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COMPARATIVE STUDIES ON THE SUSCEPTIBILITY OF DIFFERENT GRAINS TO PULSE BEETLE, *Callosobruchus maculatus*

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Abstract: The comparative studies on the susceptibility of different legume seeds infested by *Callosobruchus maculatus* was studied in multiple choice and dual choice experiments. Greengram was found to be most preferred host for *C. maculatus* for ovipositional preference (30.00 eggs/5g), per cent survival (84.49%), and number of grains damaged (9.37%) and weight loss of grains (3.07%) in multiple choice test. In dual choice experiment, the most preferred host-grain was mixed with other host-grains to minimise the level of infestation. At 120 days after release (DAR), the per cent number of grains damaged was found to be highest in greengram +cowpea (85.63 + 81.10) followed by greengram + soybean (84.01 + 78.92), greengram + bengalgram (82.30 + 80.57) and greengram + pillipesara (87.24 + 75.12), whereas the per cent weight loss of grains was highest in greengram + cowpea (56.99 + 55.92) followed by greengram + pillipesara (61.37 + 43.78), greengram + soybean (64.93 + 25.03) and greengram + bengalgram (48.40 + 39.43). The experimental results revealed that greengram + cowpea admixture was highly susceptible to *C. maculates* both in terms of per cent number of grains damaged as well as per cent weight loss of grains.
Keywords: *C. maculatus*, admixture, greengram, blackgram, bengalgram, redgram, soybean, pillipesara, cowpea and pea.

Introduction

Pulses are excellent source of easily digestible proteins with low flatulence which complements the staple rice diet in India. Pulses are drought resistant, suitable for dry land farming and predominantly used as an intercrop with other crops. Legumes cultivated since more than 6000 years in the world produces nutrient rich dry pulses which contains proteins (20-40%), carbohydrates (50-60%), small amount of fats, phosphorus, calcium, iron and a number of essential vitamins and necessary fats (Shanmugas, 1988). One of the major constraints in production of pulses is the insect pests which inflict severe losses both in the field and storage. Insects are the most numerous and successful animals on earth and well known for their beneficial and harmful effects in agriculture. They cause heavy losses to stored grains throughout the world and their impacts are more devastating in developing countries (Ekeh *et al.,* 2013). Both the crop in field and the grains in stores are infested by a

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large number of insect pests. The storage pests cause colossal damage to the commodity which reduces not only the quantity but also the quality of stored grains.

The genus *Callosobruchus* attacks grain legumes during both pre and post-harvest stages all over the world; but in India, *C. maculatus, C. analis* and *C. chinensis* are predominant pest species of the genera (Dias, 1988 and Jat *et al*., 2013). *C. maculatus* (F.), a cosmopolitan bruchid is a continuous pest from the field to the store (Jiao *et al*., 2011). It starts infestation in the field but heavy damage is done in storage (Swell and Mushobozy, 2007). The infested seeds may be almost completely hollowed by the feeding activities of the larvae, and characteristic emergence holes or 'windows' are evident after the adults leave the seeds (Giga and Smith 1983). The proportion of loss caused by this pest is 25-30% in the field and 80% in store within 6-8 months in temperate zone (Hill, 1990). Cowpea seed beetle, *C. maculatus* (Fab.) is a major insect pest of stored legumes, in Africa and Asia (Mohamed *et al*., 2009).

Mungbean, *Vigna radiata* Wilczed, is extensively grown in Southeast Asia, where it is stockpiled by producers or consumers from season to season. Subsistence agriculture requires that the farmer store a percentage of staple food to feed his family and livestock between harvests. The largest quantity of food in the tropics is stored in traditional farmer's granaries and in most cases under one roof. This type of storage may lead to cross infestation among the stored products which are sharing a common pest. Although most of these are serious pests in the tropics, little is known about their biology, ecology, the damage they cause, their distribution, their host plants and their natural parasites and predators.

Knowledge of host, pest and the environment interaction is an important prerequisite when devising a cost-effective pest management package. For a polyphagous pest like *C. maculatus*, it is important to know its host range so that storage planning can be made to avoid cross-infestation among susceptible legume seeds species when stored in one place. This will prevent heavy build-up of C. maculatus populations. The present study was undertaken to determine the comparative susceptibility of different pulse host-grains in terms of weight loss and number of grains damaged to *C. maculatus.*

Material and Methods

The experiment was carried out to determine the comparative susceptibility of eight different host-grains to infestation by *C. maculatus* in both multiple and dual choice experiments at Department of Entomology, Agricultural College, Bapatla, Guntur district and Andhra Pradesh during 2013-2014. The initial adult cultures of the test insect, *C. maculates* was collected from the Post-harvest technology centre, Agricultural College, Bapatla and were maintained further in the laboratory on the greengram. Rearing procedures were in detail described by Swella and Mushobozy (2007). Insects were reared for two generations before they were used in the experiments. The legume species studied were: greengram (*Vigna radiata* L.), blackgram (*V. mungo* L.), bengalgram (*Cicer arietinum* L.), redgram (*Cajanus cajan* L.), cowpea (*Vigna sinensis* L.), soybean (*Glycine max* L.), pea (*Pisum sativum* L.) and pillipesara (*Phaseolus trilobus* L.). The host-grains were disinfested by fumigating with aluminium phosphide (Celphos) @ three tablets (9 g) per tonne for seven days. The mass culture was maintained at an optimum temperature of 32 ± 1^0C and 75 per cent relative humidity throughout the period of investigation for conducting experiments in the laboratory. These seeds were then conditioned to a room temperature before being used for experimental purposes. 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 aim was to precondition the bruchids so as to eliminate any short term changes in behaviour associated with the change of host species from that used for culturing to that being tested (Dobie, 1974). 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.

In multiple host-grain choice test, all the eight types of host- grains (20 g each) were placed in a circle in a box type metallic trough using petriplates (15 cm). The trough was covered after releasing a pair of freshly emerged adults in the center of the circle of the petriplates for giving a free option for the test insect to choose the host- grains of its choice (Fig 1). The bruchids were removed after 3 days and the number of eggs laid on different pulses was counted and a total count in a mixture was recorded before the means were calculated. Among different pulse host grains, the most preferred host-grains was chosen based on ovipositional preference, per cent adult survival, per cent number of grains damaged and per cent weight loss of grains in different pulses was recorded.

For a choice experiment, 50 grams of the most preferred host-grain *i.e.* greengram from the above mentioned experiment was mixed with each of the remaining all possible host-grains (50 g). One pair (male: female) of freshly emerged adult beetles of similar age was introduced into the plastic jars containing admixtures. The jars were then covered with perforated covers and tied with rubber band around the jar bottles to prevent the bruchids from escaping. Observations were recorded on per cent number of grains damaged and per cent weight loss of grains.

Per cent number of grains damaged: From each host-grain, a representative sample of five grams was taken; the damaged and the total number of grains were counted and subjected to the formula,

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

Per cent weight loss of grains was calculated by using formula (Adams and Schulten, 1978), as detailed below.

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

Where,

U = Weight of undamaged grains,

Nu = Number of undamaged grains

D = Weight of damaged grains

Nd = Number of damaged grains.

Results and Discussion

The preferential development and damage of *C. maculatus* in all the test host- grains when provided at once in multiple choice test. The mean number of eggs per 20 g sample, number of adults emerged, per cent survival of *C. maculatus* were furnished in Table 1. The mean number of eggs per 20 g sample was maximum in greengram (30.00) followed by cowpea (18.50), pillipesara (11.00), blackgram (9.75), soybean (8.75), bengalgram (7.00), redgram (6.50) and pea (5.75) (Fig 1). The ovipositional preference in the multiple host-grain choice tests was significantly different among the host- grains but for soybean and bengalgram who were at par with each other followed by redgram and pea. The number of adults emerged was highest in greeengram (25.75) followed by cowpea (14.75) and pillipesara. The number of adults emerged in blackgram (4.25), redgram (3.75) and bengalgram (3.5) which were at par with each other. There was no adult emergence in soybean and pea. Then with reference to per cent survival of the insects from egg stage to adult stage, it was highest in greengram (84.49), followed by cowpea (80.12) and pillipesara (79.42) which were at par with each other followed by redgram (63.25), bengalgram (50.72), blackgram (45.74), soybean (0.00) and pea (0.00). Under multiple host- grain choice test, the highest per cent number of grains damaged was recorded again in greengram (9.37) followed by cowpea (7.40), bengalgram (4.37), redgram (1.92), blackgram (0.71), pillipesara (0.47), soybean (0.00) and pea (0.00) (Table 2, Fig 3). The trend was almost similar with reference to damage in terms of per cent weight loss of grain which was also maximum in greengram (3.07) followed by cowpea (1.56), redgram (0.97), bengalgram (0.91), blackgram (0.67), pillipesara (0.14), soybean (0.00) and pea (0.00) (Table 2, Fig 4). Thus, zero per cent survival of the test insect was found on soybean and pea, even with 8.75 and 5.75 eggs per 20 g grain, respectively did not result any damage in terms of number of grains damaged, per cent weight loss in the grains.

Thus, in the multiple host- grain choice test, significantly greengram was the most preferred host grain with highest number of eggs laid and survival of insects, followed by cowpea and pillipesara. The present findings are true with reports of Shivanna *et al*. (2011) where the host preference of *C. maculatus* and *C. analis* on the selected pulses and the results were the lowest adult survival of 77.67, 79.33 and 82.67 per cent was recorded in redgram, fieldbean and blackgram, respectively and were at par with each other. Significantly, the highest survival was recorded in cowpea (91.00), followed by greengram (90.33), horsegram (86.67) and blackgram (82.67) in case of *C. maculatus*. For *C. analis*, the adult survival was minimum in field bean (72) and maximum in greengram (90.33). The present per cent survival values were in confirmity with the findings of Mannan *et al*. (1994), who reported that there was no adult emergence from frenchbean and soybean. Similarly Bhaduria and Jakhmola (2006) reported that the ovipositional preference and survival of *C. maculatus* was less on blackgram, frenchbean and redgram. The per cent weight loss of grains was maximum in greengram (55.4) followed by bengalgram (11.1) and pea (8.8).

Assessment of Damage in Admixtures of 50 of greengram with 50 g of other host- grains

Per cent number of grains damaged: Preferential damage of *C. maculatus* in terms of per cent number of grains damaged in preferred host- grain greengram with other host- grains was furnished in Table 2. The results at 30 DAR showed that the per cent number of grains damaged was highest in greengram + soybean (11.78 + 0.00) followed by greengram + redgram (9.72 + 2.04), greengram + bengalgram (8.54 + 1.49), greengram + cowpea (6.29 + 2.36), greengram + pea (8.64), greengram + pillipesara (7.81 + 0.00) and greengram + blackgram (5.80 + 0.00). At 60 DAR it was maximum in greengram + bengalgram (30.22 + 42.17) followed by greengram + redgram (30.22 + 42.17), greengram + cowpea (31.97 +23.45), greengram + pea (24.28 + 25.72), greengram + pillipesara (35.03 + 5.19), greengram + soybean (29.06+ 10.09) and greengram + blackgram (28.90 + 8.23).At 90 DAR the per cent number of grains damaged was highest in the combination of greengram + pillipesara (70.48 + 65.71) followed by greengram + cowpea (75.28 + 55.37), greengram + bengalgram (69.03 + 55.85), greengram + soybean (66.80 + 50.60), greengram + pea (73.57 + 42.50), greengram + redgram (72.61 + 41.21) and greengram + blackgram (73.08 + 34.83). Finally at 120 DAR, the per cent number of grains damaged was highest in greengram +cowpea (85.63 + 81.10) followed by greengram + soybean (84.01 + 78.92), greengram + bengalgram (82.30 + 80.57), greengram + pillipesara (87.24 + 75.12), greengram + pea (87.22 + 67.57), greengram + redgram (77.46 + 67.54) and greengram + blackgram (88.60 + 43.23).

Thus, the admixtures of greengram + blackgram in the ratio of 45: 55 recorded significantly less per cent number of grain damaged at 30, 90 and 120 DAR. This could be directly attributed to the least ovipositional preference for *C. maculatus* was observed on greengram + blackgram.

Per cent weight loss of grains: Preferential damage of *C. maculatus* in terms of per cent weight loss of grains in preferred host- grain greengram with other host- grains was furnished in Table 3.Results at 30 DAR showed that the per cent weight loss of grains was highest in greengram + soybean (3.14 + 0.00) followed by greengram + bengalgram (2.72 + 0.15), greengram + redgram (2.59 + 0.16), greengram + pea (2.22 + 0.00), greengram + pillipesara (2.11 + 0.00), greengram + cowpea (1.66 + 0.38) and greengram + blackgram (1.29 + 0.00). At 60 DAR the per cent weight loss of grains was highest in greengram + pillipesara (25.03+ 3.45) followed by greengram + soybean (21.78 + 2.74), greengram + cowpea (11.25 + 8.99), greengram + pea (14.79 + 4.77), greengram + bengalgram (10.38 + 4.87), greengram + blackgram (11.05 + 0.76) and greengram + redgram (7.87 + 2.94).At 90 DAR the per cent weight loss of grains damaged was highest in the combination of greengram + pillipesara (45.10 + 25.06) followed by greengram + cowpea (35.14 + 18.28), greengram + redgram (39.75 + 9.86), greengram + blackgram (39.75 + 9.86), greengram + soybean (35.37 + 12.46), greengram + pea (35.10 + 10.93) and greengram + bengalgram (17.86 + 17.02).At 120 DAR the per cent weight loss of grains was highest in greengram + cowpea (56.99 + 55.92) followed by greengram + pillipesara (61.37 + 43.78), greengram + soybean (64.93 + 25.03), greengram + bengalgram (48.40 + 39.43), greengram + blackgram (55.25 + 30.80), greengram + redgram (58.44 + 27.53) and greengram + pea (47.06 + 24.91).

But with reference to per cent weight loss of grains, greengram + blackgram was successful in the ratio of 50: 50 by recording least per cent weight loss at 30 DAR, almost similarly at 60

DAR. But at 90, 120 DAR, greengram + bengalgram and greengram + pea recorded least per cent weight loss. Thus, indicating that the per cent weight loss of grain did not match with that of per cent number of grains damaged. However, the ovipositional preference by *C. maculatus* gone hand in hand with per cent number of grains damaged in combination of greengram + blackgram at all intervals of observations.

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Table 1: Preferential damage of *Callosobruchus maculatus* in different host-grains in one month after the release of insects in multiple host-grain choice test

Treatment No.	Host-grains	Mean number of eggs/ 20g *	Per cent survival of the insects **	Per cent No. of grains damaged**	Per cent weight loss of grains **
1	Greengram	30.00 (5.48)[a]	84.49 (66.83)[a]	9.37 (17.82)[a]	3.07 (10.08)[a]
2	Blackgram	9.75 (3.11)[c]	45.74 (42.55)[e]	0.71 (4.78)[e]	0.67 (4.67)[d]
3	Bengalgram	7.00 (2.62)[cd]	50.72 (45.41)[d]	4.37 (12.02)[c]	0.91 (5.46)[c]
4	Redgram	6.50 (2.52)[de]	63.25 (52.72)[c]	1.92 (7.91)[d]	0.97 (5.65)[c]
5	Cowpea	18.50 (4.29)[b]	80.12 (63.55)[b]	7.40 (15.79)[b]	1.56 (7.18)[b]
6	Soybean	8.75 (2.96)[cd]	0.00 (0.00)[f]	0.00 (0.00)[f]	0.00 (0.00)[f]
7	Pea	5.75 (2.38)[e]	0.00 (0.00)[f]	0.00 (0.00)[f]	0.00 (0.00)[f]
8	Pillipesara	11.00 (3.31)[c]	79.42 (63.03)[b]	0.47 (3.93)[e]	0.14 (2.09)[e]
SEm (±)		0.15	0.75	0.35	0.31
CD (P=0.05)		0.44	2.19	1.02	0.32

DAR- Days After Release
*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

Table 2: Preferential damage of *Callosobruchus maculatus* in terms of per cent number of grains damaged in preferred host- grain greengram and other host- grains in dual- choice experiment

Treatment No.	Type of Admixture	Per cent number of grains damaged in 50 g + 50 g of admixture of host- grains							
		30 DAR		60 DAR		90 DAR		120 DAR	
		50 g of greengram	50 g of other host- grain	50 g of greengram	50 g of other host- grain	50 g of greengram	50 g of other host- grain	50 g of greengram	50 g of other host- grain
1	Greengram + Blackgram	5.80 (13.93)^{e}	0.00 (0.00)^{c}	28.90 (32.52)^{c}	8.23 (16.63)^{e}	73.08 (58.76)^{ab}	34.83 (36.17)^{e}	88.60 (70.27)^{a}	43.23 (41.11)^{d}
2	Greengram + Bengalgram	8.54 (16.97)^{bc}	1.49 (6.95)^{b}	30.22 (33.34)^{bc}	42.17 (40.49)^{a}	69.03 (56.17)^{cd}	55.85 (48.36)^{b}	82.30 (65.12)^{d}	80.57 (63.85)^{a}
3	Greengram + Redgram	9.72 (18.15)^{ab}	2.04 (8.21)^{a}	28.18 (32.06)^{c}	29.72 (33.03)^{b}	72.61 (58.45)^{ab}	41.21 (39.94)^{d}	77.46 (61.66)^{e}	67.54 (55.27)^{c}
4	Greengram + Cowpea	6.29 (14.50)^{de}	2.36 (8.83)^{a}	31.97 (34.43)^{b}	23.45 (28.84)^{c}	75.28 (60.19)^{a}	55.37 (48.09)^{b}	85.63 (67.73)^{bc}	81.10 (64.24)^{a}
5	Greengram + Soybean	11.78 (20.04)^{a}	0.00 (0.00)^{c}	29.06 (32.62)^{c}	10.09 (18.51)^{d}	66.80 (54.82)^{d}	50.60 (45.34)^{c}	84.01 (66.43)^{cd}	78.92 (62.67)^{a}
6	Greengram + Pea	8.64 (17.05)^{bc}	0.00 (0.00)^{c}	24.28 (29.52)^{d}	25.72 (30.47)^{c}	73.57 (59.06)^{a}	42.50 (40.69)^{d}	87.22 (69.11)^{ab}	67.57 (55.29)^{c}
7	Greengram + Pillipesara	7.81 (16.21)^{cd}	0.00 (0.00)^{c}	35.03 (36.28)^{a}	5.19 (13.15)^{f}	70.48 (57.10)^{bc}	65.71 (54.16)^{a}	87.24 (69.08)^{ab}	75.12 (60.10)^{b}
SEm (±)		0.63	0.08	0.46	0.62	0.61	0.68	0.55	0.57
CD (P=0.05)		1.92	0.24	1.40	1.88	1.83	2.07	1.66	1.72

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

Table 3: Preferential damage of *Callosobruchus maculatus* in terms of per cent weight loss of grains in preferred host-grain greengram and other host- grains in dual- choice experiment

Treatment No.	Type of Admixture	Per cent weight loss of grains in 50 g + 50 g of Admixture of host- grains							
		30 DAR		60 DAR		90 DAR		120 DAR	
		50 g of greengram	50 g of other host- grain	50 g of greengram	50 g of other host- grain	50 g of greengram	50 g of other host- grain	50 g of greengram	50 g of other host- grain
1	Greengram + Blackgram	1.29 (6.53)^{e}	0.00 (0.00)^{c}	11.05 (19.41)^{d}	0.76 (4.98)^{d}	32.62 (34.83)^{d}	16.71 (24.12)^{b}	55.25 (48.02)^{c}	30.80 (33.71)^{d}
2	Greengram + Bengalgram	2.72 (9.49)^{ab}	0.15 (2.25)^{b}	10.38 (18.78)^{d}	4.87 (12.72)^{b}	17.86 (24.99)^{e}	17.02 (24.36)^{b}	48.40 (44.08)^{c}	39.43 (38.89)^{c}
3	Greengram + Redgram	2.59 (9.26)^{abc}	0.16 (2.32)^{b}	7.87 (16.29)^{e}	2.94 (9.88)^{c}	39.75 (39.08)^{b}	9.86 (18.29)^{c}	58.44 (48.04)^{c}	27.53 (31.66)^{e}
4	Greengram + Cowpea	1.66 (7.40)^{de}	0.38 (3.55)^{a}	11.25 (19.59)^{d}	8.99 (17.44)^{a}	35.14 (36.35)^{c}	18.28 (25.26)^{b}	56.99 (49.02)^{c}	55.92 (48.40)^{a}
5	Greengram + Soybean	3.14 (10.16)^{a}	0.00 (0.00)^{c}	21.78 (27.82)^{b}	2.74 (9.52)^{c}	35.37 (36.49)^{c}	12.46 (20.65)^{c}	64.93 (53.69)^{a}	25.03 (30.02)^{e}
6	Greengram + Pea	2.22 (8.52)^{bc}	0.00 (0.00)^{c}	14.79 (22.61)^{c}	4.77 (12.58)^{b}	35.10 (36.33)^{c}	10.93 (19.30)^{c}	47.06 (43.32)^{d}	24.91 (29.92)^{e}
7	Greengram + Pillipesara	2.11 (8.34)^{cd}	0.00 (0.00)^{c}	25.03 (30.02)^{a}	3.45 (10.68)^{c}	45.10 (42.19)^{a}	25.06 (30.02)^{a}	61.37 (51.58)^{b}	43.78 (41.42)^{b}
SEm (±)		0.36	0.03	0.35	0.45	0.40	0.80	0.68	0.65
CD (P=0.05)		1.10	0.10	1.07	1.36	1.21	2.43	2.05	1.98

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