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Research Article

Developmental Response of *Callosobruchus Maculatus* F. and C. *Chinensis* L. on Different Pulse Host-Grains

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Abstract

Eight different host-grains *viz.*, greengram, blackgram, bengalgram, redgram, cowpea, pea, soybean and pillipesara were subjected to infestation by two species of bruchids *i.e*., *C. maculatus* and *C. chinensis* under storage conditions. For *C. maculatus* and *C. chinensis* the most preferred host-grains for oviposition were pillipesara (10.25 eggs/5g) and blackgram (7.75 eggs/5g), whereas for per cent survival greengram (89.52%) and bengalgram (86.43%) were the most preferred, respectively. In case of mean developmental period and index of susceptibility, greengram alone was most preferred by *C. maculatus* (27.32 days and 6.91) and *C. chinensis* (28.47 days and 6.09). On completion of total storage period (120 DAR) the damage caused by *C. maculatus* and *C. chinensis* in terms of per cent number of grains damaged was the highest in greengram (94.88%) and bengalgram (90.65%) while the lowest in pea (17.65 and 27.59), for per cent weight loss of grains was highest in greengram (74.92%) and bengalgram (58.55%) while it was the least in pea and soybean (9.89% and 18.19%), and the per cent moisture was the highest in greengram (18.61%) and pillipesara (15.56%), whereas it was the lowest in soybean (12.01%) and pea (8.61%), respectively.

Keywords: *C. maculatus*, *C. chinensis*, greengram, blackgram, bengalgram, redgram, cowpea, pea, soybean and pillipesara.

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Introduction

Grain legumes popularly known as pulses, play an important role in agriculture not only to increase soil fertility for obtaining higher yields from succeeding crops but also in providing proteinaceous grain and nutritive fodder. Pulses contain at least two to three times more protein than cereals. They are known as “poor man’s meat” as pulses are the cheapest source of dietary proteins and valuable animal feed. The pulses have also played a vital role in the improvement of agricultural economy by occupying 68.32 million hectare area under cultivation and contribute 57.51 million tonnes to the world’s food basket (Chaturvedi and Ali, 2002). India shares 35 per cent of area and 25 per cent of the global production (Anonymous, 2007). The present per capita availability of 44 g pulses per day per head falls much shorter than the 105g required in a balanced diet as prescribed by Food and Agriculture Organization (FAO) and World Health Organization (WHO).

One of the major constraints in production of pulses is the insect pests which inflict severe losses both in the field and storage. Among the insect pests, the bruchids, *Callosobruchus maculatus* and *C. chinensis* are the most devastating and widespread storage pests that infest many edible legumes including mungbean, blackgram, chickpea, pigeonpea, pea and cowpea (Arora, 1977; and Singhal, 1986). The initial infestation originates in the field where the adult beetles lay eggs on green pods and the larva bore through pod and feed on the developing seed (Southgate, 1979) and field-level infestation accounts to only 1-2% damage. When the seeds are harvested and stored the insects continue to feed, emerge into adults and cause further infestation, which results in the total destruction of seeds within 3-4 months.

Material and Methods

A laboratory experiment was carried out to determine the population development and damage of *C. maculatus* and *C. chinensis* in different host-grains. The initial adult cultures of both *C. maculatus* and *C. chinensis* were collected from the Post-harvest technology centre, Agricultural College, Bapatla and were maintained further in the laboratory on the greengram (*Vigna radiata* L.). Prior to the release, the host-grains were disinfested by fumigating with

aluminium phosphide (Celphos) @ of three tablets (9 g) per tonne for seven days. One pair of freshly emerged adult beetles of similar age were introduced in one plastic jar (45x15 cm) with perforated lids containing 100 g of each host-grain and covered with muslin cloth. The beetles were removed after seven days and the jars containing the host-grains along with eggs were left for further development. The data was subjected to analysis of variance (ANOVA) by completely randomized design (CRD) with four replications.

The observations were recorded on population development *viz*, ovipositional preference, per cent survival, mean developmental period and index of susceptibility. Whereas the observations under the assessment of damage include, per cent number of grains damaged, per cent weight loss of grain and per cent moisture content were recorded at monthly intervals.

Assessment of Population development

Ovipositional Preference

The eggs laid on different host- grains were counted and recorded at seven days after release of the adults by using magnifying lens. These eggs were observed daily until the eggs hatched. After hatching, larva bore down in the seed making window for escaping of adults (**Figure 1**).

Figure 1: Damage symptoms of *Callosobruchus maculatus* & *C. chinensis* : Egg of of *Callosobruchus* spp (blue circle), Window (yellow circle) made by the grub for emergence of adults, Grub inside the host-grain and Grub of *Callosobruchus* spp.

Per cent survival

The adults that emerged were counted and recorded every day till the emergence of adults was ceased. The percentage of survival of the test insect was calculated by the formula (Howe, 1971),

$$\text{Per cent survival} = \frac{\text{No. of adults emerged}}{\text{No. of eggs laid}} \times 100$$

Mean developmental period

This can be determined by subtracting the first day of egg lying from first day of adult emergence as suggested by Howe, (1971).

$$\text{Mean developmental period} = \frac{d_1a_1 + d_2a_2 + d_3a_3 + \text{----------} + d_na_n}{\text{Total number of adults emerged}}$$

Where, d_1 = day at which the adults started emerging (1^{st} day), a_1 = number of adults emerged on d_1^{th} day

Index of susceptibility

It is calculated by the formula given by Dobie (1974) as follows,

$$\text{Index of susceptibility (I)} = \text{Log}_e Y \times 100 \text{ t}$$

Where, Y = Total number of emerged adults, t = average developmental period of the progeny

Assessment of Damage

Per cent number of grains damaged

From each host-grain, a representative sample of five grams was taken; the damaged (grains with characteristic holes) (**Figure 2**) and the total number of grains were counted and were subjected to the formula,

$$\text{Per cent number of grains damaged} = \frac{\text{No. of damaged grains}}{\text{Total no. of grains}} \times 100$$

Figure 2: a) Damaged grains with characteristic holes (b) Adult of *C. maculatus* (c) Adult of *C. chinensis*

Per cent weight loss of the grains

Weight loss assessment was conducted from five gram sample in each jar. The grains were separated into damaged and undamaged portions. The grains in each portion were then counted and weighed. The per cent weight loss of grain was calculated by the formula given by Adams and Schulten (1978) as follows.

$$\text{Per cent weight loss} = \frac{(U\ Nd) - (D\ Nu)}{U\ (Nd + Nu)} \times 100$$

Where, U = Weight of undamaged grains, Nu = Number of undamaged grains, D = Weight of damaged grains, Nd = Number of damaged grains.

Per cent moisture

The moisture content in five gram sample of each host-grain was estimated using electronic moisture balance (M/s Shimadzu Corporation, Analytical and measuring instruments division, Kyoto 604-8511, Japan).

Results and Discussion

Population Dynamics of Different Host- grains

The results on the preferential oviposition, per cent survival, mean developmental period and index of susceptibility of *C. maculatus* and *C. chinensis* in different host-grains were furnished in the **Table1**.

The ovipositional preference of *C. maculatus* was maximum in pillipesara (10.25 eggs/5g) followed by greengram (8.50 eggs/5g) and cowpea (8.00 eggs/5g) whereas minimum in soybean (5.0 eggs/5g) followed by pea (5.75 eggs/5g). In case of *C. chinensis* it was maximum in blackgram (7.75 eggs/5g) followed by cowpea (7.50 eggs/5g), greengram (7.25 eggs/5g) whereas the minimum (5.25) number of eggs laid on bengalgram and soybean which on par with each other in seven days after release of a pair of insects. In general *C. chinensis* were less fecund than *C. maculatus.* In the similar lines, Wijenayake and Karunarathe (1999) reported that the ovipositional preference of the *C. chinensis* varied with different pulses except for chickpea, all the other pulses were utilized by the females for egg laying. The highest number of eggs laid per 40 seeds were observed in mungbean (35.1) followed by soybean

(32.3) and white (25) and black (27.2) varieties of cowpea. The lowest numbers of eggs (6.9) were deposited on green pea, whereas the oviposition was not observed on chickpea.

Table 1 Ovipositional preference, Per cent survival, Mean developmental Period and Index of Susceptibility of *C. maculatus* and *C. chinensis* in different host- grains

Treatment No.	Host-grains	Mean number of eggs/ 5 g of host- grain *		Per cent Survival of the insects **		Mean developmental period (days)		Index of susceptibility	
		C. maculatus	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*
1	Greengram	8.50 (2.91)^{b}	7.25 (2.69)^{ab}	89.52 (71.28)^{a}	83.51 (66.07)^{b}	27.32^{b}	28.47^{f}	6.91^{a}	6.11^{a}
2	Blackgram	7.00 (2.64)^{bcd}	7.75 (2.78)^{a}	78.51 (62.42)^{d}	80.49 (63.82)^{c}	35.08^{a}	35.82^{c}	5.02^{c}	4.78^{d}
3	Bengalgram	6.75 (2.59)^{cd}	5.25 (2.28)^{c}	81.71 (64.72)^{cd}	86.43 (68.40)^{a}	28.76^{b}	32.64^{d}	6.06^{b}	5.07^{bc}
4	Redgram	7.50 (2.74)^{bc}	7.00 (2.64)^{ab}	79.89 (63.41)^{d}	83.65 (66.16)^{b}	30.05^{b}	33.41^{d}	5.91^{b}	4.93^{cd}
5	Cowpea	8.00 (2.82)^{bc}	7.50 (2.74)^{a}	85.73 (67.88)^{b}	76.78 (61.19)^{d}	26.97^{b}	31.26^{e}	6.26^{b}	5.31^{b}
6	Soybean	5.00 (2.23)^{e}	5.25 (2.29)^{c}	40.79 (39.68)^{e}	47.64 (43.65)^{f}	35.47^{a}	41.65^{a}	3.94^{d}	3.16^{e}
7	Pea	5.75 (2.39)^{de}	6.00 (2.45)^{bc}	31.91 (34.41)^{f}	50.34 (45.48)^{e}	36.33^{a}	38.72^{b}	3.56^{d}	3.27^{e}
8	Pillipesara	10.25 (3.20)^{a}	6.50 (2.54)^{abc}	84.78 (67.08)^{bc}	84.78 (67.04)^{ab}	30.25^{b}	28.55^{f}	6.38^{ab}	6.03^{a}
SEm (±)		0.10	0.10	0.93	0.52	1.40	0.28	0.21	0.09
CD (P=0.05)		0.28	0.28	2.71	1.50	4.08	0.82	0.62	0.26

*Values in parenthesis are square root transformed values
**Values in parentheses are angular transformed values
In each column values with similar alphabet do not vary significantly at P=0.05

Per cent survival of *C. maculatus* was the highest in greengram (89.52%) followed by cowpea (85.73%) and pillipesara (84.78%) while the least per cent survival was recorded in pea (31.91) followed by soybean (40.79). Whereas in *C. chinensis* the highest per cent survival was recorded in bengalgram (86.43%) followed by pillipesara (84.78%) and redgram (83.65%) which were significantly different from one another and the least was recorded in soybean (47.64) followed by pea (50.34). These results were in conformity with the findings of Bhaduria and Jakhmola (2006) that the number of adults emerged were directly proportional to average number of eggs. The average number of eggs laid on greengram, redgram and blackgram after fifteen days of release was 109.3, 52.6 and 50.6 per fifty grains, respectively. Whereas the number of adults emerged were 73.6, 31.3 and 19.6, respectively.

The least mean developmental period of *C. maculatus* was recorded in cowpea (26.97 days) followed by greengram (27.32 days) and bengalgram (28.76days) whereas the longest mean developmental period was recorded in pea (36.33 days). The shortest mean developmental period of *C. chinensis* was recorded in greengram (28.47 days) followed by pillipesara (28.77 days), whereas the longest was observed in soybean (41.65 days). The results obtained under this experiment can be supported by the findings of Ghosal and Senapati (2007), who opinioned that the developmental period of *C. maculatus* was shortest in cowpea (26 days) and longest in pea (31 days). The developmental period in cowpea was very low may be because favoured of physiochemical properties of the host-grains.

The index of susceptibility of the host- grains to *C. maculatus* and *C. chinensis*, the most preferred hosts recorded by both the species were greengram (6.91 and 6.09) followed by pillipesara (6.38 and 6.03) and cowpea (6.26 and 5.31), whereas the least preferred hosts by both the species were soybean (3.94 and 3.16) and pea (3.56 and 3.27).

Assessment of Damage

The damage caused by *C. maculatus* and *C. chinensis* on different host-grains visualized in terms of per cent number of grains damaged and per cent weight loss of grain was increased with increase in storage period of 120 days (**Table 2**). The weight loss and per cent no. of grains damaged were increased significantly with increase in storage period of

120 days. At the end of the storage period (120 DAR), the per cent number of grains damaged due to *C. maculatus* was recorded the highest in greengram (94.88) followed by bengalgram (88.54) and cowpea (86.84) and the least was recorded in pea (17.65) followed by soybean (24.23). In case of *C. chinensis* the highest per cent number of grains damaged was recorded in bengalgram (90.65) followed by cowpea (82.63) and greengram (81.82), whereas the least grain damage was observed in pea and soybean (27.59 and 42.47). The present per cent number of grains damaged were in conformity with the findings of Quzi (2007), who reported that the damaged caused by *C. chinensis* in terms of per cent number of grains damaged in eight legumes was maximum in greengram (79.59), followed by black gram (59.30), cowpea (51.04), white gram (29.98) and pea (1.70). No damage was recorded in black bean, lentil and soybean.

Table 2 Preferential damage of *C. maculatus* and *C. chinensis* in terms of per cent number of damaged in different host- grains grains

Treatment No.	Host-grains	Per cent number of grains damaged after the release of insects							
		30 DAR		60 DAR		90 DAR		`120 DAR	
		C. maculatus	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*
1	Greengram	6.57 (14.86)^{a}	7.30 (15.67)^{c}	41.83 (40.32)^{a}	22.09 (28.03)^{c}	70.78 (57.28)^{a}	45.38 (42.34)^{c}	94.88 (77.13)^{a}	81.82 (64.78)^{b}
2	Blackgram	4.52 (12.28)^{c}	1.15 (6.07)^{f}	33.93 (17.48)^{e}	4.83 (12.68)^{e}	61.57 (36.91)^{f}	21.44 (27.55)^{d}	88.16 (69.89)^{b}	60.50 (51.06)^{d}
3	Bengalgram	5.82 (13.92)^{b}	12.57 (20.77)^{a}	35.04 (36.31)^{c}	26.83 (31.19)^{b}	55.78 (48.32)^{d}	65.17 (53.85)^{a}	87.54 (70.30)^{b}	90.65 (72.40)^{a}
4	Redgram	2.09 (8.28)^{e}	9.68 (18.12)^{b}	9.02 (38.70)^{b}	15.51 (23.19)^{d}	36.07 (54.06)^{b}	61.70 (51.77)^{a}	75.20 (60.14)^{d}	78.49 (62.38)^{c}
5	Cowpea	3.08 (10.10)^{d}	5.74 (13.85)^{d}	39.06 (35.64)^{c}	40.80 (39.70)^{a}	65.54 (51.75)^{c}	44.62 (41.91)^{c}	83.08 (65.72)^{c}	82.63 (65.78)^{b}
6	Soybean	0.00 (0.64)^{g}	0.00 (0.00)^{g}	5.21 (13.13)^{g}	2.76 (9.43)^{f}	14.69 (22.54)^{g}	14.63 (22.48)^{e}	24.23 (29.46)^{e}	42.47 (40.67)^{e}
7	Pea	0.00 (0.64)^{g}	5.77 (13.90)^{d}	7.01 (15.35)^{f}	17.41 (24.58)^{d}	11.33 (19.65)^{h}	24.39 (29.59)^{d}	16.12 (23.68)^{f}	27.59 (31.69)^{f}
8	Pillipesara	0.56 (4.26)^{f}	1.61 (7.25)^{e}	30.22 (33.36)^{d}	2.60 (9.13)^{f}	45.57 (42.46)^{e}	50.85 (45.49)^{b}	72.13 (58.14)^{d}	77.91 (62/02)^{c}
SEm (±)		0.29	0.35	0.51	0.78	0.69	0.91	0.78	0.81
CD (P=0.05)		0.84	1.02	1.49	2.28	2.02	2.65	2.29	2.37

DAR- Days After Release
Values in parentheses are angular transformed values
In each column values with similar alphabet do not vary significantly at P=0.05

Similarly, in terms of the per cent weight loss of grains due to *C. maculatus* was recorded the highest in greengram (74.92) followed by cowpea (63.98) and pillipesara (53.46), whereas the least was recorded in pea (9.89) followed by soybean (14.45). In case of *C. chinensis* the highest per cent weight loss of grains was recorded in bengalgram (58.55) followed by redgram (55.79) and greeengram (44.39), whereas the least was recorded in soybean and pea (18.19 and 21.22) at 120 DAR (**Table 3**). The present per cent weight loss values were in conformity with the findings of Doharey *et al.* (1987), who reported that the significant increase in weight loss in greengram was due to infestation of *C. chinensis* was 0.62, 16.74 and 25.56% at 30, 60 and 90 days after storage, respectively.

As the storage period is advancing the per cent moisture was gradually and significantly increased in all the host-grains (**Table 4**). The per cent moisture content was non-significant at one day after storage (1DAR). The Per cent increase in moisture due to *C. maculatus* infestation at 120 DAR was recorded maximum in greengram (18.61) followed by pillipesara (17.05) and cowpea (15.61) while minimum in soybean (12.01) followed by pea (12.52). Whereas in case of *C. chinensis* the per cent increase in moisture was maximum in pillipesara (15.56) followed by greengram (13.48) and blackgram (13.02) while minimum in pea (8.61) followed by soybean (9.10).

The increased moisture content in the stored grains is due to increased bruchid population, presence of their excreta and metabolic activity of the increased population adds more water to seed which further increase seed moisture. Thus the present per cent increase in moisture content in different host-grains were in conformity with the findings of Rawat and Srivastava (2011) who reported that the maximum increase of moisture content was found in greengram (8.27%) followed by mothbean (8.2%) while minimum in cowpea (7.6%) after 40 days of storage period.

Table 3 Preferential damage of *C. maculatus* and *C. chinensis* in terms of per cent weight loss of grains in different host- grains

Treatment No.	Host-grains	Per cent weight loss of grains after the release of insects							
		30 DAR		60 DAR		90 DAR		120 DAR	
		C. maculatus	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*
1	Greengram	1.39 (6.87)^{a}	2.94 (9.86)^{a}	10.85 (19.23)^{a}	6.93 (15.26)^{b}	41.20 (39.93)^{a}	28.54 (32.29)^{b}	77.70 (61.82)^{a}	48.94 (44.39)^{a}
2	Blackgram	0.21 (6.47)^{b}	0.21 (2.63)^{d}	6.25 (13.38)^{c}	6.81 (15.12)^{b}	26.25 (32.89)^{c}	13.96 (21.93)^{d}	44.61 (41.91)^{e}	35.41 (36.52)^{e}
3	Bengalgram	0.21 (2.72)^{d}	3.10 (10.14)^{a}	2.98 (9.94)^{d}	4.89 (12.78)^{c}	17.71 (24.88)^{e}	21.45 (27.58)^{c}	35.69 (36.69)^{f}	58.55 (49.92)^{a}
4	Redgram	1.26 (2.63)^{d}	0.50 (4.05)^{c}	5.35 (14.48)^{c}	2.69 (9.42)^{d}	29.50 (30.82)^{d}	22.84 (28.55)^{c}	44.61 (44.33)^{d}	55.79 (48.33)^{b}
5	Cowpea	0.52 (4.17)^{c}	0.56 (4.30)^{c}	8.57 (17.15)^{b}	9.34 (17.79)^{a}	34.78 (36.14)^{b}	33.21 (35.19)^{a}	63.98 (53.13)^{b}	35.43 (36.53)^{e}
6	Soybean	0.00 (0.00)^{e}	0.00 (0.00)^{e}	1.16 (6.17)^{f}	1.24 (6.40)^{f}	10.26 (18.66)^{f}	5.76 (13.86)^{e}	14.45 (22.33)^{g}	18.19 (25.21)^{g}
7	Pea	0.00 (0.00)^{e}	0.52 (4.14)^{c}	2.19 (8.51)^{e}	2.16 (8.40)^{e}	6.93 (15.26)^{g}	4.74 (12.56)^{f}	9.89 (18.33)^{h}	21.22 (27.41)^{f}
8	Pillipesara	0.25 (2.76)^{d}	1.09 (5.99)^{b}	2.48 (8.86)^{de}	2.78 (9.59)^{d}	28.70 (32.49)^{c}	29.94 (33.17)^{b}	53.46 (46.98)^{c}	44.39 (41.78)^{d}
SEm (±)		0.09	0.16	0.40	0.32	0.39	0.42	0.46	0.55
CD (P=0.05)		0.22	0.46	1.18	0.93	1.15	1.23	1.33	1.60

DAR- Day After Release
Values in parentheses are transformed values
In each column values with similar alphabet do not vary significantly at P=0.05

Table 4 Preferential damage of *C. maculatus* and *C. chinensis* in terms of increase in per cent moisture in different host- grains

Treatment No.	Host-grains	Per cent moisture							
		30 DAR		60 DAR		90 DAR		120 DAR	
		C. maculatus	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*	*C. maculatus*	*C. chinensis*
1	Greengram	7.81 (16.22)^{a}	8.37 (16.82)^{a}	12.38 (22.28)^{a}	9.83 (18.26)^{a}	15.65 (24.27)^{a}	11.61 (19.90)^{b}	18.61 (25.55)^{a}	13.48 (21.52)^{b}
2	Blackgram	7.25 (15.62)^{ab}	6.71 (15.00)^{b}	8.04 (16.47)^{d}	7.97 (16.38)^{bc}	11.96 (20.21)^{b}	10.03 (18.46)^{d}	13.25 (21.32)^{c}	13.02 (21.14)^{bc}
3	Bengalgram	7.33 (15.68)^{ab}	7.98 (16.41)^{a}	9.54 (17.97)^{c}	9.97 (18.39)^{a}	12.53 (20.73)^{b}	11.19 (19.53)^{bc}	13.39 (21.46)^{c}	12.65 (20.83)^{bc}
4	Redgram	7.28 (15.62)^{ab}	8.03 (16.46)^{a}	10.84 (19.21)^{bc}	9.78 (18.22)^{a}	11.95 (20.19)^{b}	10.55 (18.95)^{cd}	13.14 (21.24)^{c}	11.23 (19.57)^{d}
5	Cowpea	7.53 (15.89)^{ab}	8.13 (16.56)^{a}	11.71 (19.92)^{b}	8.81 (17.26)^{b}	13.04 (21.16)^{b}	10.20 (18.62)^{d}	15.61 (23.27)^{b}	12.10 (20.35)^{cd}
6	Soybean	5.88 (14.02)^{c}	6.13 (14.33)^{c}	7.75 (16.16)^{d}	7.22 (15.58)^{cd}	11.71 (19.98)^{b}	7.95 (16.38)^{e}	12.01 (20.26)^{c}	9.10 (17.56)^{e}
7	Pea	6.41 (14.66)^{bc}	5.98 (14.15)^{c}	7.85 (16.27)^{d}	6.80 (15.11)^{d}	9.97 (18.39)^{c}	7.56 (15.96)^{e}	12.52 (20.72)^{c}	8.61 (17.06)^{e}
8	Pillipesara	7.91 (16.33)^{a}	8.23 (16.67)^{a}	10.44 (18.85)^{bc}	10.71 (19.09)^{a}	15.61 (23.25)^{a}	13.43 (21.49)^{a}	17.05 (24.38)^{ab}	15.56 (23.21)^{a}
SEm (±)		0.42	0.17	0.51	0.32	0.50	0.30	0.42	0.40
CD (P=0.05)		1.23	0.49	1.49	0.93	1.46	0.86	1.24	1.17

DAR- Day After Release
Values in parentheses are transformed values
In each column values with similar alphabet do not vary significantly at P=0.05

Conclusions

From this study, it can be concluded that greengram and bengalgram were most preferred hosts for both *Callosobruchus maculatus* and *C. chinensis* in terms of both development and damage while soybean and pea were least preferred.

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