SUSCEPTIBILITY OF SOME EGYPTIAN PULSES TO INFESTATION BY *CALLOSOBRUCHUS CHINENSIS* (L.) AND *CALLOSOBRUCHUS MACULATUS* (F.)

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(Manuscript received 29 November 2004)

Abstract

The present study determines the infestation potential of *Callosobruchus chinensis* and *C. maculatus* on seeds of seven pulse crops. The tested crops were cowpea, mung bean, lentil, chickpea, kidney bean, peas and broad bean. The parameters of evaluation included susceptibility index values, weight loss and some biological activities. The results showed that seeds of the kidney bean were completely resistant to infestation by both bruchids while seeds of the cowpea and mung bean were completely susceptible. The other four pulses were found to have varying degrees of susceptibility. However, it was also found that, all studied crops were more susceptible to *C. chinensis* than to *C. maculatus.*

INTRODUCTION

Various leguminous crops and their stored seeds are heavily attacked by several bruchids of the Family Bruchidae. This Family includes about 1300 species, grouped into 56 genera, placed with five subfamilies. Some of the bruchids species have showed high specificity to one or more species of host plant while others are capable of feeding on a range of hosts. The major pests of family Bruchidae are *Callosobruchus* spp. They originated in Africa and Asia where they cause significant losses to stored edible pulses. The larvae of *Callosobruchus* spp. are the only dangerous stage, which cause a great reduction in seed weight, germination potential and commercial value. The two bruchids found in Egypt are the pulse beetle, *C. chinensis* and the cowpea beetle, *C. maculatus.* They are the most dangerous pests of the stored edible pulses and are considered as a polyvoltine species (Shomar, 1963). They have showed great variations in their behavior, ecology and morphology (Avidov *et al.*, 1965, Yadav and Pant, 1978, Credland 1986 and Chun and Ryo 1992). The present study determine the infestation potential of *C. chinensis* and *C. maculatus* on seeds of seven pulse crops, including susceptibility index values, weight loss and some biological characters.

MATERIALS AND METHODS

1. Insect cultures: The pulse beetle, *C.chinensis* and the cowpea beetle, *C. maculatus* were maintained on a commercial variety of broad bean seeds for several generations. The two sexes of the beetles were easily distinguished and according to the key of Southgate (1958) and Shomar (1963).

2. **The tested pulse seed:** Seven legume seeds were used in the present investigation (Table 1). They were purchased from Food Legume Research Section of the Field Crop Research Institute. The seeds were previously fumigated with phostoxin tablets for three days at a rate of 3 tablets /m^3, then were washed several times with ether and left to dry at room temperature and then stored in a refrigerator until use.

Table 1. List of tested pulses

Common name		Scientific name
English	Arabic	
Cowpea	اللوبيا	*Vigna unguiculata* (L.)
Lentil	العدس الشتوى	*Lens culinaris* (Medick)
Mungbean (green gram)	العدس الصيفى	*Vigna radiata* (Wilzek)
Pea	البسلة	*Pisum sativum* (L.)
Chickpea (Bengal gram, Kabli gram)	الحمص	*Cicer arietinum* (L.)
Kidney bean (Navy bean)	الفاصوليا	*Phaseolus vulgaris* (L.)
Broad bean (Faba bean)	الفول البلدى	*Vicia faba* (L.)

3. **Infestation procedure and measured criteria:** Five grams of each seed type were placed in small tubes (5x1.5 cm). At least ten replicates were made from each pulse seed, five for each insect species. The glass tubes the seeds were incubated at 28 ±1 °C and 60 ±5 % R.H. for a week for equilibrium conditioning. Each replicate was infested with a pair of newly emerged adult insects and left for oviposition until death, then removed and discarded. The tubes were re-incubated again for another week. The fecundity and hatchability were counted followed by

daily check for the emergence of adult new progeny. The emerged adults were removed and counted daily and the developmental period determined from time of eggs laying up to first appearance of new emerged adult.

4. **Susceptibility Index (SI):** The total number of emerged adults, from each replicate, was counted and the percentage of adult emergence was calculated, in relation to the number of hatched larvae penetrated into the seeds according to Howe (1971) and Dobie (1974) as follows:

$$\text{Adult emergence (\%)} = \frac{\text{Total number of emerged adults}}{\text{Total number of penetrated larvae}} \times 100$$

The duration of developmental period of the immature stages were taken as criteria for calculating the susceptibility indices (SI) according to the method described by Howe (1971) and Dobie (1974) as follows:

$$SI = \frac{\text{Log } S}{T} \times 100$$

Where S= adult emergence (%), T= developmental period (days). The values of susceptibility indices were categorized into five ranks according to Mensah (1986) as shown in table 2

Table 2. Ranks of susceptibility index values and its symbol meaning

SI value	Susceptibility indication	Symbol
0.0- 2.5	Resistant	R
2.6- 5.0	Moderately Resistant	MR
5.1- 7.5	Moderately Susceptible	MS
7.6- 10.0	Susceptible	S
> 10.0	Highly Susceptible	HS

5. **Weight loss (%):** Seeds used for insect rearing were reweighed and the quantitative losses arising from the consumed portion by the larvae of the bruchids were estimated. This was obtained by finding the differences in the weight of the replicates recorded before and after infestation period. The feces and all dusts were carefully removed and the moisture content was adjusted. The weight loss (%) was calculated as follows:

$$\text{Weight loss (\%)} = \frac{\text{Initial dry weight} - \text{final dry weight}}{\text{Initial dry weight}} \times 100$$

On the basis of the quantitative losses, Khare and Johari (1984) provided three categories as follows: The values of weight loss (%) between 8.4 to 16.3 %, the pulse is considered least susceptible (LS). The values of weight loss (%) between 16.3 to 24.3 %, the pulse is considered moderately susceptible (MS). The values of weight loss (%) above 24.3 % the pulse is considered highly susceptible (HS).

5. **Statistical analysis:** The obtained data were statistically analyzed with analysis of variance (ANOVA test) using a computer program (Costat). Means were compared by Duncan (1956) multiple range test at 0.05% probability level. Standard error was also calculated. The Correlation coefficient (r) was also calculated between the different biological characters of each insect species on all the different pulse seeds.

RESULTS AND DISCUSSION

During this study the criteria used for determining the relative susceptibility or resistance of different pulses to bruchid infestation were oviposition (fecundity), egg hatch and larval penetration (%), mean developmental period (MDP), number of emerged progeny, adult emergence (%) and weight loss (%) have been used in the present work. The obtained data of tested pulses for both insects are shown in Tables 3 and 4.

In respect to oviposition, larval penetration, beetle progeny and weight loss (%) of both insects on the different pulses (Table3), the results showed significant variations among all the tested pulse seeds. Both insects preferred lentil, Mungbean and cowpea for oviposition and larval penetration (%). Significant higher rates of oviposition per female *C. chinensis* was recorded on cowpea and chickpea followed by mungbean and lentil (Table 3), while the oviposition rate per female *C. maculatus* was recorded on mungbean followed by lentil and broad bean (Table 3). The number of eggs laid/ female of *C. chinensis* and *C. maculatus* reached 70.9(cowpea) and 82.1 and decreased to 47.3 in kidney bean and 63.6 in chickpea respectively. Larval penetration of both insects was insignificant among tested pulses (except kidney bean with *C. chinensis*). Significant differences were found among tested pulses in respect to emerged progeny and weight loss (%) and all tested pulses (except kidney bean) suffered highly significant values of weight loss and were considered least susceptible (LS) with *C. chinensis* infestation, while for *C. maculatus*, ranks of weight loss ranged from least susceptible (LS) in Mungbean (13.6) moderately susceptible (MS) in cowpea (16.5) to completely resistant (CR) in kidney bean (0.0). Both insects failed to complete their development after larval penetration on kidney bean and significantly lower eggs were laid on it. The order of ovipositional preference for *C. maculatus* was mungbean > lentil > broad bean > cowpea > kidney bean > chickpea > peas > while that of *C. chinensis* was cowpea > chickpea > mungbean > lentil > pea > kidney bean.

Regarding to duration of development, adult emergence (%) and susceptibility indices of both bruchids (Table 4), the kidney bean followed by peas are considered unsuitable for the development of the two bruchids while mungbean and cowpea could be grouped as the most suitable for the development. The obtained results also indicated that adult progeny, MDP and calculated susceptibility indices are interdependent. The percentages of the adult emergence of *C. maculatus* were higher in chickpea (90.4), cowpea (81.5), and mungbean (70.7) (Table 4). The susceptibility indices significantly different among tested pulses for both insects, which it reached its maximum in mungbean (8.90 & 8.16) and its lowest value (0.00) in kidney bean for both insects respectively.

The correlation coefficient (r) between the studied variables representing the insect performance of *C. chinensis* on the six pulses is presented in Table (5). Oviposition was highly significant and positively correlated with the larval penetration (%). The susceptibility indices (SI) and weight loss (%) are negatively correlated with MDP (days). Larval penetration (%) and other parameters are insignificant. MDP (days) was significant and negatively correlated with both susceptibility index and weight loss (%). Adult emergence (%) and susceptibility indices were also positively correlated with weight loss (%).

In respect to *C. maculatus,* the correlation coefficient values of the different traits are shown in Table 6, they showed correlation between oviposition and MDP and weight loss (%) and not correlated with larval penetration, adult emergence and susceptibility index (SI). Oviposition was positively correlated with weight loss and negatively correlated with MDP. A significant negatively correlation was found between MDP and adult emergence, susceptibility index and weight loss. Both susceptibility index and weight loss were positively correlated. In the present study, the obtained results indicated that adult emergence was greatly correlated with the developmental period of *C. maculatus* (Table 6) on most pulse seeds, while no significant correlation was found in case of *C. chinensis* (Table 5*)*. This might be due to the longer MDP in *C. maculatus* compared to *C. chinensis* on all pulse seeds.

In general, each pulse had its own effect on egg laying or female fecundity. However, specific studies on natural resistance concerning the lower weight and fecundity of progeny resulted from the resistant varieties of cowpea seeds were performed by many workers (Ofuya, 1987, Gatehouse *et al,* 1979 and Gatehouse and Boulter, 1983) who suggested that high levels of trypsin inhibitor was responsible for the observed resistance to *C. maculatus*. Baker *et al.* (1989) did not find a significant relationship between tannins and *C. maculatus* larval mortality or developmental time. In contrast, Redden and McGuire (1983) have reported that the developmental period could be the most discriminating. Further investigations are needed, to explain the relationship between plants and bruchids on a biochemical basis. Baker *et al.*, 1989, Xavier-Filho *et al.*, 1989, Fernandes *et al.,* 1993 did not obtain a significant correlation between the level of cysteine proteinase inhibitors in seeds of cowpea and their susceptibility or resistance to predation by *C. maculatus*. Xavier-Filho. (1991) and Maccedo *et al.,* 1993 found that resistance to *C. maculatus* larval development is due to a variant form and vicilin storage protein, which is resistant to digestion by the larval midgut proteinases and thereby limits the food supply to the larva. The summary and conclusion of the present work showed that female fecundity did not change according to the physico-chemical nature of pulse seeds. Each pulse has its own effect on egg laying. The data of the ovipositional preference for *C. maculatus* showed that mung bean was the most preferred pulse while the chickpea was the least preferred pulse and other pulses showed insignificant variation. In respect to data of *C. chinensis,* were insignificantly different among cowpea, chickpea, mungbean and lentil. On the other hand, pea and kidney bean seeds received lower number of eggs, respectively. The kidney bean was considered the most resistant pulse followed by pea for both bruchids, while the mungbean and the cowpea could be grouped as the most susceptible for both bruchids in the terms of oviposition, developmental period, susceptibility indices values and weight loss (%).

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Table 3. Fecundity, larval penetration (%), weight loss (%) and progeny of *Callosobruchus chinensis* (*C.ch*) and *C. maculatus* (*C.m*) on different pulse seeds.

Pulse Seed	Fecundity (Eggs no.)		Larval penetration (%)		Beetle progeny		Weight loss (%)	
	C.ch	*C.m*	*C.ch*	*C.m*	*C.ch*	*C.m*	*C.ch*	*C.m*
Pea	63.5±2.40ab	58.6± 6.9bc	82.10±0.6a	78.9± 1.7a	47.4± 4.8b	22.4± 2.5b	9.07± 0.8 b (LS)	6.50±0.8c (MR)
Lentil	66.8±1.70a	78.0± 4.3b	82.13±1.4a	81.2± 1.1a	57.5± 2.1ab	28.3± 2.o3b	10.96±1.9ab (LS)	7.50±0.8c (MR)
Cowpea	70.9±3.10a	74.5± 7.0b	82.03±1.1a	80.9± 0.5a	50.0± 5.7b	56.8± 5.7a	12.30±1.3a (LS)	16.50±1.1a (MS)
Chickpea	69.8±3.10a	63.6± 4.1bc	79.70±0.9ab	67.3± 1.1ab	60.2± 3.01a	54.9± 4.0a	12.20±0.5a (LS)	11.78±1.0b (LS)
Mungbean	67.9±2.97a	92.8± 4.1a	81.40±1.96a	79.1± 1.4a	51.3± 2.6ab	61.4± 2.9a	10.20± 0.5ab (LS)	13.6±0.5ab (LS)
Broad bean	54.9±1.30b	77.9± 1.4b	78.7±0.7ab	76.9± 1.0a	40.2± 1.02b	31.6± 1.4b	9.25± 0.2b (LS)	9.96±0.4bc (LS)
Kidney bean	47.3±2.02bc	66.7± 2.8bc	74.6±1.7b	80.6± 1.96a	0.0c	0.0c	0.0 (CR)	0.0d(CR)
F-value	14.20	2.05	3.86	9.16	73.24	59.86	67.15	4.82
LSD-5%	10.60	12.024	5.72	14.28	9.93	11.64	2.12	2.998

Means within a column followed by the same letter(s) are not significantly different at 5 % level of significance. LS=least susceptible, CR=completely resistant, MS=moderately susceptible, MR=moderately resistant.

Table 4. Mean developmental period (MDP, days), adult emergence (%) and susceptibility indices (SI) of *C. chinensis* (*C.ch*) and *C. maculatus* (*C.m*) on different pulses.

Pulse Seed	MDP (Days)		Adult emergence (%)		Susceptibility Index (SI)	
	C.ch	*C.m*	*C.ch*	*C.m*	*C.ch*	*C.m*
Pea	32.90± 0.4a	42.30± 0.6a	77.2± 6.3b	39.6± 3.03cd	5.70±0.2e (MS)	3.78±0.4d (MR)
Lentil	25.20± 0.2c	38.30± 0.57b	89.9± 2.7a	39.2± 3.40cd	7.78±0.2c (S)	4.13±0.3d (MR)
Cowpea	21.50± 0.6e	23.50± 0.2e	72.7± 6.9b	81.5± 4.10ab	8.69±0.4a (S)	8.11±0.1a (S)
Chickpea	23.70± 0.2d	28.13± 0.3d	90.8± 1.9a	90.4± 1.5a	8.25±0.1b (S)	6.97±0.1b (MS)
Mungbean	21.30± 0.15e	22.60± 0.2ef	79.7± 2.5ab	70.7± 2.60b	8.91±0.1a (S)	8.16±0.1a (S)
Broad bean	26.25± 0.1b	33.19± 0.2c	78.5± 1.4ab	41.8± 1.70c	7.20±0.1d (MS)	4.87±0.07c (MR)
Kidney bean	0.0f	0.0g	0.0c	0.0e	0.0f (CR)	0.0e (CR)
F-value	22.75	1814.4	71.60	109.3	796.8	493.1
LSD-5%	0.91	1.35	12.50	9.85	0.46	0.53

Means within a column followed by the same letter(s) are not significantly different at 5 % level of significance, CR=completely resistant, MS=moderately susceptible, S=susceptible, MR=moderately resistant.

Table 5. Correlation among different characters (parameters) of susceptibility determination in different pulse seeds to *C. chinensis* infestation.

Parameters	Total eggs number	Larval penetration (%)	MDP (Days)	Adult emergence (%)	Susceptibility Index (SI)
Larval penetration (%)	0.299***	-	-	-	-
MDP (Days)	-0.299***	-0.036 NS	-	-	-
Adult Emergence (%)	0.0529 NS	-0.047 NS	-0.144 NS	-	-
Susceptibility Index (SI)	0.318***	0.048 NS	-0.929***	0.430***	-
Weight loss (%)	0.693***	0.164 NS	-0.356***	0.295***	0.436***

*** = Very highly significant correlation.
NS = Non- significant correlation.

Table 6. Correlation among different characters (parameters) of susceptibility determination in different pulse seeds to *C. maculatus* infestation.

Parameters	Total eggs number	Larval Penetration (%)	MDP (Days)	Adult Emergence (%)	Susceptibility Index (SI)
Larval penetration (%)	0.124NS	-	-	-	-
MDP (Days)	-0.267**	0.0074 NS	-	-	-
Adult Emergence (%)	-0.154NS	-0.116 NS	-0.66***	-	-
Susceptibility Index (SI)	0.151NS	-0.035 NS	-0.94***	0.82***	-
Weight loss (%)	0.496***	0.032 NS	-0.67***	0.54***	0.675***

*** = Very highly significant correlation.
** = Highly significant correlation.
NS = Non- significant correlation

حساسية بذور بعض البقوليات المصرية للإصابة بخنافس البقول

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تصاب بذور المحاصيل البقولية بخنافس البقول خلال فترة التخزين، وهذه الحشرات تفضل بعض العوائل لوضع البيض فقط، بينما بعض البذور الأخرى تكون مفضلة لكل من وضع البيض ونمو هذه الحشرات. ومن أشهر الأنواع في مصر خنفساء البقول، وخنفساء اللوبيا، وكلاهما متعدد العوائل مع اختلافات كبيرة في سلوكها البيولوجي نحو هذه العوائل. وبيولوجي هذه الحشرات متماثل، حيث تضع الإناث البيض ملتصقا بالبذور وتتغذى اليرقات علي البذور محدثة خسائر كبيرة في الوزن، بجانب فقد الإنبات، وأيضا فقدان القيمة التجارية والتسويقية للبذور المخزنة.

وتم في هذا البحث تحديد حساسية بذور سبعة محاصيل بقولية تزرع في مصر وهي اللوبيا والعدس الشتوي والعدس الصيفي والبسلة و الحمص والفول البلدي والفاصوليا، وتحديد عدد البيض الذي تضعه الإناث، والنسبة المئوية لاختراق اليرقات للبذور، وعدد حشرات الجيل الأول ونسبة الفقد في الوزن، وقيمة دليل الحساسية كمقياس رياضي. وكذلك تم تحليل علاقة الارتباط بين الصفات المذكورة ودليل الحساسية لكل من حشرتي الاختبار.

ومن النتائج تبين الأتي:

-بذور محصولي اللوبيا والحمص كانتا أكثر الأنواع حساسية للإصابة بالحشرتين، نتيجة خروج أعداد كبيرة من حشرات الجيل الأول وخلال فترة زمنية قصيرة مقارنة بالمحاصيل الاخري، وكانت قيم دليل الحساسية لهما أعلي القيم.

– بذور الفاصوليا كانت منيعة تماما للإصابة بالحشرتين، علي الرغم من وضع كميات كبيرة من البيض عليها وفقس البيض ودخوله البذور ولم يكتمل النمو وعدم خروج أي حشرات، وبالتالي لم يحدث للفاصوليا أي فقد في الوزن. كما بينت النتائج أن وضع البيض وخصوبة الإناث ليس له علاقة بمدى ملائمة البذور لنمو الحشرتين.

-بقية بذور المحاصيل الأخرى أظهرت درجات متوسطة من الحساسية علي أساس القيم المحسوبة لدليل الحساسية، بجانب فقدا متفاوتا في الوزن.

–دراسة الارتباط بين صفات حشرة خنفساء البقول وخنفساء اللوبيا علـــي بــذور المحاصـــيل المختلفة وحساسية هذه المحاصيل للإصابة، وجد ارتباط معنوي موجب بين كل من عدد البيض وعدد حشرات الجيل الأول ونسبة الفقد في الوزن مع قيم دليل الحساسية بينما وجد ارتباط سلبي بـــين فتـــرة لتطور ودليل الحساسية.

– أظهرت النتائج أن كل بذور البقوليات المختبرة ماعدا الفاصـــوليا كانـــت أكثـــر حساســـية للإصابة بخنفساء البقول مقارنة بخنفساء اللوبيا علي أساس قيم دليل الحساسية.