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Relative susceptibility of faba bean varieties to *Callosobruchus maculatus* (f.)

Abo Arab, R.B.S.* and Samia Adel Hamid Salama**
*Dept. of Stored Product Pests Institute of Plant Protection Agric. Res. Center, Giza, Egypt.
**Dept. of Seed Technology, Field Crops Research Institute Agric. Res. Center, Giza, Egypt.

ABSTRACT

Seven faba bean varieties were assessed to study their susceptibility to the bruchid *Callosobruchus maculatus* infestation. The association between some physical and chemical characteristics and the susceptibility were investigated, under laboratory conditions. The physical characteristics were seed weight, seed volume and relative density. Furthermore the chemical parameters of moisture, protein, fat, ash, crude fibers, total carbohydrates and tannic acid were studied. The results, evaluated on the basis of oviposition, % hatchability, % progeny and % damage. In fact, the faba bean varieties differ greatly to the attack of *C. maculates*. In no-choice conditions, the English variety had the least susceptibility level (10 % damage value) followed by Sakha 1 (25.84 % damage) and Giza 717 (29.11% damage). Giza 643 and Giza 461 were significantly more susceptible to infestation levels and showed 67.71 and 62.89 % damage, respectively. In free-choice condition, also the English variety was the highest tolerant with 38.37 % damage value, while the triple white variety was the least resistant one (100 % damage). Results indicated that tannic acid content significantly reduce the damage of certain varieties in the present work.

Keywords: Susceptibility, faba bean, varieties, *Callosobruchus maculatus*

INTRODUCTION

Faba bean is one of the most important sources of proteins, carbohydrates, B. complex vitamins and minerals. The seeds of faba bean are liable to attack during storage by several insect pests of which *C. maculatus* (F.), is the most serious insect pest of stored pulses. Worldwide pests cause approximately 25% loss of seed yield of this important food crop (Gate house *et al.*, 1989).

Breeding for resistance to insects, germplasm materials must be evaluated to determine their degree of susceptibility or resistance to key pests. For stored product insects, the evaluations can be performed in a relatively short time in the laboratory. Susceptibility and resistance of some stored seeds to certain insects have been reported by several authors (Dick and Credland 1986; Dongre *et al*., 1993; Oigiangbe and Qnigbinde, 1996; Ram and Singh, 1996; Su *et al.,* 1996; Meikle *et al*., 1998; Ignacimuthu *et al*., 2000 and Ali *et al.,* 2004).

The present work was carried out to evaluate levels of infestation of local six varieties of faba bean seeds according to the physical and chemical properties of each variety as well as the commercial English variety.

MATERIALS AND METHODS

This study was carried out in the laboratories of seed Technology and Stored Product Pests Research Departments, at Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt. Six local varieties of faba bean (Ficia faba); Giza 717, 643, 716 and 461, Sakha 1 as well as Triple white were used in this study in season 2001-2002. The seeds were obtained from legume Department at Sakha Agricultural Research station Kafr El-Sheikh, field crops Res. Inst. Agric. Res. Center, Egypt, one month after harvesting. Another commercial variety (English variety) was obtained from the local market.

Samples from each variety were cleaned and then grounded to fine powder to pass through 2mm mesh for chemical analysis. Dry matter, protein, ash, crude fiber, fat (ether extract), total carbohydrates and tannins were determined according to procedure outlined in AOAC (1990). Some physical properties as relative density were determined, one hundred seed from each variety were weighed and their volume was measured by absolute displacement to calculate the relative density as described by Krammer and Twigg (1962).

NB: Triple white (T.W.): Introduced from Sudan. It has white flowers, white seeds, white hilum and early flowering.

Anti-nutritional factor: Tannins (as tannic acid): Total tannins were determined colorimetrically as described in A.O.A.C. (1990). Stock culture

of the *C. maculatus* was maintained in glass jars containing abundant seeds of cowpea in the laboratory at conditions of (25 ± 5 °C and 65 ± 5 % RH). Seven faba bean varieties were evaluated in order to assess their susceptibility to *C. maculatus*. Two types of infestation experiments were conducted:

1. The first experiment was conducted to study the cowpea beetle resistance under no-choice conditions using 20 g of each variety of faba been seeds in glass jars (250 ml). Three replicates for each cultivar were used. Ten pairs of adult beetle (1-3 days old) were introduced to each jar and allowed to mate and lay eggs on the seeds under the formentioned experimental conditions. After six days, the number of deposited eggs and their hatchability were recorded, while after 30 days, the progeny as number of adults were recorded. Seeds with the exit holes of insects were separated from the samples and counted to estimate the percentage of infestation according to the following equation :

$$\% \text{ infestation} = \frac{\text{No. of infested kernels}}{\text{No. of total kernels (sound and infested)}} \times 100$$

2. The second infestation experiment was carried out to study the cowpea beetle infestation levels under free-choice condition. In this experiment, plastic jar accommodates twenty petri dishes (9cm diameter), each contains 20 gm of a faba bean variety was used as choice chamber. Two thousands and fifty adult females and 250 adult males (1-3 days old) were placed in the center part of each jar to give the insects a free-choice to oviposit on any variety. Three replicates were conducted. The experiment was conducted at the same conditions mentioned before. After six days, the numbers of deposited eggs were recorded. After 30 days, the percent of damage was estimated according to the same equation mentioned above. An analysis of the variance and Duncan's Multiple Range Test (1955) were performed, to rank the varieties according to their susceptability to the pest. Simple correlation coefficients were calculated.

RESULTS AND DISCUSSION

The analysis of variance for all traits is shown in Table (1). The data indicated that the degree of damage, laid eggs and percent of progeny of *C. maculates* were highly affected by the variety of faba bean seeds. Also,

100 seed weight, 100 seed volume and relative density greatly influenced by the variety of faba bean seed. On the other hand, the analysis of the different materials of tested varieties had no effect on infestation levels of seeds except the tannic acid content. It is cleary evident that highly significant differences occurred among various faba bean varieties.

Table (1): Analysis of variance for susceptibility, preferability, chemical and physical characters in seven faba bean varieties.

S.O.V.	d.f	Mean squares															
		Susceptibility				Preferability		Chemical characters							Physical characters		
		Laid eggs	% hatch	% progeny	% Damage	Laid eggs	% damage	%MC	%Protein	%Fat	%Ash	CF	%TC	%TA	100 SW	100 SV	RD
Rep.	2	2887.19	13.20	186.58	1.28	4.43	1.29	2.18	18.12	0.02	0.93	11.18	1.69	0.04	11.33	19.01	0.01
Var.	6	51685.05**	39.00	374.43**	1261.73**	4801.10**	1309.62**	3.06	69.82	0.18	1.26	19.12	31.14	0.48**	774.72**	783.71**	0.01**
Error	12	1456.86	16.12	79.21	11.85	239.43	4.53	2.44	38.46	0.23	0.63	15.21	28.06	0.03	3.39	7.58	0.002

Where :

MC	= Moisture content	SW	= Seed weight
CF	= Crude fiber	SV	= Seed value
TC	= Total carbohydrate	RD	= Relative density
TA	= Tannic acid	Var.	= variety

Regarding chemical components (Table 2), no significant differences were detected for studied characters except for tannic acid, indicating probable absence of differences among these varieties involved in the present investigation. The English (E) and Triple white (T.W) varieties had the highest (2.61 %) and the lowest (1.34 %) values of tannic acid,

respectively. (T.W) variety also had the highest moisture content (12.18 %) and the lowest crude fibre (8.56 %).

Table (2): Some chemical compositions for seven faba bean varities.

No.	Variety	df	MC	Protein	Fat	Ash	CF	TC	TA
1	Sakha 1		11.69	29.94	1.23	4.28	13.86	39.00	1.77b
2	G. 716		11.08	34.59	1.24	5.01	11.09	40.34	1.76b
3	G. 717		10.20	29.36	1.31	4.21	11.23	40.31	1.81b
4	G. 461		11.32	26.04	1.45	5.00	10.47	47.04	1.80b
5	G. 643		9.27	30.42	1.91	4.53	16.34	37.54	1.52bc
6	E		11.72	19.75	1.58	3.26	11.31	44.01	2.61a
7	T.w.		12.18	32.34	1.35	5.07	8.56	40.52	1.34c
	Replicates	2	2.18	18.12	0.02	0.93	11.18	1.69	0.04
MS	Variety	6	3.06	69.82	0.18	1.26	19.12	31.14	0.48**
	Error	12	2.44	38.46	0.23	0.63	15.21	28.06	0.03

Where :

G. = Giza E = English TW = Triple white

The results of physical characters (100 seed weight, 100 seed volume and relative density) are summarized in Table 3. It is of great interest to mention that the analysis of variance revealed significant differences between these faba bean varieties for all studied physical characters, indicating considerable variation. Thus, these varieties were genetically different for genes controlling these characters. Data given in Table 3 provided that English variety had the lowest values of 100 seed weight (48.95 g) and 100 seed size (38.5 cm^3) and the highest value for relative density trait (1.28 g / cm) followed by Triple White variety for the first two characters (58.41 and 50.0), respectively. Giza 716 variety had the opposite direction for the three previous mentioned attributes (95.22, 87.83 and 1.07), respectively. Ramy and Singh (1996) reported that susceptibility to rice weevil was found to be correlated positively with grain size and negatively with crude fiber and protein contents of the grain.

Table (3): Some physical traits for seven faba bean varieties.

No.	Variety	df	100 SW	100 SV	RD
1	Sakha 1		67.62^{d}	61.00^{c}	1.11^{bc}
2	G. 716		95.22^{a}	87.83^{a}	1.07^{b}
3	G. 717		76.48^{c}	64.00^{c}	1.19^{b}
4	G. 461		82.29^{b}	70.17^{b}	1.17^{b}
5	G. 643		84.75^{b}	74.33^{b}	1.14^{b}
6	E		48.95^{f}	38.50^{e}	1.28^{a}
7	T.W.		58.41^{e}	50.00^{d}	1.17^{b}
	Replicates.	2	11.33	19.01	0.01
MS	Variety	6	774.72**	783.71**	0.01**
	Error	12	2.39	7.58	0.002

Where:

SW = Seed weight (g).
SV = Seed volume (cm^3)
RD = Relative density (g/cm).

Resistance of the tested faba bean varieties to insect damage: The resistance of the seven faba bean varieties to *C. maculatus* was evaluated in the basis of total laid eggs, % hatchability, % progeny and % damage and the obtained results are presented in Tables 4 and 5. Concerning susceptibility (Table 4), the data of egg laying revealed that among the seven faba bean tested Giza 461, Triple White and English varieties were most preferred for oviposition (425, 451 and 394 eggs), respectively. Giza

Table (4): Averages of total eggs, hatchability %, progeny % and damage % of *C. maculatus* in seven faba bean varieties by no-choice condition.

Varieties	Susceptibility (no-choice condition)			
	Total eggs	Hatchability %	Progeny %	Damage %
Sakha 1	150.00^{c}	89.38	27.97^{ab}	25.84^{d}
G 716	141.33^{c}	86.63	17.61^{bc}	34.69^{bc}
G 717	287.33^{b}	84.80	12.06^{bc}	29.11^{cd}
G 461	425.00^{a}	90.48	14.23^{bc}	82.89^{a}
G 643	208.33^{c}	92.12	40.73^{a}	67.71^{a}
E	394.67^{a}	91.39	7.76^{c}	10.00^{e}
TW	451.00^{a}	95.70	2.16^{bc}	37.84^{b}

716, Sakha 1 and Giza 643 were the least preferred with numbers of eggs 141.33, 150.0 and 208.33, respectively. The results also revealed that the highest values of Giza 643 variety for % progeny (40.73) and % damage (67.71), while English variety exhibited the opposite trend for the same characters (7.76 and 10.0), respectively. Ahmed *et al*. (1989) found that no correlation was found between the number of eggs laid and the number of adults emerged. Amol-Gupta *et al*. (1996) evaluated 50 rice varieties for grain damage after emergence of adult moths. They found that nine varieties were classed as highly tolerant, exhibiting 0-0.91 % grain damage. A further 11 varieties were classed as tolerant (1.22-2.94 % damage).

Table (5): Averages of laid eggs and damage % of *C. maculatus* in seven faba bean varieties by free-choice condition.

Varieties	Preferability (free-choice condition)	
	Laid eggs	Damage %
Sakha 1	109.33[b]	69.64[b]
G 716	115.33[b]	40.00[d]
G 717	134.00[b]	61.54[c]
G 461	109.33[b]	67.31[b]
G 643	78.00[c]	70.45[b]
E	207.00[a]	38.37[d]
TW	128.00[b]	100.00[a]

Concerning preferability, English variety possessed the lowest value for % damage (38.37) whereas, Triple White variety exihibted the highest value for % damage (100.0) followed by Giza 643 (70.45), Sakha 1 (69.64), Giza 461 (67.31) and Giza 717 (61.54) varieties.

Based on % progeny and % damage in both no-choice and free-choice conditions, the present results show that English variety had the least number of emergence (7.76) and the lowest damage (10.0 % and 38.37%) under the two conditions, respectively. On the other hand, Triple white variety had (37.84 % and 100 %) damage in the two experiments, indicating that the English variety was the most tolerant while Triple White was the most susceptible one. These results are in parallel to the obtained data of chemical and physical characters where the English variety has the highest content of tannic acid (2.61), crude fibre (11.31) and moisture (11.72) while the Triple White variety showed the lowest values of the three mentioned

chemical characters (1.34, 8.56 and 12.18, respectively). Correlation values of several traits related to susceptibility and preferability parameters of *C. maculates* are shown in Table 6.

No correlation was found between percentages of moisture, protein, fat, ash and total carbohydrates and any other in no-choice and free-choice conditions for *C. maculatus*. A significant negative correlation was found between tannic acid and % damage in no-choice and free-choice conditions (r= -0.578 and -0.700), respectively. All physical seed characters had high and highly significant correlations with egg laying in the two experiments (susceptibility and preferability) where the laying eggs values were r = -0.538 and -0.704 with 100 SW and r = -0.618 and -0.715 with 100 SV while the r values were 0.641 and 646 with relative density. In no-choice condition the physical parameters had significant effect on the damage % where r = 0.607, 0.553 and –0.306 with 100 SW, 100 SV and RD, respectively.

The present results are in agreement with those of Oigiangbe and Onigbinde (1996) who indicated that tannic acid significantly reduce F_1 progeny and consequently, the percentage adult emergence. The tannic acid content of the cotyledon appears to reduce larval growth and development while that of the seed-coat reduces penentration of first instar larvae into the seed and, possibly, adult emergence. Wongo (1998) assessed tannic acid extracts of two sorghum (*Sorghum bicolor*) cultivars, BKS 5 and BTX 623, for their bioactivity against the rice weevil, *Sitophilus oryzae* and the angoumois grain moth, *Sitotroga cerealella*, in whole flour pellets and against the red flour beetle, *Tribolium castaneum*, in whole wheat flour at three treatment levels. He found that the number of adult progeny was reduced and number of days to emergence increased by tannins extracted from both sorghum cultivars at all treatment levels. Baker *et al.* (1989) suggested that seed density, moisture content, protein, fat, ash and carbohydrate percentages were not associated with the activity of *C. maculatus* on faba bean varieties. Consequently, the resistance of the seeds can therefore arise from a combination of physical and chemical factors Ogiangbe and Onigbinde (1996). Maldonado *et al*. (1996) evaluated 17 common bean cultivars for resistance to infestation by *Zabrotes subfasciatus* and *Acanthoscelides obtectus* under no-choice and free-choice conditions. They found that resistance cultivars showed high levels of tannins.

Table (6): Correlation matrix for several variables of seven faba been varieties related to parameters of susceptibility (laid eggs, % hatchability, protein % and damage %) and preferability (laid eggs and damage %) for C. maculates.

Parameters	MC	Protein	Fat	Ash	Crude fiber	Total Carbo - hdrate	Tannic acid	100 seed weight	100 seed volume	Relative density	Susceptibility				Preferability	
											LE	H%	P%	D%	LE	D%
Susceptibility:																
LE	0.182	-0.341	0.029	-0.050	-0.422	-0.006	0.072	-0.538*	-0.618*	0.641**	-	-	-	-	-	-
H%	-0.130	-0.144	0.040	-0.255	0.204	0.104	0.162	0.021	0.006	0.060	0.068	-	-	-	-	-
P%	0.039	0.248	0.180	0.286	0.566*	0.257	-0.412	0.225	0.316	-0.526*	-0.479	-0.027	-	-	-	-
D%	-0.346	0.239	0.269	0.432	0.219	-0.077	-0.578*	0.607*	0.553*	-0.306	0.012	0.086	0.439	-	-	-
Preferability:																
LE	0.392	-0.451	-0.089	-0.432	-0.138	-0.023	0.730**	-0.704**	-0.715**	0.646**	0.426	0.115	-0.553*	-0.762**	-	-
D%	0.078	0.238	-0.007	0.342	-0.130	-0.009	-0.700**	-0.185	-0.471	0.085	0.342	0.150	0.351	0.384	-0.427	-

Where:

n= 14	LE = Laid eggs	H% = Hatchability	P% = % protein	D% = % damage			
* Significant p ≤ 0.05		** Significant p ≤ 0.01					

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