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Comparative Resistance as Function of Physical and Chemical Properties of Selected Faba Bean Promising Lines against *Callosobruchus maculatus* Post Harvest

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ABSTRACT

The present investigation was conducted during two growing seasons 2015/2016 and 2016/2017 at Sakha Agricultural Research Station farm, in order to evaluate thirteen faba bean genotypes to physical and chemical properties against insects attack to faba bean seed from breeding program, under early and late sowing dates (mid-October and mid- November, respectively) comparing with three varieties were assessed to study their response to infestation with Cowpea weevil *Callosobruchus maculatus* post- harvest through storage under laboratory conditions. Susceptibility index (SI), Seed yield /plant as well as net weight after discarding the all negative factors which affect the final yield were taken as gauge of susceptibility of studied lines. Actually, the results indicated that the studied lines greatly differed to the attack of *C. maculatus*. According to (SI)i.e. the line with high values of SI, high number of progeny, weight losses and shorter life cycle were classified as susceptible. In contrast, the lines with intermediate S.I (5.1-7.5) and revealed lower number of adults emerged (lower, weight loss and longerlife cycle were considered tolerant or moderately resistant (MR). The results clearly indicated that the complete resistant lines were relatively absent. Furthermore, appositive relationship was fond between the physic-chemical characters and infestation with *C. maculatus*. According to S.I, seed yield/plant, net weight the lines 2 and 16 were the most tolerant, while line 14 and 4 were the most susceptible one. In addition, that the mid October was the suitable sowing date where it actualized the higher seed yield along the two planting seasons. Based on the highest net weight %, the line 2 and Sakha3 may be recommended to plant at mid-October and for storage at long periods where they were tolerant against the tested beetle in storage, some diseases in field and climatic sowing. In order to early maturity character, the promising breeding line 2 as an early mature faba line that characterizes with tolerant to insect infestation along with high yield potential, especially under the stresses associated with early sowing date. Therefore, it should be taken into consideration to select the promising line 2 for faba bean breeding program to improve productivity and tolerance to insect infestation to avoid insecticide usage. In conclusion, this investigation showed the importance of physical and chemical properties for protects the seeds of faba bean against the insect attack.

Keywords: faba bean promising line, *C. maculatus,* seed yield

INTRODUCTION

Faba Bean (*Vicia faba* L.) is one of the major winter legume crops grown in the Mediterranean region, and has considerable importance as a low cost food rich in proteins and carbohydrates in Egypt. Faba bean is the most important legume crop in Egypt, due to its high nutritive value for human food and its role as a break crop in cereal rotation system. The cultivated area of faba bean was about 112.000 feddan in the least five seasons with an average yield of9.0ardab/faddan. The total production in 2015/16 season was about 119.000 tons, while the total consumption was estimated to be about 420.000 tons. This means that the percentage of self-sufficiency is only about 28%. So, to reduce the gap between production and consumption, the most effective is being developing new varieties with high yielding potentiality and using the proper cultural practices.

Many factors affect faba bean productivity like sowing dates affect the productivity due to differences in growth periods. Moreover, the stored seeds are also heavily attacked in storage by several insects of family Bruchidae. Pulse seeds are liable to attack during storage period with *C. maculatus* (F) which is one of the most important and serious pest of stored pulses. It starts the infestation in the field but a heavy damage is done in storage (Swella and Mushobozy, 2007). The infestation of pulse seeds with *C. maculatus* results in high values of weight losses, germination and reduced nutrient valuable due to development of larval stage inside the seeds. The estimated losses due to *C. maculatus* in various pulses ranged from 30-40% within a period of six month and the post-harvest seed wastage can reach even 100% during severe infestation (Mahendra and Mohan,2002).Applying control of stored product pests by chemical pesticides, lead to residual toxicity, environmental pollution as well as undesirable effects on human health. An effective and environment friendly management options against stored product pests in different legume could be achieved by improving the genetic resistance of the host plant (Somta *et al*,2008). The main objectives of faba bean breeding programs are developing a new cultivars with high productivity, good physical and chemical contents and resistant to insects and diseases.

Molecular tools give us an opportunity to develop genotypes that carry resistance traits (Ranjekar *et al*,2003). Moreover, breeding legumes to improve their resistance against storage insect pests, limitations are the best way. A plant possessing biochemical insect resistant properties in nutritionally incomplete for the insect that becomes unable to complete their life cycle (Relf,1996). Resistant plants appear to be one of the most promising alternatives to the use of chemicals for cowpea pest control (Amro,2004) .Therefore, the goal of the present study is to evaluate the susceptibility of certain faba bean promising under early and late sowing dates at SakhaAgricultural Research Station to artificial infestation with *C. maculatus* under laboratory conditions comparing with three commercial cultivars to recognize the susceptible, tolerant and resistant genotypes. This research was designed to investigate of crop resistance to insect pests are very important to investigate the physical and chemical properties for protecting the seeds of faba bean against the insect attack.

MATERIALS AND METHODS

This investigation was conducted Sakha Agricultural Research Station farm, Kafr El-Sheikh

Governorate Egypt during the seasons of 2015/2016 and 2016/2017 Thirteen faba bean promising lines selected from the breeding program at Sakha, for their high yield potential and or resistance to foliar diseases were evaluated under two different sowing dates comparing with three commercial cultivars. The names, pedigrees and remarkable characters of the studied genotypes are presented in Table 1.Sowing dates were mid- October (early) and mid- November (late) in both seasons. Each sowing date was conducted in a separate randomized complete blocks design (RCBD) experiment with three replications,each plot consisted of four ridges, 3 m long and 60 cm apart as outlined by Snedecor and Cochran (1982) and then combined analysis across sowing dates was calculated. Bartlett test has been done for error mean squares ±of the environments to estimate homogeneity or not, while combined analysis was done in the case of homogeneity.

***Callosobruchus maculatus**:*

The storage experiments post-harvest were carried out at Department of Stored Product Pests, Plant Protection Research Institute, and Sakha Agricultural Research Station. The cowpea weevil *C. maculatus* were collected from the stock culture, were released in sterilized jars at 30± 2 c and 70 ± 5 relative humidity(%) (R.H), each contains 300g of cowpea seeds and 100-200 un-sexed adults of *C. maculatus,* the mouth of jars were covered with muslin cloth and kept in position with rubber band. The culture medium was sieved and the insects that had emerged were collected for experiments in the next day.

Table1. Names, pedigrees and remarkable characters of studied faba bean genotypes.

Genotype	Pedigree	Remarkable characters
Line1	(Sakha 2 x Misr 1) x (Giza 40 x Giza 429)	LM and R
Line2	(Giza 3 x Giza 429) x (Giza 40 x Giza 429)	EM and S
Line3	(Giza 3 x Giza 429) x (Giza 40 x Giza 429)	EM and R
Line4	(Giza 3 x Misr 1) x (Giza 716 x T.W)	EM and S
Line5	(Sakha 1 x Misr 1) x (Giza 716 x T.W)	EM and S
Line6	(Giza 40 x Giza 716)	EM and R
Line7	(Nubaria 1 x Giza 716)	EM and R
Line8	Sakha 1 x Otona	EM and R
Line9	Sakha 1 x Sakha 2	EM and R
Line10	Giza 717 x Otona	LM and S
Line11	Giza 717 x Otona	EM and R
Line12	Giza 717 x Sakha 2	LM and R
Line 13	Misr 1 x ILB5329	EM and R
Giza 40	Selected from Rebai 40	EM and HS
Sakha 1	Giza 716 x 620/283/85	EM and R
Sakha 3	Individual selection from Giza 716	LM and HR

EM= Early mature LM=Late mature=High resistance to foliar diseases R= Resistance to foliar diseases
HS=High susceptibility to foliar diseases S= Susceptible to foliar diseases

Susceptibility experiments:

Insect infestation under non-choice conditions:

Newly harvested seeds of 13 faba bean promising lines as well as three commercial varieties (Giza 40, Sakha1 and Sakha3) were evaluated for resistance to infestation with *C. maculatus* under non choice conditions. Small glass jars (11.5 cm height and 6 cm diameter) each contains 20g of faba bean seeds of each treatment, then ten adults of *C. maculatus*, five males and five females (0-24 day old) immediately transferred to each glass jars. Three replicates of each treatment were made. The jars were covered with muslin cloth and kept under laboratory conditions at 30± 2 C^0 and 70 ± 5 %relative humidity until the beginning of adults emerged (F1 progeny).

At the end of experiment the following parameters were estimated:

1-Total number of eggs lying.
2-Life cycle (total developmental period).
3- Percent of weight loss.
4- Susceptibility index (SI).
5- Net weight.

All cultural practices were done as recommended in both seasons. In each growing season, a seed sample was taken at harvest from each genotype in each sowing date to determine the standard germination, physical properties and protein. All seed properties were carried out Sakha Seed Technology Dept. Agric. Research Station as follow:Standard germination test was conducted according to the international rules at testing (ISTA, 1993). Seeds were incubated in a growth chamber at 20C^0±1 and were considered germinated after the emergence of radical. Germination was scored when a2mm radical hademerged from the seed coat. Seeds were germinated for 10 days. Germination count was made after 4 days and daily till the end of the test. Normal seedling was counted expressed as germination percentage at final count.

1- **Germination%=** $\frac{\text{Number of normal seedling}}{\text{Number of tested seed}} \times 100$

2- **Percentageofseed coat**: One hundred seeds from each sample were decorticated, and then seed coats and cotyledons were weighed separately (Youssef, 1978 and Shehta*etal.,* 1885a).

3- **The percentage of seed coat :** was calculated as follows:

$$\frac{\text{Weight of seed coat}}{\text{Weight of whole seed}} \times 100$$

4- **Protein and fiber Percentage**: a part from each seed sample was taken and grounded to pass through 2mm mesh for protein%. Total nitrogen percentage was determined using Kildahl method (A.O.A.C.1990).

5- **Crude Protein Percentage :** was calculated by multiplying the total nitrogen% by 6.25.The

recommended package of cultural practices was followed.

6- In both seasons, measurements were taken on the basis of individual plants as follows: number of days to maturity, 100-seed weight, and seed yield / plant.

RESULTS

A. Susceptibility experiments:

Insect infestation under non-choice condition:

In order to evaluate the susceptibility of the tested faba bean genotypes to insect infestation by(*C. maculatus*);laboratory experiments were conducted to determine some biological parameters which show the relationship between the host genotypes and the insect (*C. maculatus*). These parameters included, number of eggs laying, number of adult emerged, weight loss%, life cycle and susceptibility index (S.I.) through the two seasons 2015/2016 and 2016/2017 at the two sowing dates. Among these parameters the presented study selected SI criterion to recognize the susceptible, tolerant and resistant genotypes. Based on the susceptibility index (SI) results obtained obviously showed that no any one of the tested genotypes was resistant against the insect infestation by (*C. maculatus*) beetle through the two seasons with the two sowing dates of each(Table 2-5) . Results cleared that the two sowing dates had the same trend. Consequently, the all 13lines as well as three commercial cultivars may divided into two groups according to(SI), the first was tolerant (moderately susceptible (MS)) which includes the genotypes that have S.I ranged between 5.1-7.5, while the second group susceptible consists the genotypes of S.I that have position between 7.6-10.0.For the first season with the first sowing date Table 1 the susceptible group had /emergence and weight loss% ranged between 75-78 and 14.5-22%, respectively.

Table 2. First planting date impact of the first season on biology of *C. maculatus* as indicator to the susceptibility of faba bean genotypes to insect infestation post-harvest.

Genotypes	No. of eggs	No. of hatched eggs	No. of adults emerged	% emergency	Weight loss %	Life cycle	S.I
1	190b	159b	124b	78.0	22.0	22	8.6
2	151ef	117ef	85g	73.0	11.5	25	7.5
3	184bc	155bc	116bc	75.0	16.5	24	7.8
4	154e	128de	96f	75.0	18.0	23	8.1
5	141efg	109fg	74gh	69.0	8.0	27	6.8
6	174cd	146c	108cde	74.0	12.0	25	7.5
7	147efg	115f	84g	73.0	10.5	26	7.2
8	137g	100g	71h	71.0	8.0	29	6.4
9	144efg	115f	83g	72.0	11.5	26	7.1
10	177ed	147bc	114cd	76.0	14.5	22	8.5
11	166d	129d	99ef	77.0	15.5	23	7.9
12	251a	210a	165a	78.0	21.0	22	8.6
13	173cd	132d	99ef	75.0	19.0	23	7.8
Sakha 1	174cd	144c	108cde	75.0	19.0	22	8.5
Giza 40	153fg	117ef	83g	71.0	10.0	26	7.1
Sakha 3	139e	109fg	74h	68.0	9.5	27	6.8
F-test	*	*	*	ns	ns	ns	ns

***Similar letters were not significant and difference letter were significant**

Table 3. Second planting date impact of the first season on biology of *C. maculatusas* indicator to the susceptibility of faba bean genotypes to insect infestation post-harvest.

Genotypes	No. of eggs	No. of hatched eggs	No. of adults emerged	%emergency	Weight loss %	Life cycle	S.I
1	233a	197b	154b	78.0a	21.0a	22ab	8.6
2	142e	113ijk	81ghi	72.0b	11.0b	25a	7.4
3	199b	167c	127c	76.0a	17.0a	23ab	8.2
4	161cd	127gh	96ef	76.0a	19.0a	23ab	8.5
5	135e	101k	73i	72.0b	8.0c	27a	7.4
6	174c	151de	113d	75.0a	13.0b	25a	7.5
7	146e	120hi	90fg	75.0a	11.0b	26a	7.2
8	135e	103jk	72i	70.0b	8.0c	29a	6.6
9	149de	120hi	86fgh	72.0b	11.0b	26a	7.4
10	175c	147ef	113d	77.0a	16.5a	22ab	8.6
11	163cd	137fg	105de	77.0a	17.0a	23ab	8.2
12	237a	212a	166a	78.0a	21.0a	22ab	8.6
13	172c	142ef	108d	76.0a	20.0a	23ab	8.2
Sakha 1	196b	167c	128c	77.0a	18.0a	22ab	8.6
Giza 40	142e	109jk	78hi	71.0b	10.5c	26a	7.1
Sakha 3	136e	104jk	73i	70.0b	9.5c	27a	6.8
F-test at 5%	*	*	*	*	*	*	ns

***Similar letters were not significant and difference letter were significant**

Table 4. First planting date impact of the first season on biology of C. maculatus as indicator to the susceptibility of faba bean genotypes to insect infestation post-harvest.

Genotypes	No. of eggs	No. of hatched eggs	No. of adults emerged	% emergency	Weight loss %	Life cycle	S.I
1	201b	186.0b	146.0b	78.0a	21.0a	22ab	8.6
2	162efg	102.0fg	74.0fg	72.5ab	11.0b	26a	7.2
3	193.3bc	163.0c	125.0b	77.0a	17.5a	23ab	8.2
4	160efg	125.0e	95.0e	76.0a	18.0a	23ab	8.2
5	151.3fgh	91.0h	65.0h	71.0b	8.0c	26a	7.7
6	164.0efg	137.0d	102.0de	74.5a	12.0b	25a	7.5
7	143hi	110.0f	81.0f	74.0a	10.0c	26a	7.2
8	136.7i	95.0gh	66.0h	69.0b	7.5c	29a	6.6
9	154fgh	97.0gh	70.0fg	72.0b	10.0c	25a	7.4
10	162.6efg	136.0d	104.0d	76.0a	15.0b	22ab	8.5
11	173.3de	125.0e	95.0e	76.0a	16.0a	23ab	8.2
12	245a	197.0a	152.0d	77.0a	20.0a	22ab	8.6
13	168ef	131.0de	101.0de	77.0a	21.0a	23ab	8.2
Sakha 1	183cd	154.0c	116.0c	75.0a	19.0a	23ab	8.2
Giza 40	140hi	104.0fg	74.0gh	71.0b	10.0c	26a	7.1
Sakha 3	137i	100.0fgh	70.0fg	70.0b	9.0c	27a	6.8
F-test at 5%	*	*	*	*	*	*	ns

***Similar letters were not significant and difference letter were significant**

While the (M.S) tolerant group had emergence (%) and weight loss (%) ranged between 68-74/and 8-11.5%, respectively. The same trend was observed with the second date where the susceptible group produced emergence (%) and weight loss% ranged between 76-78 and 16.5-21% respectively.

Meanwhile the tolerant group presented 70-75% and 8-13%for emergence and weight loss. Similarly, the second season either with the first or the second date had the same line of the first season where emergence and weight loss had the extent of 75-78, 71-74.50%. And 74-78.5, 66.5-72, for emergence of susceptible and tolerant groups, respectively. For the weight loss the latitude was between 15-21 to 7.5-12 and from 12-21 to 7.5-12 for the same dates mentioned above with the same groups, respectively.

Table 5. Second planting date impact of the first season on biology of *C. maculatus* as indicator to the susceptibility of faba bean genotypes to insect infestation post-harvest.

Genotypes	No. of eggs	No. of hatched eggs	No. of adults emerged	%emergency	Weight loss%	Life cycle	S.I
1	231a	193.3a	152.0a	78.6	20.0	22	8.6
2	128g	99.0e	72.0fg	72.7	11.5	25	7.4
3	196.3b	158.0b	117.0b	74.0	17.0	24	8.1
4	140.7e	119.0e	90.0f	75.3	17.5	23	8.2
5	126.3g	93.3g	65.0hi	70.0	8.0	26	7.0
6	162.3d	140.3c	104.0cd	74.3	12.0	25	7.5
7	138.0f	108.0f	78.0g	72.2	11.0	26	7.4
8	116.0h	91.7g	61.0i	66.5	7.5	29	6.3
9	129.0g	98.3f	71.0fgh	72.4	10.5	25	7.4
10	161.3d	133.0d	100.0de	75.6	14.0	22	8.5
11	148.3e	120.7e	92.0f	76.7	16.5	23	8.2
12	237.0a	199.0a	156.0a	78.4	21.0	22	8.6
13	157.0d	126.0c	96.0ef	76.2	20.0	23	8.2
Sakha 1	185.7c	149.0c	109.0c	73.2	19.5	22	8.5
Giza 40	124.0g	100.0f	71.0fgh	71.0	10.0	26	7.1
Sakha 3	119.0h	91.0e	61.0i	67.0	9.0	28	6.5
F-test at 5%	*	*	*	*	*	*	ns

***Similar letters were not significant and difference letter were significant**

B. Chemical and physical traits;

Results in Tables 6&7 included the physical and chemical analysis of some parameters of the thirteen lines as well as three commercial cultivars under study. The investigated parameters were germination %, seed coat %, endosperm%, protein %, fiber % and seed yield/plant. To recognize the best lines the seed yield\plant parameter was selected for this purpose. Where, the aim of this study is producing new cultivars with high yielding potentiality. According to the criteria of seed yield/plant, lines 2,10,12 and Sakha3 had the highest yield with seed yield/plant values, 46.70, 44.13, 38.98 and 38.33 respectively. While, the lowest values were with genotypes,1, 13, 8, 4 which had seed yield/plant, 26.43, 27.63, 28.03, and 28.11 respectively, for the first season. For the second season, the highest yield was found with the lines 16,6, 13 and line 2 which had the values of 36.83, 34.33, 33.17, and 33.16 g seed yield/plant, respectively. The lines which had the lowest yield were 12, 14, 5, and 4 with values of 20.33, 24.17, 26.5, and 27.0, respectively. Also data obtained in Table 6&7 markedly showed that the early sown at 15 October had the highest seed yield/plant for both sowing seasons with values of 39.74 and 30.6g, respectively.

The variation of seed yield/plant between the two seasons may due to the dominant climatic conditions and the insect infestation as well some diseases.

In addition that, result in Table 6 summarized the percentages of tested parameters for the all sixteen genotypes under study. Data obtained cleared that the tolerant group have (SI between5.1-7.5) recorded the highest rates of fiber and seed coat with values ranged between 7.85-9.95 and 2.3-2.6, respectively. And also it

had the lowest rates of protein and endosperm with values of 24.27 to 26.92 and 85.09 to 87.16 %, respectively.

In contrast, the susceptible genotypes group (SI between 7.8-10.0) had the lowest rates of fiber, seed coat, and it recorded the highest values of protein and endosperm. Similarly the data in Table 7 had the same trend of that presented in Table 6. The results obtained revealed that the tolerant group had higher rates of fiber and seed coat between 10.34-12.33, 9.99-12.16 and respectively. Also the same group had lower rate of protein and endosperm ranged between 24.82-29.08, and 86.50-87.66, respectively. Oppositely the susceptible genotypes group had the lower rate of fiber and seed coat, also recorded higher rates of protein and endosperm. In addition that, results presented that there are significant differences between rate of the investigated parameters (germination, fiber, seed coat ,protein, endosperm and seed yield) at the two seasons. Overall the results in Tables 2-7 for the all tested parameters show that tolerant genotypes recorded the reduced rates of emergence%, weight loss%, protein and endosperm and also presented increasing ratio for fiber, seed coat. While the susceptible genotypes in contrary had the lowest rates of fiber, seed coat, and recorded the highest rates of emergence, weight loss, protein and endosperm. Ultimately, there is positive relationship between the tolerant genotypes and the highest yield while there is negative relationship between susceptible genotypes and seed yield. The current study high lights the relationship between the tested parameters and the susceptibility of the investigated genotypes to insect infestation by *C. maculatus*. The obtained data accentuate the following points: in general there were significant differences between the studied criteria with the two seasons at the two sowing dates. Based on the data summarized in Table 8, the all parameters indicate that the genotypes that had lowest weight loss and emergency% also had the highest percentage of fiber and seed coat. Thus probably there is a positive relationship between the fiber and seed coat content and the reduced weight loss this lowest weight might be attributed to un ability of the tested insect to attack the cowpea seeds where the high content of fiber and the thick of seed coat hinder or minimize the ability of insect to feed on the seeds. In the same context the low endosperm and protein cause the seeds unpalatable or of poor nutritive quality. Oppositely, the genotypes contained high protein and high endosperm, low fiber content and thin seed coat were preferred to the *C. maculatus* .So, the preference of *C. maculatus* to some genotypes might be due to the chemical composition of seeds and the physical properties. Therefore, the tested genotypes may divide to two categories. The first includes the susceptible genotypes, 1, 3, 4, 10, 11, 12, 13, and 14 .while, the second group comprises the tolerant genotypes of 2, 5, 6, 7, 8, 9, 15, and 16 data in Table (8) included overall means of physical, chemical and biological criteria in relation to the susceptibility of studied faba bean genotypes to insect infestation by *C .maculatus*. It is known that the present study aimed to get the greatest net weight of any genotype after discount the effect of insect infestation either in field or storage. Based on the net weight in Table 8 it is evident that the line 2 and Sakha3 achieved the highest net weight after discarding, the all negative factors which reduce the final yield such as insect infestation in field or storage and disorders of climatic conditions. Oppositely, Giza 40 and line 4were produced the lowest yield. According to the results in Table 8 the line 2and Sakha3 had net weight (35.43, 32.99), emergency (72.55, 68.75), weight loss% (11.25, 9.25), life cycle (25.3, 27.3) and S.I (7.37, 6.73). While the Giza 40 and line 4 had the highest susceptibility with net weight %(12.85, 22.57), emergency % (75.0, 75.6), weight loss% (18.9, 18.0), life cycle (22.3, 23.00) and S.I(8.45, 8.25).

It could be concluded that the current study showed the importance of physical and chemical properties for protects the seeds of faba bean against the insect attack. These properties must be taken in consideration for having resistant or tolerant faba bean varieties to insect invading. Based on the highest net weight %, the line 2 and Sakha3 may be recommended to plant at 15 October date and for storage at long periods where they were tolerant against the tested beetle in storage, some diseases in field and climatic swing.

Table 6. Effect of sowing date on germination, some physical and chemical properties of indicated faba bean genotypes in the first season.

Genotypes	Germination %	Seed coat %	Endosperm %	Protein %	Fiber %	Seed yield/plant	100-seed yield(g)	Maturity
15-October	95.41b	9.81b	87.80a	27.75a	9.83b	39.74a	85.79a	187.33
15-November	96.53a	10.20a	87.65b	27.02b	10.05a	28.29b	81.70b	166.60
Genotypes 1	91.83g	8.77i	88.83abc	28.69bcd	9.30f	26.43e	85.97ab	180.00ab
2	94.17ef	10.38cd	87.16c	26.92def	10.32d	46.70a	75.80cd	173.67e
3	97.50bc	9.27h	88.70abc	30.32ab	9.02fg	37.11bcd	85.50ab	173.83de
4	100.00a	9.30h	88.40abc	30.99a	8.39h	28.11de	83.35bc	177.50be
5	96.00cdf	10.59c	86.92c	24.84gh	11.75b	33.75cde	86.21ab	173.50e
6	94.00ef	10.08de	87.24c	26.92def	10.42d	32.33cde	81.28bc	178.17ad
7	95.50cf	10.09de	87.45c	25.91fgh	10.51d	35.60be	88.04ab	175.17cde
8	93.85ef	12.41a	85.09d	24.27h	12.19a	28.03de	85.83ab	173.83de
9	97.18bcd	10.43cd	87.00cd	25.33fgh	11.34c	32.48cde	93.73a	176.33be
10	98.50ab	9.95ef	87.55bc	27.85cde	9.95e	38.98abc	89.42ab	179.33abc
11	98.23ab	9.88efg	89.36ab	29.24bc	7.85i	31.00cde	88.82ab	175.16cde
12	95.17def	8.38j	89.63a	30.34ab	8.82g	38.33abc	86.36ab	182.00a
13	93.60fg	9.54gh	88.18abc	28.44cd	9.35f	27.63c	82.79bc	176.83be
Sakha 1	100.00a	9.30def	88.31abc	28.10cde	8.26h	29.70cde	70.68d	178.67abc
Giza 40	95.83cde	10.59c	86.92c	25.25fgh	11.54dc	33.80cde	69.20d	175.50cde
Sakha 3	94.17ef	12.07b	85.52d	25.08gh	11.64bc	44.13ab	86.93ab	182.00a
F-test at 5%	*	*	*	*	*	*	*	*

***Similar letters were not significant and difference letter were significant**

Table 7. Effect of sowing date on germination, some physical and chemical properties of indicated faba bean genotypes in the second season.

Genotypes	Germination %	Seed coat %	Endosperm %	Protein %	Fiber %	Seed yield/plant	100-seed yield(g)	Maturity
15-October	96.00b	9.96b	87.70a	28.02a	9.92b	30.60a	93.51a	186.90a
15-November	97.00a	10.71a	87.00b	27.67b	10.30a	28.29b	92.24b	165.27b
Genotypes 1	92.83i	9.27h	88.58b	29.00ad	9.42ef	32.00abc	99.61abc	178.50a
2	95.83f	10.60cd	86.83gh	27.62cf	10.34cd	33.16abc	95.23cde	175.50ab
3	97.50de	9.66fgh	88.27bcd	30.40a	10.22d	29.67ad	84.91fg	172.16b
4	99.67a	9.88f	87.67ef	29.59ab	8.69hi	27.00bcd	91.87cf	176.67ab
5	96.33f	11.01c	86.50h	25.40g	11.68b	26.50bcd	91.35def	175.83ab
6	96.00f	10.10f	87.51f	29.08a-d	10.34cd	34.33ab	95.56cde	177.67ab
7	96.00f	10.75cd	86.99g	26.09efg	10.61c	30.83abc	94.45cde	175.17ab
8	93.83h	13.29a	84.35j	24.82g	12.33a	27.50ad	96.47be	174.17ab
9	98.16bc	10.44de	87.05g	26.05fg	11.51b	29.33ad	103.99a	175.33ab
10	98.50b	9.99f	87.66ef	28.56abcd	9.53e	30.00abc	95.55cde	176.67ab
11	97.83cd	9.87f	88.07cde	28.96abcd	8.82gh	28.67ad	103.81ab	175.83ab
12	97.00e	8.44i	89.86a	29.60abc	8.39h	20.33d	88.89ef	179.17a
13	94.67g	9.70fg	87.86def	29.39abc	9.09fh	33.17abc	97.66ad	175.67ab
Sakha 1	99.50a	9.39gh	88.49bc	27.40def	9.09fg	24.17cd	80.84gh	176.16ab
Giza 40	96.33f	10.81cd	86.70gh	25.99fg	11.52fgh	27.66ad	74.14h	173.83ab
Sakha 3	95.83f	12.16b	85.47i	25.83fg	11.86b	36.83a	91.72def	179.00a
F-test at 5%	*	*	*	*	*	*	*	*

***Similar letters were not significant and difference letter were significant**

Table 8. Overall means of physical, chemical and biological criteria in relation to the susceptibility of faba bean genotypes to infestation by *C. maculatus*.

Genotypes	Seed coat %	Endosperm %	Protein %	Fiber %	Seed yield /plant	Weight losses %	Net weight %	Life cycle days	Emergency %	Susceptibility index	Identification
Line 1	9.02i	88.70abc	28.48bcd	9.36f	29.21e	21.00a	23.08bc	22.00ab	78.15a	8.60	Susceptible
Line 2	10.49cd	86.99c	27.27def	10.33d	39.93a	11.25b	35.43a	25.30a	72.55ab	7.37	Tolerant
Line 3	9.47h	88.48abc	30.36ab	9.62fg	33.39bcd	17.00a	27.17a	23.30ab	75.50a	8.00	Susceptible
Line 4	9.59h	88.03abc	30.39a	8.80h	27.56de	18.00a	22.57c	23.00ab	75.60a	8.25	Susceptible
Line 5	10.80c	86.71c	35.12gh	11.71b	30.12cde	8.00c	27.71b	26.50a	71.75b	7.00	Tolerant
Line 6	10.09de	87.37c	38.00def	10.38d	33.33cde	12.30b	29.23a	25.00a	72.45a	7.50	Tolerant
Line 7	10.42de	87.22c	26.00fgh	10.56d	33.21be	10.60c	29.69a	26.50a	74.55a	7.25	Tolerant
Line 8	12.85a	84.72d	24.54h	12.26a	27.90de	7.75c	25.81ab	29.00a	69.10b	6.47	Tolerant
Line 9	10.43cd	87.03cd	25.69fgh	11.42c	30.90cde	10.75c	27.58a	25.30a	72.10a	7.30	Tolerant
Line 10	9.97ef	87.60c	28.20cde	9.74e	34.49abc	15.00b	29.32a	22.00ab	76.15a	8.50	Susceptible
Line 11	9.83efg	88.71b	29.10bc	8.33i	29.53cde	16.25a	24.98ab	23.00ab	76.70a	8.10	Susceptible
Line 12	8.41j	89.74a	29.97ab	8.60g	29.33abc	18.30a	23.24bc	22.00ab	77.85a	8.60	Susceptible
Line 13	9.62gh	88.02abc	28.91cd	9.22f	30.40c	20.25a	24.32ab	23.00ab	76.00a	8.00	Susceptible
Giza 40	9.34def	88.35abc	27.75cde	8.65h	26.93cde	18.90a	21.85c	22.30ab	75.00a	8.45	Susceptible
Sakha 1	10.70c	86.81c	25.62fgh	11.53dc	30.73cde	10.12c	27.30b	26.00a	71.00b	7.10	Tolerant
Sakha 3	12.72b	85.49d	25.45gh	11.75bc	40.98ab	9.25c	32.99a	27.30a	68.75b	6.73	Tolerant
F-test at 5%	*	*	*	*	*	*	*	*	*	ns	

***Similar letters were not significant and difference letter were significant**

DISCUSSION

The results study revealed a significant diversity of the tested genotypes as well as commercial cultivars to infestation by *C.maculatus* under laboratory conditions. SI was selected as criterion to distinguish thesusceptible genotypes, tolerant and resistant ones. SI, is the most important factor, which mainly depends on the biology of the insect *i .e* the total number of adults emerged, the duration of developmental period of immature stages (life cycle). The results explained that the studied lines with high values of SI (1, 3, 4, 10, 11, 12, and 13) were supported with high values of progeny (emergency %) and shorter growth duration were susceptible. While, the lines with intermediate values of SI (2, 5, 6, 7, 8, 9, Sakha1 and Sakha3) which in contrast has the lowest values of progeny and longer growth duration period(life cycle) were considered tolerant or moderately resistant (MR). Results also clearly showed that, there is no any genotype or commercial cultivars exhibited complete resistant to infestation with *C. maculatus*. This result indicated that the studied genotypes were varied in their response to infestation with *C. maculatus*in accordance with Osman *et al*. (2015) who found that the tested pulse species differed in their susceptibility to infestation with pulse beetle *C .maculatus*. Also they found that the tested species affected on the biological aspects, ovipoisition period, the mean number of eggs laid and longevity of adult males and females. The extent of weight loss due to the damage of pulse beetle is quite variable and depends on the storage period, storage conditions, storage containers and varieties of legume grains (Nchimbi- Msolla and Misangu, 2002&Mebeasilassie, 2004). Furthermore, the current findings are in harmony with those recorded earlier by Wijeratne (1998) and Kazemi *et al*., (2009) who concluded that host species influenced egg and adult production. Also, the present results are in the line of Sarwar (2015) who found that there was variability for tolerance in

different wheat lines and none of them found to be completely resistant. Significant differences existed among the varieties lines for number of board grain and grain weight loss caused by *Tribolium castaneum*. Additionally, he reported that all wheat lines varied significantly in their present infestation.

Regarding to the physical and chemical composition the results clearly indicated that the tolerant group exhibited the reduced rate of emergency%, weight loss, protein % endosperm, and high ratio of seed coat, fiber %, the lowest weight loss, may be due to inability of *C. maculatus* to attack faba bean genotypes while the high content of fiber and thick of seed coat minimize capacity of insect and larvae to fed on the seed as well as , low endosperm and protein cause the seed unpalatable for insects. On the other hand, genotypes contained high endosperm, high protein, low fiber and thin seed coat supported with high rates of emergency %, weight loss %, and has shorter life cycle *i.e* considered susceptible or preferred to *C. maculatus*. Therefore, the preference of *C.maculatus* to some genotypes might be due to the physical properties and chemical composition. These properties must be taken in consideration for having resistant or tolerant seed of faba bean varieties to insect attack. These results are in agreement with Ahmed and Ahmed (2002) who concluded that the resistance of wheat grains to storage insects is a complex phenomenon which can be attributed to various physic-chemical characteristics of grains and insect species. Moreover, all the stored wheat grain of different varieties exhibited the phenomenon of preference \non preference to *Tribolium castaneum*. This phenomenon is due to the structure and composition of wheat such as, starches, carbohydrates and enzymes (Evers *et al*, 1999). And proteins (Gupta *et al* ,2000) to determine the level of resistance of cultivars to grain insect infestation. They stated that the resistance of these cultivars might be attributed to the low content of protein and high content of carbohydrate compared to the susceptible cultivars. Kernel hardness, gluten, amylase, content, larval and adult preference and emergence showed difference between resistance and susceptible cultivars (Sayed *et al* 2006, Mebarkia *et al* ,2009). Mebarkia *et al* (2010) who suggested that the susceptibility of wheat varieties to pest infestation may be attributed to the high content of protein and low content of carbohydrate compared to resistance varieties. Sarwar (2012) reported that the tolerant genotypes exhibited hard and wrinkled seed coat, dark brown color and small size grain; these characters demonstrated a significant harmful effect to pest appearance and grain damage. Ahmed *et al*. (1993) reported that cultivars with hard seed coat showed non-preference by pulse beetle. Many authors reported differences in susceptibility to brushed attack among genotypes of chickpea, suggesting the use of resistance varieties as a method to avoid infestation during storage. The tests conducted by Kashiwaba *et al* (2003) revealed that chemical compound contained in the cotyledon of bean had an inhibitory effect on the growth of the brushed species, the variation in different parameters may be due to genetic factors, possible presence of biochemical content of seeds such as antibiotics, tannin content, trypsin inhibitor, phenol content etc. (Deshpande *et al*, (2011).Adjadi *et al* (1985) proved that resistance to *C. maculatus* is controlled by two recessive genes, and indicated that for physical and chemical factors responsible for resistance, recessive genes should be present in all resistant lines and absents in all susceptible. El-Aidy *et al* (2008) studied the relationship between some chemical, physical viability seed traits and susceptibility of eight faba bean cultivars to infestation with cowpea weevil. They indicated to significant differences between cultivars in dry Mather, crude fiber, phenols ,tannins and physical traits, thickness of hull and seed coat percentage. Further results demonstrated negative correlation between number of adult progeny and holes and crude fiber, phenols, tannins and thickness of hull and these parameters affected the degree of *C.maculatus* infestation. The use of resistance cultivars is effective and economical strategy for protecting crops against insect pest attacking whilst minimizes the use of pesticides.

Concerning the differences among the 16 tested faba bean genotypes in maturity, it was noticed that the promising cultivar Sakha 1 was the best in earliness 175.5 days and reached maturity earlier than the late cultivar Sakha 3 (182 days) by 6.5 days, while other genotype lines 2, 3, 5 and lines7 reached maturity earlier than the recommended cultivars, Sakha 1 and Sakha 3 (Table 6&7). At the same trend, line 2 had the highest value in seed yield 46.70g compared with all genotypes. Therefore, lines 2 consider a good promising line for earliness and seed yield as well. These results are in full agreement with those obtained by Amer *et al.* (2014) and El-Galaly*et al* (2008). Regarding to seed yield/plant, the results of the study markedly indicated that, the early date 15- October had the highest seed yield/plant for both sowing seasons with values of 39.74 and 30.6, respectively. This variation between two seasons may be due to the climatic conditions and insect infestation as well as more disease. These results were in agreement with Amer *et al* (1992), Hussein *et al* (1994) and El-Galaly *et al* (2006) they found that, sowing on mid-October gave the highest seed yield. While, Mahmoud (1996) found that the highest seed yield was obtained from optimum sowing date. Dent, 1991 reported that sowing date was one of the main agronomic practices that could directly effect on the level of insect infestation. The interactions between genotypes and sowing date were highly significant for maturity date, no of seeds/plant and seed yield/plant (Abou-Zaid *et al*, 2017). No of seeds/plant, 100-seed weight and seed yield/plant could behave in different way from season to another and from sowing date to another (Abou-Zaid *et al* , 2017).Amer *et al* (1992), El-Deeb *et al* ,(2006), Khalil *et al* (2011) and Abebe *et al* (2015).In conclusion, the promising breeding line 2 as an early mature faba bean line that characterizes with tolerant to insect infestation along with high yield potential, especially under the stresses associated with early sowing date. Therefore, it should be taken into consideration to select the promising line 2 for faba bean breeding program to improve productivity and tolerance to insect infestation to avoid insecticide usage.

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مقارنة المقاومة الناتجة عن الصفات الفيزيائية والكميائية لسلالات مبشرة من الفول البلدي ضد خنفساء اللوبيا بعد الحصاد

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أجريت تجربتان حقليتان خلال الموسمين 2016/2015 ، 2017/2016 بمحطة البحوث الزراعية بسخا لتقيم ثلاثة عشرة سلالة مبشرة من الفول البلدي مختارة من برنامج التربية بسخا سبق زراعتها في منتصف اكتوبر كميعاد مبكر ,ومنتصف نوفمبر كميعاد متأخر ضد خنفساء اللوبيا وذلك مقارنة بثلاثة اصناف تجارية هي سخا 1,جيزة 40,سخا 3 ثم أجريت تجربتين معمليتين خلال الموسمين بعد الحصاد. وأوضحت النتائج أن: 1- كان دليل الحساسية ومحصول البذور لكل نبات والوزن الصافي هي المعايير المستخدمة في التقيم و قد اظهرت النتائج اختلاف اصابة السلالات والاصناف المحتبرة بخنفساء اللوبيا اختلافا واضحا, وقد تم تقسيم السلالات والاصناف موضع الاختبار الي مجموعتين طبقا لقيم دليل الحساسية. المجموعة الاولي ذات القيم العالية من دليل الحساسية تتراوح بين (10,0-7,5), عدد الحشرات الناتجة في الجيل الاول, الفقد في الوزن واقل دورة حياة فقد تم تصنيفها علي انها حساسة الاصابة اماالمجموعة الثانية والتي اظهرت قيما متوسطة من دليل الحساسية (7,5-5,1) واقل عدد من الحشرات الناتجة في الجيل الاول مع اقل نسبة من الفقد في الوزن واطول دورة حياة كانت مجموعة متوسطة الاصابة (متحملة) . 2- اظهرت النتائج غياب ظاهرة المقاومة الكاملة تماما من السلالات والاصناف المدروسة. 3- كان هناك علاقة ايجابية بين الصفات الفيزيائية والكميائية ونسبة الاصابة بحشرة خنفساء اللوبيا. وطبقا لقيم دليل الحساسية ومحصول البذور/ نبات والنسبة المئوية للوزن الصافي فإن السلالة2 والصنف سخا3هي الاكثر تحملا بينما كانت السلالة4 والصنف جيزة 40 هي الاكثر حساسية بالاضافة الي ذلك كان ميعاد الزراعة منتصف اكتوبر هو تاريخ الزراعة المناسب لتحقيق اعلي انتاجية علي امتداد موسمي الزراعة.بالنسبه لصفه المحصول والتبكير اظهرت السلاله 2 مقاومه للاصابه الحشريه مع الحفاظ على الانتاجيه العاليه والتبكير خاصه تحت ظروف الاصابه خلال ميعاد الزراعه المبكر. لذلك يجب يجب الاخذ فى الاعتبار استخدام السلاله 2 فى برامج التربيه فى الفول البلدى لتحسين صفه المقاومه للحشرات مما يقلل من استخدام المبيدات. كما اظهرت الدراسه اهميه الخصائص الكيماويه والفيزيقيه لبذور الفول البلدى للوقايه من الاصابه الحشريه.