00 a	10.33 c	10.00 cd	9.17 e	1.83 e
Figures indicate original means of three replications; Means followed by same letter(s) are not significantly different (P>0.05) from each other by DMRT						

Table 2: Host preference of *C. chinensis* on different mungbean varieties.

Mungbean varieties	Egg deposition (No.)	Egg hatching (%)	Larvae developed (%)	Pupae developed (%)	Adult emergence (No.)	Seed damage (%)
BU Mug-1	866.7 cd	83.33 a	33.33 d	35.00 d	81.67 de	19.00 d
BU Mug-2	803.3 e	85.00 a	26.67 de	28.33 de	65.00 ef	9.83 ef
BARI Mug-2	973.3 b	82.33 a	25.00 e	26.67 e	55.00 f	8.50 f
BARI Mug-3	993.3 b	84.67 a	73.33 a	75.00 a	140.0 b	26.00 b
BARI Mug-4	960.0 b	84.33 a	43.33 c	45.00 c	110.0 c	21.50 cd
BARI Mug-5	826.7 de	79.67 a	42.33 c	41.67 c	88.33 d	21.00 cd
BARI Mug-6	1043 a	83.67 a	31.67 de	33.33 de	75.00 de	15.00 e
BINA Mug-1	876.7 c	85.00 a	65.00 b	66.67 b	120.0 c	23.50 c
Barisal local	976.7 b	86.00 a	76.67 a	79.33 a	223.3 a	29.50 a
Figures indicate original means of three replications; Means followed by same letter(s) are not significantly different (P>0.05) from each other by DMRT						

Table 3: Host preference of *C. maculatus* on different mungbean varieties.

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Host Preference of *C. chinensis* on Mungbean Varieties

Oviposition

Number of eggs laid by *C. chinensis* varied among different varieties of mungbean (Table 2). Highest number of eggs (1027) laid on the variety BARI Mug-6, followed by BARI Mug-5 (970), BARI Mug-3 (936.7), BARI Mug-4 (923.3), BARI Mug-2 (890.0) and BINA Mug-1 (830.0). In contrast, it was the lowest (696.7) in the variety BU Mug-2 followed by Barisal local (726.7) and BU Mug-1 (756.7). Therefore, the order of ovipositional preference was BARI Mug-6 > Barisal local > BARI Mug-3 > BARI Mug-4 > BARI Mug-2 > BINA Mug-1 > BU Mug-1 > BARI Mug-5 > BU Mug-2. Several previous studies resulted that seed characteristics contributes to this preference by *Callosobruchus spp.* The varieties with small seeds and glossy seed coats were shown to be associated with a higher degree of resistance than large seeds with a dull surface. Female beetles find it more difficult to lay their eggs on the highly convex and shiny surfaces of small seed [8]. Furthermore, Govindarajan, et al. [9] observed that the bigger seed size preferred mostly by the pulse beetles. In addition, Southgate [10], reported that certain factors such as seed hardiness, small size, absence of nutritional factors, and presence of toxic substances, may affect bruchid damage to legume seeds. This result implied that especially rough (wrinkled) and thick seed coat might be responsible for resistance to the test bruchid species.

Egg hatching

The percentage of egg hatching (ranging from 80.00-88.67%) by *C. chinensis* was more or less similar in different varieties of mungbean, which did not differ significantly. The result was similar with the findings of Ali, et al [5].

Development of larvae and pupae

Significant variation was observed in terms of internal larvae development among different mungbean varieties (Table 2). Highest percentage (56.85%) of larvae developed by *C. chinensis* on the variety BARI Mug-6, which was statistically similar with BARI Mug-3 (56.83%) and BARI Mug-4 (50.00%) followed by BARI Mug-5 (46.33%) and BINA Mug-1 (43.33%). On the contrary, it was the lowest (5.92%) in the variety BU Mug-2, which was statistically similar with the variety BU Mug-1 (6.47%) followed by Barisal local (10.33%) and BARI Mug-2 (13.33%). Interestingly the similar trends of results were found in terms of pupae developed. As a result, the order of suitability of larvae and pupae was more or less same, which was BARI Mug-6 > BARI Mug-3 > BARI Mug-4 > BARI Mug-5 > BINA Mug-1 > BARI Mug-2 > Barisal local > BU Mug-1 > BU Mug-2. Sison, et al. [11], found that the eggs are laid on the seed coat while the larvae develop inside the seed completing four larval instars. The larvae develop and feed on the seeds leaving only the seed coat. Pupation takes place in a cell inside the seed and the adult emerges through the entrance hole made by the larva. This variation on the development of larvae and pupae of the beetle inside the seed may be attributed to seed and moisture. Similarly, Epino and Regesus [12], reported that the chemical components of mungbean seed appeared to be correlated with varietal susceptibility to beetle infestation and internal seed damage. The resistant accessions had lower percentage of fats and starch but a higher percentage of protein than the susceptible accessions.

Adult emergence

The emergence of adult *C. chinensis* from different mungbean varieties showed significant variation (Table 2). Maximum number (238.3) of adult emergence was observed in the variety BARI Mug-6 followed by the variety BARI Mug-4 (201.7) and BARI Mug-3 (191.7). In contrast it was the lowest (4.67) in BU Mug-2 followed by the variety Barisal local (9.17), which was statistically similar with BU Mug-1 (9.33).

Seed damage

The larvae of *C. chinensis* fed inside the mungbean seed resulting the weight loss of seeds. Completion of first life cycle of pulse beetle (25 days after release) the seed damage was considered. Like adult emergence, the percentage of seed damage showed significant variation among different varieties. Highest percentage (22.33 %) of seed damage was observed in the variety BARI Mug-6, which was statistically similar with the variety BARI Mug-4 (20.00%) followed by BARI Mug-3 (19.17%), BARI Mug-5 (16.67%) and BINA Mug-1 (10.00%). It was the lowest (1.50%) in the variety BU Mug-2, which was statistically similar with Barisal local (1.83%) and BU Mug-1 (2.00%) followed BARI Mug-2 (7.67%). Thus, the order of adult emergence and seed damage was also more or less same, which was BARI Mug-6 > BARI Mug-4 > BARI Mug-3 > BARI Mug-5 > BINA Mug-1> BARI Mug-2 > BU Mug-1 > Barisal local > BU Mug-2. The findings supported the results of Ashraf *et al*. [13] who studied the effects of different varieties of mung (*Phaseolus aureus*) [*Vigna radiata*] (321, 6601, 141, No.1 and 27) for their relative resistance against *C. chinensis* under controlled laboratory conditions (25-30^{o}C) in terms of adult emergence, seed damage and percentage weight loss. In their study significant variations were observed among the mungbean varieties.

Host Preference of *C. maculatus* on Mungbean Varieties

Oviposition

Number of eggs laid by *C. maculatus* varied among different varieties of mungbean (Table 3). Highest number of eggs (1043)

laid by *C. maculatus* on the variety BARI Mug-6, followed by BARI Mug-3 (933.30), which was statistically similar with Barisal local (976.7), BARI Mug-2 (973.3) and BARI Mug-4 (960.0). In contrast it was the lowest (803.3) in the variety BU Mug-2, which was statistically similar with BARI Mug-5 (826.7) followed by BU Mug-1 (866.7) and BINA Mug-1 (876.7). The order of ovipositional preference was BARI Mug-6 > BARI Mug-3 > Barisal local > BARI Mug-2 > BARI Mug-4 > BINA Mug-1 > BU Mug-1 > BARI Mug-5 > BU Mug-2. This result indicated that different varieties of mungbean seeds influence the oviposition performance of *C. maculates.* The variation on the oviposition of the beetle may be attributed to the characteristics of the seeds in respect of seed size, colour, texture etc. These findings supported by several authors that stated above. The authors observed the ovipositional behavior of *C. maculatus* in relation to seed size. Their observations on the effect of seed size on mungbean (*Vigna radiata*) showed that two bruchids preferred to oviposit on seeds weighing more than the average of those used and the number of eggs laid on them was in proportion to seed weight.

Egg hatching

The percentage of egg hatching (ranging from 82.33-86.00%) by *C. maculatus* was more or less similar in different varieties of mungbean, which did not differ significantly.

Development of larvae and pupae

Significant variation was observed in terms of internal larvae and pupae developed among different mungbean varieties by *C. maculatus* (Table 3). Highest percentage (76.67 %) of larvae developed on the variety Barisal local, which was statistically similar with BARI Mug-3 (73.33%) followed by BINA Mug-1 (65.00%), BARI Mug-4 (43.33%), which was statistically similar with BARI Mug-5 (42.33%). On the contrary it was the lowest (25.00%) in BARI Mug-2, which was statistically similar with the variety BU Mug-2 (26.67%) and BARI Mug-6 (31.67%) followed by BU Mug-1 (33.33%). Interestingly the similar trends of results were found in terms of pupae developed. As a result, the order of suitability of larvae and pupae was more or less same, which was Barisal local > BARI Mug-3 > BINA Mug-1 > BARI Mug-4 > BARI Mug-5 > BU Mug-1 > BARI Mug-6 > BU Mug-2 > BARI Mug-2. This variation on the development of larvae and pupae of the beetle inside the seed may be attributed to seed content, moisture etc. These findings supported by several authors that stated above.

Adult emergence

The emergence of adult C. maculatus from different mungbean varieties showed significant variation (Table 3). Maximum number (223.30) of adult emergence was observed in the variety Barisal local followed by the variety BARI Mug-3 (140.00), BINA Mug-1 (120.00), BARI Mug-4 (110.00). In contrast, it was the lowest (55.00) in BARI Mug-2, which was statistically similar with BU Mug-2 (65.00) followed by BARI Mug-6 (75.00) and BU Mug-1 (81.67). Besides, duration of adult emergence of *C. chinensis* and *C. maculatus* was observed (Figure 1). Adult emergence started at 20 days after release (DAR) of adults for both species of pulse beetles. Duration of adult emergence was gradually increased, and the highest number of adults were emerged at 22 DAR and 23 DAR for *C. chinensis* and *C. maculatus*, respectively.

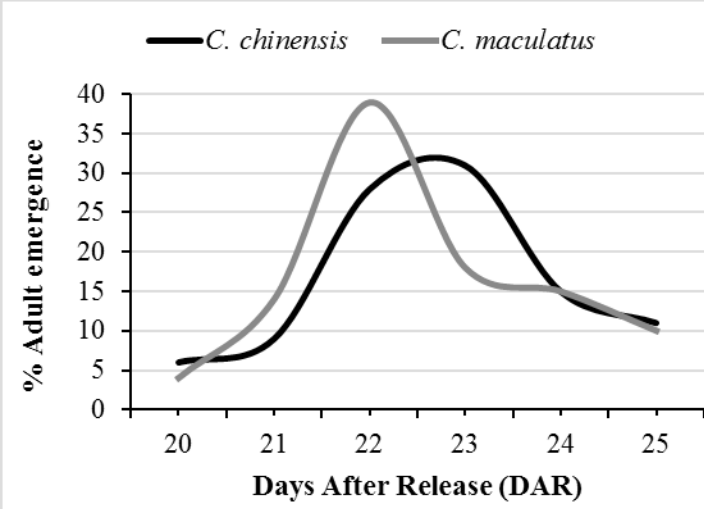

Figure 1: Trend of adult emergence of *C. chinensis* and *C. maculatus* on mungbean in different days after release.

Seed damage

Highest percentage (29.50%) of grain content loss occurred by *C. maculatus* in the variety Barisal local followed by BARI Mug-3 (26.00%), BINA Mug-1 (23.50%), which statistically similar with BARI Mug-4 (21.50%) and BARI Mug-5 (21.00%). It was the lowest (8.50%) in BARI Mug-2, which was statistically similar with BU Mug-2 (9.83%) followed by BU Mug-1 (19.00%) and BARI Mug-6 (15.00%). Thus, the order of adult emergence and grain content loss was also more or less same, which was Barisal local > BARI Mug-3 > BINA Mug-1 > BARI Mug-4 > BARI Mug-5 > BU Mug-1 > BARI Mug-6 > BU Mug-2 > BARI Mug-2. The results were similar with the findings. They found that some varieties of mungbean were highly susceptible to *C. maculatus* in terms of adult emergence, seed damage and percentage weight loss. Besides, Ranganath and Ram had done more or less similar works and they reported that out of 13 varieties of mungbean [*Vigna radiata*] for resistance to *C. maculatus,* lowest feeding damage and adult emergence was recorded with cv. PDM-14. In a study by Gujar and Yadav [6], 55-60% loss was observed in seed weight due to the damage of *C. maculatus.*

It is concluded that BARI Mug-6 was the most suitable host for *C. chinensis* among the mungbean varieties whereas Barisal local was for *C. maculatus*. It is believed that the findings of this study will increase our knowledge for better management of pulse beetles (*C. chinensis* and *C. maculatus*) in storage mungbean.

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