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Host Preference and Damage Assessment of Pulse Beetle, *Callosobruchus maculatus* (Fabricius) (Chrysomelidae: Coleoptera) on Different Hosts

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ABSTRACT

The host preference of pulse beetle, *C. maculatus* to selected host grains were evaluated under laboratory conditions in the Department of Entomology and Agricultural Zoology, Banaras Hindu University during the year 2018. Cowpea and green gram were most preferred hosts for *C. maculatus* in terms of oviposition, per cent survival and mean developmental periods. Red gram and soybean were comparatively less preferred host for oviposition (66.38 eggs/50 seeds and 69.00 eggs/50 seeds respectively) than other host grains. In terms of per cent grain damage (92.25%; 90.19%) and per cent weight loss of grains (76.27%; 75.92%) cowpea and green gram were most preferable hosts respectively after 120 days after insect inoculation.

Key words: *C. maculatus*, Grain damage, Host preference.

INTRODUCTION

Pulses are rich sources of protein (20-40%), carbohydrates (50-60%) and are good sources of thiamin, niacin, calcium and iron. They are the second most important constituents of Indian diet after cereals. The pulses also play a vital role in the improvement of agricultural economy globally by occupying 68.32 million hectare area under cultivation and contribute 57.51 million tonnes to the world's food production (Chaturvedi and Ali, 2002). India is world's largest pulse producer, accounting for 34% of area and 24% of production. The major pulses producing states are Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan and Andhra Pradesh.

The present per capita availability of 44 g pulses per day per head falls much short than the 105 g required in a balanced diet as prescribed by Food and Agriculture Organization (FAO) and World Health Organization (WHO). Therefore, for fulfilling the requirement of pulses either the production has to be increased, which currently seems to be at a slower pace, or we can reduce the losses done by several insect pests and diseases to pulses both in field and storage while remembering a famous adage *i.e*, "a grain saved is a grain produced". Among the storage pests of pulses, pulse beetle is one of the major insect pests under storage conditions. Mainly three species of pulse beetle *viz*., *Callasobruchus maculatus* F., *C. analis* F. and *C. chinensis* L. (Chrysomelidae: Coleoptera) have been reported to cause damage to different kinds of pulses in India (Ramzan *et al*., 1986). Among different species of bruchids, *C. maculatus* is considered to be the most serious in India and causing severe damage to the seed to the extent of 93.33% in different pulse grains under storage (Parsai *et al*., 1989). It has wide host range which includes many pulses. The damage due to this pest affects the germinative ability and nutritive value of the seed. Hence, there is an urgent need to evaluate the behaviour and preferential infestation that leads to economic damage by the pest for its successful management.

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MATERIALS AND METHODS

To study the host preference and damage potential of *C. maculatus*, whole grain of different pulses *viz.,* chickpea, greengram, blackgram, redgram, cowpea and soybean were used. Two pairs of freshly emerged adult beetles of similar age were introduced in one plastic jar (15 × 10 cm) containing 50 g of host-grain and covered with muslin cloth. The beetles were removed after 10 days and the jars containing the host-grains along with eggs were left for further development. The observations were recorded on population build up that include, number of eggs laid, per cent survival, mean developmental period and index of susceptibility.

Whereas, the observations under the assessment of damage include, per cent weight loss of grain and per cent grain damage that were recorded at monthly intervals. The experiment was repeated thrice.

Assessment of population development

Fecundity

To determine the number of eggs, 50 seeds from each host grain from each repetition was drawn and used to count the average number of eggs laid per seed by using magnifying lens (10X). The eggs laid on different host-grains were counted and recorded after ten days of release of the adults.

Per cent survival

The fifty seeds drawn from each host-grain to record the number of eggs laid and the average number of eggs per seed were maintained separately, replication wise. After 20-25 days of egg laying, adult emergence from each sample kept in separate jars were checked. The adults that emerged were counted and removed till the emergence of adults was ceased. The per cent survival of the test insect was calculated as for the below given formula (Howe, 1971).

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

Mean developmental period

To determine the mean developmental period, a sample of 50 seeds from each type of host grain containing 50 g of seeds were taken from each replication. Two pairs of adults were released in 50 g of seeds and the adults were removed after 10 days after egg laying. Based on number of eggs laid, the seeds were categorized having varying no of eggs and developmental period was calculated separately. After 20-25 days of egg laying, the adult emergence was counted on daily basis. The mean developmental period of *C. maculatus* on each host grain was determined by using the formula given by Howe (1971).

$$\text{Mean developmental period} = \frac{d1a1 + d2a2 + d3a3 + \text{------} + dnan}{\text{Total no. of adults emerged}}$$

Where,
d1 = Day at which the adults started emerging (1st day).
a1 = Number of adults emerged on d1th day.

Index of susceptibility

The index of susceptibility of host grain will be calculated based on the following formula suggested by Dobie (1974).

$$\text{Index of susceptibility (I)} = \text{Loge}^{Y} \times 100 / T$$

Where,
Y = Total number of emerged adults.
T = Average developmental period of the progeny.

Assessment of damage

Per cent grain damage

From each lot of host-grain, a representative sample of 25 g were taken, the damaged and the total number of grains was counted and subjected to the formula given by Quitco and Quindoza (1986).

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

Per cent weight loss of the grains

Weight loss assessment was conducted from 25 g sample in each jar. The grains were separated into damaged and undamaged portions. The grains in each portion were counted and weighed using the electrical balance. The per cent weight loss of grain was calculated as per the formula given by Adams and Schulten (1978) as follows,

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

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

Statistical analysis

Statistical analysis after appropriate transformation of data was undertaken as per Gomez and Gomez (1984). Data from laboratory studies were analyzed by completely randomized design (CRD).

RESULTS AND DISCUSSION

Assessment of population development

Ovipositional preference

From the Table 1 it is evident that oviposition preference of *C. maculatus* on different host grains was varied significantly. Mean number of eggs laid on different host grains ranged from 116.33 to 66.33 eggs/50 seeds of host grains. Significantly higher egg counts per 50 seeds were recorded on cowpea (116.33). Significantly lowest numbers of eggs per 50 seeds were recorded in red gram (66.33) which was on par with soybean (69.00). Though, chickpea grains were recorded 93.67 eggs per 50 seeds which was on par with black gram (87.67).

These above results reveal that the obvious effects of different host grains on the ovipositional preference of *C. maculaus*. Studies by investigators demonstrated that the growth and development of *C. maculaus* is greatly affected by nutritional value of the host grains (Creadland, 1987; Van Hius and Derooy, 1998), temperature and humidity (Chandrakantha and Mathavans, 1986), host grain size (El-Hafway *et al*., 1972, Sandhu *et al*., 1987) and competition (Meyer *et al*., 1986).

The present findings are in conformity with Girish *et al.* (1974) who concluded that ovi-positional preference of the bruchid might be guided by smoothness of seed coat and size of the grain. Similarly, Bansod *et al.* (2006) reported that seed surface had a definite relation with the rate of oviposition by females of *C. maculatus*. The females of *C. maculatus* avoided rough seed coat for oviposition. However, there were no significant differences recorded among seed coat thickness, seed coat colour, seed length, seed density for oviposition by *C. maculatus.* Thus, the present findings are of suggestive that nutritional content of the host grain plays a significant role in host grain preference.

Per cent survival

The per cent survival was highest on cowpea (91.12%) followed by green gram (90.03%) and chickpea (87.38%) which were on par with each other. This was followed by chickpea (87.38%), black gram (77.70%) and red gram (72.83%). The least per cent survival was recorded in soybean (59.74%) which was significantly different among the host grains (Table 1).

These results were in conformity with the findings of Bhaduria and Jakhmola (2006) who reported that the number of adults emerged were directly proportional to average number of eggs. The average number of eggs laid on green gram, red gram and black gram after fifteen days of release was 109.3, 52.6 and 50.6 per fifty grains, respectively and the number of adults emerged subsequently were 73.6, 31.3 and 19.6, respectively.

Mean developmental period

One egg/seed

The least mean developmental period of 27.00 days was recorded in cowpea having one egg per grain followed by green gram (28.17), chickpea (29.96) which were on par with each other. Maximum mean developmental period of 35.84 days was recorded on soybean followed by red gram (33.72) and black gram (32.33) which was on par with each other and significantly different from the other earlier mentioned grains (Table 2).

Two eggs/seed

The least mean developmental period of 28.34 days was recorded in cowpea having two eggs per grain followed by green gram (30.07), chickpea (32.15) which were on par with each other. Maximum mean developmental period of 37.07 days was recorded on soybean followed by red gram (36.08) and black gram (33.66) which Was on par with each other and significantly different from the other earlier mentioned grains (Table 2).

Three eggs/seed

The least mean developmental period of 29.45 days was recorded in cowpea having three eggs per grain followed by green gram (31.63), chickpea (34.03) which were on par with each other. Maximum mean developmental period of 39.39 days was recorded on soybean followed by red gram (37.14) and black gram (34.60) which was on par with each other and significantly different from the other earlier mentioned grains (Table 2).

The results obtained under this experiment can be supported by the findings of Ghosal and Senapati (2007) and Sharma *et al*. (2016), who opined that the developmental period of *C. maculatus* was shortest in cowpea (26 days)

Table 1: Ovipositional preference of *C. maculatus* on different host grains.

Treatment no.	Host grains	*Mean number of grains/50 g	*Mean number of eggs/50 seeds	*Average number of eggs/seed	*Per cent survival
1	Chickpea	134.33 (11.61)**	93.67 (9.70)	1.87 (1.54)	87.38 (69.19)***
2	Green gram	511.33 (22.62)	113.33 (10.67)	2.27 (1.66)	90.03 (71.59)
3	Black gram	502.00 (22.42)	87.67(9.39)	1.75 (1.50)	77.70 (61.82)
4	Red gram	202.67 (14.25)	66.33 (8.18)	1.33 (1.35)	72.83 (58.58)
5	Cowpea	130.33 (11.44)	116.33 (10.81)	2.33 (1.68)	91.12 (72.66)
6	Soybean	245.67 (15.69)	69.00 (8.34)	1.38 (1.37)	59.74 (50.61)
SEm (±)		0.09	0.03	0.01	2.84
CD (P=0.05)		0.29	0.09	0.03	8.87

*Average of three replications.

**Values in parentheses are squre root (√ x+0.5) transformed values.

*** Values in parentheses are angular transformed values.

Table 2: Population development of *C. maculatus* on different host grains.

Treatment no.	Host grains	*Mean developmental period (Days)					*Index of susceptibility
		One egg/seed	Two egg/seed	Three egg/seed	SEm (±)	CD	
1	Chickpea	29.96 (5.52)**	32.15 (5.71)	34.03 (5.88)	0.07	0.26	7.32 (2.80)
2	Green gram	28.17 (5.35)	30.07 (5.53)	31.63 (5.67)	0.05	0.20	8.15 (2.94)
3	Black gram	32.33 (5.73)	33.66 (5.84)	34.60 (5.92)	0.02	0.10	6.76 (2.69)
4	Red gram	33.72 (5.85)	36.08 (6.05)	37.14 (6.14)	0.03	0.13	5.94 (2.54)
5	Cowpea	27.00 (5.24)	28.34 (5.31)	29.45 (5.49)	0.03	0.13	8.68 (3.03)
6	Soybean	35.84 (6.03)	37.07 (6.13)	39.39 (6.32)	0.03	0.11	5.47 (2.44)
SEm (±)		0.043	0.048	0.046	-	-	0.018
CD(P=0.05)		0.135	0.150	0.143	-	-	0.055

*Average of three replications.

** Values in parentheses are square root (√ x+0.5) transformed values.

and the longest in pea (31 days). The developmental period in pea was very high may be because of physico-chemical properties of the host-grains. The mean developmental period of *C. maculatus* in different pulses was ranged from 29.33 to 36.00 days. Cowpea, green gram, bengal gram and horse gram recorded significantly the lowest developmental period of 29.33, 29.67, 31.33 and 31.67days, respectively and they were on par with each other. Whereas, red gram (36 days) recorded maximum of developmental period followed by black gram (32.67) and field bean (32.33 days) (Shivanna *et al*., 2011). Similarly Sachdeva *et al.* (1986) found variation in the development period of *C. maculatus* on different varieties of cowpea. It was maximum (35.50 days) in CG-7 and minimum (29.00 days) in V-87 variety of cowpea. Legume seeds which had the highest mean egg counts and high per cent of adult emergence correspondingly had the shortest development period.

Index of susceptibility

The index of susceptibility of the host-grain was higher in cowpea (8.68) which was on par with green gram (8.15) followed by chickpea (7.32) and black gram (6.76) which were on par with each other and followed by red gram (5.94). The least index of susceptibility was recorded in soybean (5.47). The index of susceptibility had positive correlation with the mean number of adults emerged and resulted in heavier infestation (Adam and Baidoo, 2008) (Table 2).

Assessment of damage

Per cent grain damage

The damage of *C. maculatus* in different host-grains in terms of per cent grain damage has increased significantly with increase in storage period. The grain damage caused by *C. maculatus* in terms of per cent grain damage not only significantly different among the host-grain selected but also significantly increased from 30 days after insect release (DAIR) to 120 days after insect release.

In the present investigation it was found that per cent grain damage after 30 DAIR was highest in cowpea (17.70) followed in decreasing order by green gram (16.02) and chickpea (14.04) black gram (12.39), red gram (10.41) and least in soybean (9.12). The per cent grain damage was further increased after 60 DAIR in the same order of preference as of cowpea (38.46%), green gram (35.95%), chickpea (35.62%), black gram (30.19%), red gram (21.55%) and soybean (14.27%). After 90 DAIR per cent grain damage was further increased due to increased exposure and pest population number that recorded 72.72 % in cowpea followed by green gram (70.75%), chickpea (66.99%), black gram (54.60%), red gram (29.33%) and soybean (18.26%). The per cent of grains damaged was even increased after 120 DAIR in cowpea (92.25%), green gram (90.19%), chickpea (86.70%), black gram (81.71%), red gram (65.92%) and soybean (27.47%), but with preferential insect infestation (Table 3).

The above findings are in support of earlier studies conducted by Rawat and Srivastava (2011) indicating that the per cent seed damage by *C. chinensis* was maximum in cowpea (96.15%) followed by green gram (88.44%) and minimum seed damage was observed in mothbean (74.22%). Simailarly, Caswell (1981) stated that the bruchid, *C. maculatus* (F.) can cause 100% damage during storage in five months while up to 50% damage was recorded during storage in 3 to 4 months. Mphuru (1981) stated that the inability of *C. maculatus* to develop on soybean can be attributed mainly to the high protein-carbohydrate ratio of the seed and in part to its saponin content (Applebaum *et al.* 1969). Also, this bruchid is known for not being capable of attacking seeds with a high fat content like soybean.

Per cent weight loss of grains

The per cent weight loss of different host-grains was increased significantly with increase in storage period. The per cent weight loss caused by *C. maculatus* has not only significantly different among the host-grain selected but also significantly increased from 30 days after insect release (DAIR) to 120 days after insect release.

In the present investigation it was found that per cent weight loss after 30 DAIR was highest in cowpea (11.09), green gram (10.21) and chickpea (8.97) and least in soybean (3.90), red gram (5.63) and black gram (7.54). The per cent weight loss was further increased after 60 DAIR in cowpea

Table 3: Preferential grain damage by *C. maculatus* in different host grains.

Treatment no.	Host grains	*Average grain damage (%)			
		30 DAIR	60 DAIR	90 DAIR	120 DAIR
1	Chickpea	14.04 (22.06)**	31.96 (34.42)	66.99 (54.93)	86.70 (68.61)
2	Green gram	16.02 (23.63)	35.95 (36.84)	70.75 (57.26	90.19 (71.74)
3	Black gram	12.39 (20.70)	30.19 (33.33)	54.60 (47.64)	81.71 (64.68)
4	Red gram	10.41 (18.74)	21.55 (27.66)	29.33 (32.79)	65.92 (54.29)
5	Cowpea	17.70 (24.91)	38.46 (38.33)	72.72 (58.52)	92.25 (73.84)
6	Soybean	9.12 (17.55)	14.27 (22.20)	18.26 (25.30)	27.47 (31.61)
SEm (±)		0.11	0.51	0.65	0.69
CD (P=0.05)		0.36	1.61	2.03	2.15

DAIR- Days after insect release.

*Average of three replications.

**Values in parentheses are angular transformed values.

Table 4: Per cent weight loss of grains caused by *C. maculatus* in different host grains.

Treatment no.	Host grains	*Per cent weight loss			
		30 DAIR	60 DAIR	90 DAIR	120 DAIR
1	Chickpea	8.97 (17.43)**	14.04 (22.01)	40.55 (39.55)	69.48 (56.46)
2	Greengram	10.21 (18.64)	16.79 (24.19)	47.40 (43.51)	75.92 (60.61)
3	Blackgram	7.54 (15.93)	13.82 (21.82)	27.52 (31.64)	48.59 (44.19)
4	Redgram	5.63 (13.73)	13.13 (21.25)	24.19 (29.46)	42.04 (40.42)
5	Cowpea	11.09 (19.45)	18.02 (25.12)	50.50 (45.29)	76.27 (60.85)
6	Soybean	3.90 (11.39)	10.36 (18.78)	16.56 (24.01)	20.02 (26.58)
SEm (±)		0.22	0.42	0.38	0.68
CD (P=0.05)		0.69	1.31	1.20	2.13

DAIR- Days after insect release.

*Average of three replications.

**Values in parentheses are angular transformed values.

(18.02), green gram (16.79), chickpea (14.04), black gram (13.82), red gram (13.13) and soybean (10.36). After 90 DAIR per cent weight loss in cowpea was recorded to be 50.50% followed by green gram (47.40%), chickpea (40.55%), black gram (27.52%), red gram (24.19%) and soybean (16.56%). The per cent weight loss has increased with increase in storage period and after 120 DAIR the weight loss in cowpea was observed to be 76.27% followed by green gram (75.92%), chickpea (69.48%), black gram (48.59%), red gram (42.04%) and soybean (20.02%) (Table 4).

The above results are in support of earlier studies conducted by Doharey *et al*. (1987) indicating that gradual increase in weight loss in green gram due to *C. maculatus* with progressive increase in storage period causing 1.15, 36.36, 48.84 and 51.91 per cent weight loss after 30, 60, 90 and 120 days after storage period, respectively. Similarly, Malaikozhundan and Raj (2012) reported that the cowpea CoCp-7 recorded significantly the highest oviposition percentage, adult emergence, the shortest developmental period, the highest susceptibility indices and the highest weight loss.

CONCLUSION

From this study, it can be concluded that seeds of cowpea, green gram and chickpea are the most preferred hosts for *C. maculatus*. These hosts had the highest number of eggs oviposited and per cent adult emergence, the shortest developmental period, highest susceptibility index and maximum weight loss. This preferential host grain selection by the bruchids could be attributed to the nutritional balance and the physical properties of grain. Cowpea and green gram were the most preferred hosts for *C. maculatus* in terms of mass culturing and long-term maintenance of bruchid generations for any behavioral, physiological, pest management and resistant studies under laboratory conditions. Farmers should be advised not to store cowpea, green gram and chickpea seeds in the same place and at the same time to prevent cross infestation due to their high susceptibility to *C. maculatus*.

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