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The relationship between agronomic characters of certain soybean varieties and infestation resistance of *Etiella zinckenella* (Lepidoptera: Pyralidae) under natural conditions

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Abstract
A field experiment was carried out at Giza Agricultural Experiments and Research Station, Agricultural Research Center, Giza, Egypt during 2017 and 2018 two summer seasons. The experiment included five soybean varieties (Giza 21, Giza 22, Giza 35, Giza 111, Crawford and genotype (Dr-101)) were distributed in randomized complete block design with three replications. Therefore, the objectives of this study evaluate of the commonly grown soybean varieties and genotype (Dr101) in Egypt with respect to their relative susceptibility to infestation with *Etiella zinckenella* and the relationship between different agronomic characters of the variety and infestation rates and weight seed losses. It was observed that there was a significant difference in natural infestation of soybean varieties by *E. zinckenella*. The results indicated that soybean varieties Giza35, Crawford and Giza22 had higher susceptibility by the insect infestation than others. Soybean varieties Giza21 and Giza111 were two moderately resistant for pod infestation, while soybean genotype Dr-101 was resistant that recorded the lowest infestation percentage and weight seed losses compared with others. These results reveal that damage of *E. zinckenella* depended on soybean variety and probably due to plants of soybean genotype Dr-101 had the highest pod pubescence density, and the lowest N content in their leaves, which formed biological barrier for the young larvae of this insect to penetrate soybean pod compared with the others. However, soybean varieties Giza 22 and Giza 111 had higher values of seed yields per plant and per ha than others.

Keywords: soybean varieties, *Etiella zinckenella*, seed yield, relative resistance

Introduction

Soybean, *Glycine max* (L.) is considering as very important sources of edible vegetable oil and protein, where seeds contain about 40% protein and 20% edible vegetable oil as well as 30% carbohydrates, 10% total sugar and 5% ash [1, 2]. Also it contains lot of the essential vitamins for the body. Therefore, in Egypt, it was started agriculture from the year 1976; because it is a basic source of protein, and the soybean oil is used directly in food and preventing blood pressure, Arteriosclerosis and soybean peel used in the poultry and animal feed [3]. Now, in Egypt, production of soybean reaches more than 40% from production of world [4]. Research experiences showed that 15 - 20% of the total soybean production was lost directly or indirectly by the attack of insect pests every year [5]. Specially, the larvae of lima bean pod borer, *Etiella zinckenella* caused considerable direct damage and seed yield losses by feeding on seeds and indirect damage by reducing quality and marketability of infested crops [6]. Although the main control resistance used against this insect is aerial spraying of pesticides but the continuous use of pesticides has resulted in resurgence of pesticide-resistant insect populations and elevation of secondary pests to a status of primary importance [7]**.** It is known that the highest population of pod borer in soybean occurs in harvest, host plant can be served as source of pest population and as direct or indirect pest controller [8] where this insect caused seed yield loss up to 80% [9].
Accordingly, Amro *et al*. [10] indicated that soybean varieties Clark, Giza 22 and Toano equipped higher infestation by *E. zinckenella* than soybean varieties Hagen 32 and S5. They added that the highest damage percentage appeared on soybean variety Toano while the lowest one appeared on soybean variety Hagon 32. So, the usage of a resistant variety is able to decrease pesticide residue in environment and economically benefit [11]. There are variability responses of soybean genotypes to lima bean pod borer [12]. The importance of pubescence

density and leaf nitrogen (N) content on pod soybean varieties may represent a positive role in resistance against *E. zinckenella*. Particularly, Naroz *et al.* [13] showed that leaf N content in soybean varieties Giza 21 and Giza 111played an indirect role in increasing rate of *E. zinckenella* infestation. Therefore, the objective of this study was to evaluate of the commonly grown soybean varieties and genotype (Dr101) with respect to their relative susceptibility to infestation with *E. zinckenella* and the relationship between different agronomic characters of the variety and infestation rates, weight seed losses.

Materials and Methods

Experimental design

This study was carried out at Giza Agricultural Experiments and Research Station (Lat. 30°00′30″ N, Long. 31°12′43″ E, 26 m a.s.l), Agricultural Research Center (ARC), Giza, Egypt during two successive summer seasons (2017 and 2018). Five soybean varieties (Giza 21, Giza 22, Giza 35 and Giza 111, Crawford and genotype Dr-101) were used in this study. Table (1) shows the common names, pedigree, origin, maturity group and growth habit of the studied soybean cultivars. Furrow irrigation was the irrigation system in the area. The soybean varieties were drilled in one row of ridge, thereafter, soybean plants were thinned to two plants at 10 cm between hills. Soybean seeds were sown on May 28th and June 3rd in 2017 and 2018 seasons, respectively. Randomized Complete Block Design (RCBD) with three replications was used. The experimental plots received all regular agricultural practices and chemical control was entirely avoided. The area of plot was 9.0 m^2 with each plot consisted of five ridges and each ridge was 3.0 m in length and 0.6 m in width.

Table 1: The common names, pedigree, origin, maturity group and growth habit of the studied soybean varieties

Soybean variety	Origin	Pedigree	Maturity group	Growth habit
Giza21	Egypt	Crawford x Forrest	IV	Indeterminate
Giza22	Egypt	Giza 21 x 186 k -73	IV	Indeterminate
Giza35	Egypt	Crawford x Celest (early)	III	Indeterminate
Giza111	Egypt	Crawford x Celest (late)	IV	Indeterminate
Crawford	USA	Williams x Columbus	IV	Indeterminate
Dr-101	Egypt	Selected from Elgin	V	Determinate

III, IV and V: Development period of the varieties is after 90,120 and 150days from the agriculture, respectively

The studied Traits

Infestation percentages of soybean pods

Samples were taken after appearing pods and continued till collecting the yield at the end of September. Samples were collected from the diagonal of every plot, consisted of 90 random green pods (30 pods/each plot). The green pods were kept in a paper bags then transferred to the laboratory. These experiments were carried out to determine the mean numbers of the larval escaping holes on the green and dry soybean pods is considered as an indicator of the infestation percentage caused by *E. zinckenella*. The infestation percentage was calculated as follows:

$$\% \text{ infestation} = \frac{\text{Number of infested pods}}{\text{Number of total pods}} \times 100$$

Losses of weight seeds

The percentage of weight loss in the seed plants was calculated by the "count-and-weight" method described by Harris and Lindblad [14] applying the following equation:

$$\% \text{ Weight loss} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

Where; Wu means weight of undamaged seeds, Nd means number of damaged seeds, Wd means weight of damaged seeds and Nu means number of undamaged seeds.

The resistance status of the tested soybeans to *E. zinckenella*

The resistance status of the tested soybean varieties dependent on the mean number of pod infested.

$$\% \text{ pod infestation} = \frac{\text{Number of infested pods}}{\text{Number of total pods}} \times 100$$

$$\% \text{ seed damage} = \frac{\text{Number of seed damage}}{\text{Number of total seeds}} \times 100$$

Determination of resistance criteria based on the formula bellow [15] :< X – 2 SD = HR (Highly Resistant), X – 2 SD to X – SD = R (Resistant), X – SD to X = MR (Moderately Resistant), X to X + SD = S (Susceptible) and >X + SD = HS (Highly Susceptible). Where; X = Mean of pod damage or seed damage and SD = Standard deviation.

Leaf nitrogen content in soybean varieties

Leaf nitrogen (N) content was taken at 60 days from sowing for analyzed by the General Organization for Agricultural Equalization Fund, ARC, Giza, Egypt. The leaves (blade only) from three plants were separated, dried, in an oven set at 75° C until reaching constant mass (approximately 48h) and weighed. Leaf samples were finely ground, thoroughly mixed, and then stored dry in closed containers until analyzed for N content. N was determined by Kjeldahl digestion, followed by colorimetric assay for ammonia – N [16].

Pod pubescence density of soybean varieties

Pubescence traits were taken at 60 days from sowing on three pods of soybean varieties exhibiting a range of insect infestation levels and pubescence ratings. Pubescence density was divided into three phenotypes: dense, normal and sparse according to Singh [17]. Pubescence traits were estimated by the pubescence length (µm), number of pubescence per 500 µm and pubescence density. Pubescence traits were estimated as an indication of direct defense for insect infestation by using SEM Model Quanta 250 FEG (Field Emission Gun) in the Egyptian Mineral Resources Authority Central Laboratories Sector.

Seed yield and its attributes

At harvest, the observations on traits, namely plant height (cm), number of branches per plant, number of pods per plant, seed yield per plant and 100–seed weight were recorded on ten guarded plants from each plot. Seed yield per plot (kg) was recorded on the basis of experimental plot and expressed as ton per ha.

Statistical Analysis

The obtained data of insects were subjected to analysis of variance (ANOVA), with the means separated using Duncan's Multiple Range criterion (P<0.05). The data for each experiment were then analyzed by MSTAT-C [18] software for comparison of the mean values and the two seasons by LSD test at the 5% level. Response equations were calculated according to Snedecor and Cochran [19].

Results and Discussion

Infestation percentage of *E. zinckenella*

Data in Tables (2 and 3) and (Fig 1) reveal that the susceptibility of the tested soybean varieties to the infestation with *E. zinckenella* varied statistically according to soybean variety. In general, infestation percentage was higher for all soybean varieties during the first season than that of the second one. Mean percentage of infestation ranged among the studied soybean varieties from 21.29 to 42.31% in the first season and ranged from 19.26 to 37.04% in the second one. However, the data obtained indicate that soybean genotype Dr-101 was the lowest susceptible variety where the mean percentage of infestation recorded 21.29% in the first season and 19.26% in the second one. In the first season, soybean varieties Giza 35 and Crawford were relatively the most susceptible to *E. zinckenella* infestation followed by others as shown in Table (2). Mean percentage of the infestation was 42.31, 41.23, 38.90, 35.80, 34.32 and 21.29% for soybean varieties Giza 35, Crawford, Giza 22, Giza 21, Giza 111and Dr-101, respectively. On the other hand, soybean variety Giza 35was relatively the most susceptible to infestation followed others in the second season as shown in Table (3). Mean percentage of the infestation was 37.04, 34.57, 33.85, 30.25, 30.99 and 19.26% for soybean varieties Giza 35, Crawford, Giza 22, Giza 21, Giza 111 and Dr-101, respectively. Statistical analysis of the data has shown highly significant differences among the tested varieties in the two seasons.

These results were dissimilar to with those reported by Shaabeny [20] who found that percentage of infestation with *E. zinckenella* of Crawford variety was higher in the second season (8.5%) than the first one (7.1%). He added that soybean variety Crawford had the maximum percentage of infestation in two seasons followed by a soybean variety Giza 35 in the first season and soybean variety Giza 111 in the second one. Moreover, Kuswantoro *et al.* [9] showed that the highest percentage of pod damage by *E. zinckenella* larvae on soybean variety No.29, while the lowest percentage was found on soybean variety Tgm/Anj-790.

Table 2: Mean percentage of the infested green and dry soybean pods by *E. zinckenella* indifferent soybean varieties during 2017 season.

Sampling dates	Soybean varieties					
	Giza21	**Giza22**	**Giza35**	**Giza111**	**Crawford**	**Dr-101**
3 August	7.78	4.44	11.11	8.88	6.67	2.22
10 August	26.67	21.11	24.44	15.56	17.77	4.44
17 August	38.89	26.67	31.11	20.00	33.33	11.11
24 August	32.22	34.44	32.22	28.89	40.00	13.00
30 August	38.89	38.89	43.33	34.44	48.89	20.00
7 September	40.00	51.11	61.11	48.89	66.67	23.33
13 September	40.11	57.78	55.56	50	56.67	30.00
20 September	40.00	65.67	66.33	44.44	51.11	38.33
27 September	56.67	50.00	55.56	57.78	50	48.89
Mean	35.80bc	38.90ab	42.31a	34.32c	41.23a	21.29d
F. value	25.37					
p	0.0001					
L.S.D. 0.05	4.25					

The number followed by the same letter is not different based on least significant different at 5% level (LSD 5%).

Table 3: The mean percentage of the infested green and dry soybean pods by *E. zinckenella* in different soybean varieties during 2018 season.

Sampling dates	Soybean varieties					
	Giza 21	**Giza 22**	**Giza 35**	**Giza 111**	**Crawford**	**Dr-101**
6 August	6.67	7.78	7.78	6.67	8.89	0
13 August	13.33	25.56	24.44	13.33	15.56	3.33
20 August	17.78	27.78	27.78	22.22	23.33	7.78
27 August	21.11	33.33	30.00	32.22	35.56	13.33
3 September	23.33	27.87	35.56	23.33	37.78	18.89
9 September	27.78	26.67	40.00	22.22	42.22	22.22
17 September	44.44	33.33	43.33	38.89	45.56	28.89
23 September	56.67	46.67	54.44	56.67	50.00	35.56
30 September	61.11	75.68	70.00	63.33	52.22	43.33
Mean	30.25c	33.85abc	37.04a	30.99bc	34.57ab	19.26d
F. value	15.46					
p	0.0001					
L.S.D. 0.05	4.21					

The number followed by the same letter is not different based on least significant different at 5% level (LSD 5%).

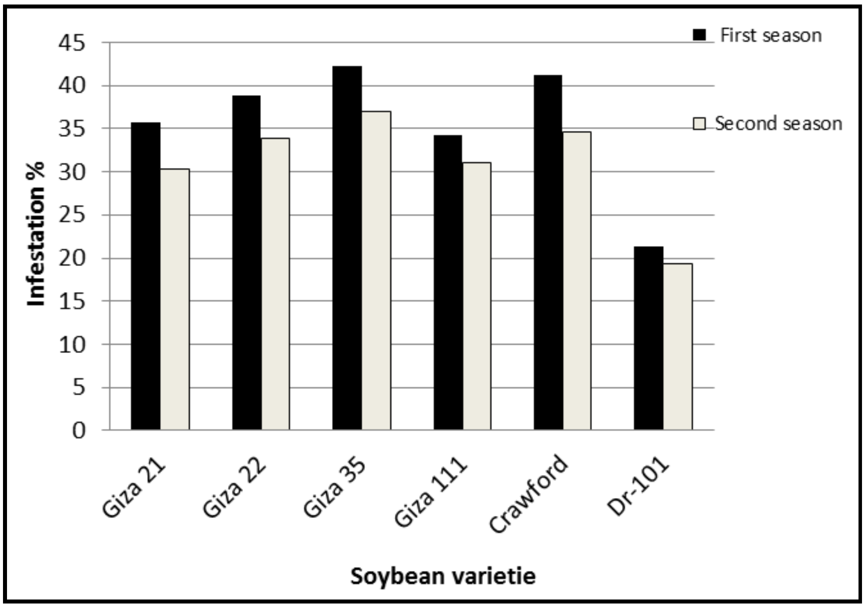

Fig 1: The mean percentage of the infested green and dry soybean pods by *E. zinckenella* in different soybean varieties during 2017 and2018 seasons

Weight losses

Data presented in Tables (4&5) and (Fig. 2) also show that soybean varieties differed significantly for percentage losses of attacked seed by *E. zinckenella*. The percentage of weight seed losses in all soybean varieties ranged from 3.95 to 15.61% in the first season and from0.67 to 13.08% in the second one. Soybean variety Giza 22 recorded the highest percentage of weight seed losses (15.6 and 13.08%) followed by soybean variety Crawford (14.73and 11.34%). Meanwhile, soybean genotype Dr-101 recorded the lowest percentage of weight seed losses 3.95and0.67% in both seasons, respectively.

Table 4: Weight losses% of seeds indifferent soybean varieties by *E. zinckenella* during2017 season.

Soybean variety	Date of assessment	Giza 21	Giza 22	Giza 35	Giza 111	Crawford	Dr-101
	24 August	7.09	8.99	5.99	3.65	9.70	2.88
	30 August	8.05	10.29	6.57	4.17	11.25	2.72
	7 September	10.00	18.75	11.32	14.03	21.34	4.68
	13 September	14.37	13.98	8.35	14.18	17.24	4.01
	20 September	13.37	26.21	12.90	10.56	12.34	4.16
	27 September	23.14	21.58	9.17	16.21	16.49	5.253
Mean		12.45b	15.61a	8.84c	10.47 bc	14.73a	3.95d
F. test 0.05		48.76					
L.S.D.0.05		2.24					

The number followed by the same letter is not different based on least significant different at 5% level (LSD 5%).

Table 5: Weight losses% of seeds in different soybean varieties by *E. zinckenella* during 2018 season

Soybean variety	Date of assessment	Giza 21	Giza 22	Giza 35	Giza 111	Crawford	Dr-101
	24 August	3.41	2.88	3.35	2.86	6.38	0.51
	30 August	3.41	3.84	3.75	3.26	6.07	0.52
	7 September	5.68	10.29	2.26	3.55	8.90	0.645
	13 September	10.42	15.34	5.15	10.76	13.08	0.602
	20 September	11.72	19.14	8.05	17.63	15.76	0.782
	27 September	16.94	26.98	14.07	21.41	17.8421	0.928
Mean		8.60bc	13.08a	6.12c	9.91b	11.34ab	0.67d
F. test 0.05		12.91					
L.S.D.0.05		2.77					

The number followed by the same letter is not different based on least significant different at 5% level (LSD 5%).

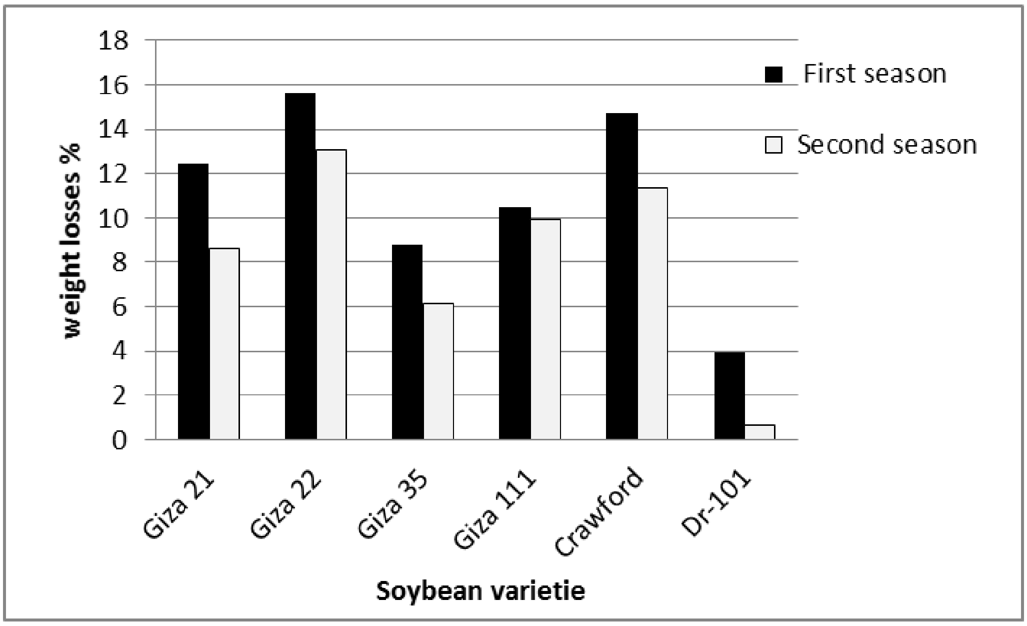

Fig 2: Weight losses% of seeds in different soybean varieties by *E. zinckenella* during2017 and2018 seasons

These results were agreement with those reported by Kuswantoro *et al.* [9] who found that differences in soybean genotype significantly affected percentage of attacked seed by *E. zinckenella*. They added that the highest percentage of seed losses by *E. zinckenella* larvae was found on genotype Tgm/Anj- 790, while the lowest percentage of pod damage found on genotype Tgm/Anj-871.

The resistance status of the tested variety to the *E. zinckenella*

Data in Table (6) presented infestation percentages and seed weight losses caused by *E. zinckenella* of different soybean varieties. According to percentage of infestation pod, the results reveal that Giza 35, Crawford and Giza22 were susceptible varieties. While, Giza21 and Giza111were moderately resistant varieties, butDr-101was resistant variety in both seasons. With respect to percentage of seed weight losses, there were three susceptible soybean varieties (Giza22, Crawford and Giza21), two moderately resistant soybean varieties (Giza35 and Giza111) and one resistant soybean variety (Dr-101) in the first season. Meanwhile, soybean varieties Giza111 and Crawford were susceptible, soybean varieties Giza21 andGiza35 were moderately resistant, and Giza 22 and genotype Dr-101 were highly susceptible and resistant, respectively in the second season. These results are harmony with those obtained by Kuswantoro *et al.* [9] who found that five soybean genotypes were resistant and seventeen soybean genotypes were moderately resistant. Moreover, Naroz *et al*. [13] showed that *E. zinckenella* caused significant losses in seed yield of soybean varieties except Giza 82 that was early maturing variety.

Table 6: The resistance status of the tested varieties to *E. zinckenella* during (2017 and 2018 seasons).

Soybean variety	2017 season				2018 season			
	Pod infested (%)	Criteria	Seed damage (%)	Criteria	Pod infested (%)	Criteria	Seed damage (%)	Criteria
Giza21	35.80	MR	12.45	S	30.25	MR	8.60	MR
Giza22	38.90	S	15.61	S	33.85	S	13.08	HS
Giza35	42.31	S	8.84	MR	37.04	S	6.12	MR
Giza111	34.32	MR	10.47	MR	30.99	MR	9.91	S
Crawford	41.23	S	14.73	S	34.57	S	11.34	S
Dr-101	21.29	HR	0.67	R	19.26	R	3.95	R

HR = highly resistant, R = resistant, MR = moderately resistant, S = susceptible, HS = highly susceptible

Leaf Nitrogen (N) content

Data in Figure (3) reveals that soybean varieties differed significantly for leaf N content after 60 days from sowing. Soybean variety Crawford was superior to others for leaf N content; meanwhile the reverse was true for soybean variety Dr-101. However, there were no significant differences between soybean varieties Giza 111 and Giza 21 for leaf N content; also, there were no significant differences between soybean varieties Giza 22 and Giza 35. This variation in the leaf N content of the tested varieties probably attributed to difference in genetic make-up of soybean varieties that translated into morphological and physiological differences among them and led to different changes in this trait. These results is similar to Abdel-Wahab EI [21] showed that soybean varieties differed in the amount of N accumulated in vegetative tissues and in the proportion of vegetative N mobilized for seed growth.

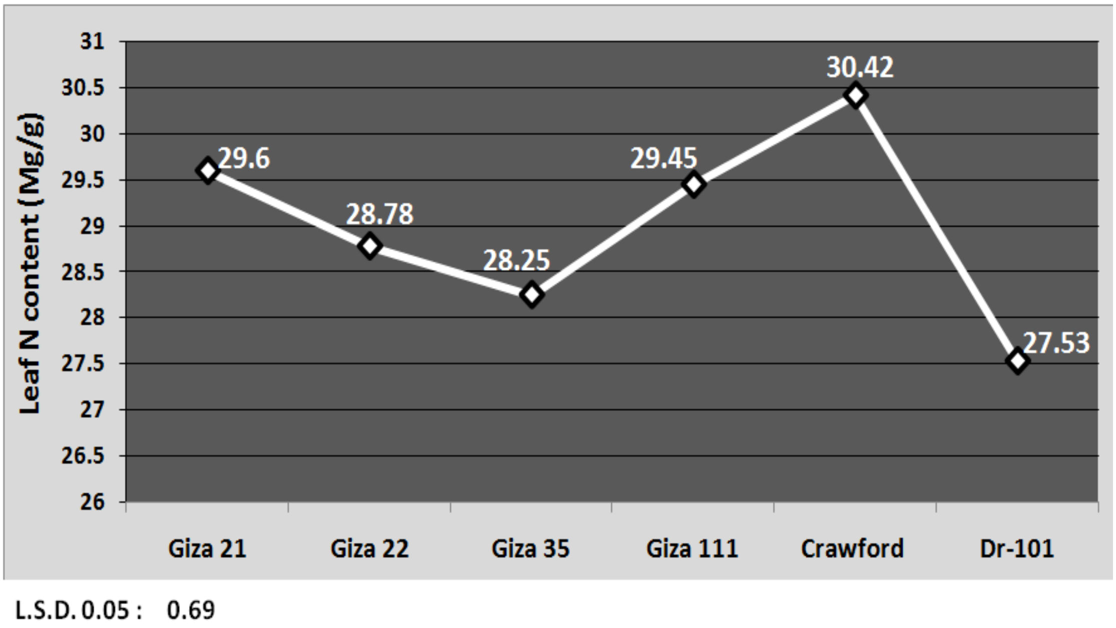

Fig 3: Leaf nitrogen (N) content (mg/g) in the studied soybean varieties

Pod pubescence density of the studied soybean varieties

Soybean varieties differed significantly for mean of pubescence length and number of pubescence per 500 µm (Table 7andFig. 4). Soybean variety Giza 22 was superior to others for pubescence length, meanwhile soybean variety Dr-101 had the shorter one compared with others. Also, soybean varieties Giza 35 and Dr-101 had higher pod pubescence density than others. On contrary, soybean variety Crawford had lower pod pubescence density than others. These results may be due to genetic makeup of the studied soybean varieties that translated into suitable anatomical characteristics which reflected on pubescence density in their pods.

Table 7: Mean of pubescence length, number of pubescence per 500 µm and pubescence density in pods of the studied soybean varieties.

Soybean varieties	Pubescence length (µm)	Number of pubescence (500 µm)	Pubescence density
Giza 21	390.6	81	Normal
Giza 22	822.1	56	Normal
Giza 35	421.9	115	Dense
Giza111	390.7	77	Normal
Crawford	443.2	29	Sparse
Dr-101	264.2	111	Dense
L.S.D. 0.05	117.63	26.39	---

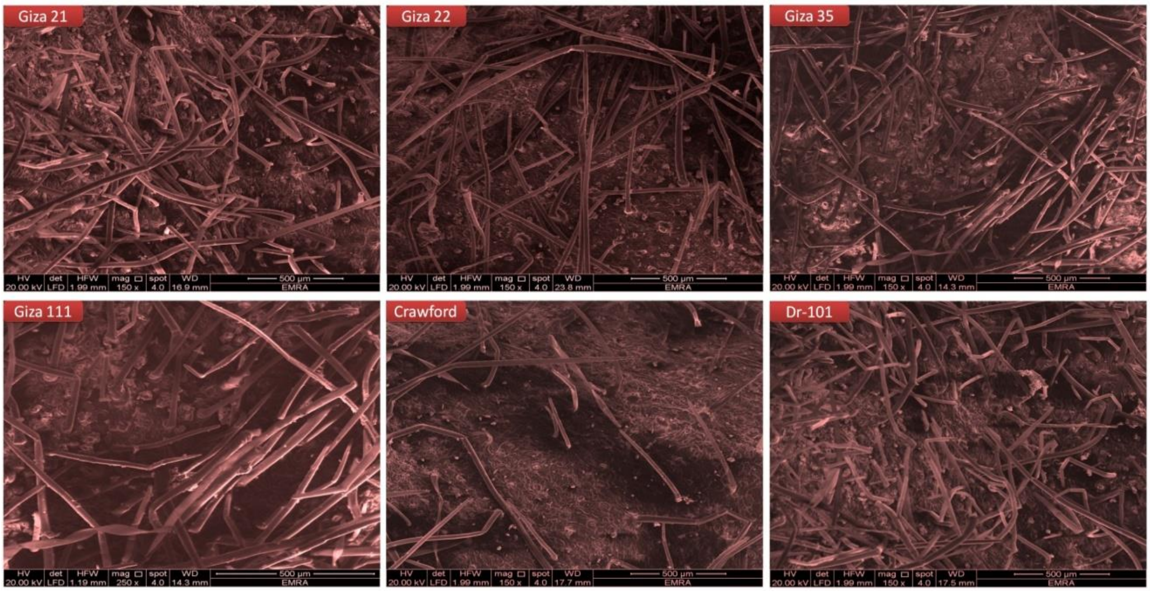

Fig 4: Scanning of pod pubescence density of the studied soybean varieties by electronic microscope

Generally, it was observed that the population density of *E. zinckenella* for all soybean varieties increased gradually and was maximum population during the end of season. However, it seems that *E. zinckenella* appeared to be little active before the maturity stage on soybean genotype Dr-101 compared with the other varieties. These results probably due to plants of soybean genotype Dr-101 had the highest pod pubescence density (Fig. 4 and Table 7), and the lowest N content in their leaves (Fig. 3), which formed biological barrier for the young larvae of this insect to penetrate soybean pod compared with the others. It is worthy to note that soybean variety Giza 111 ranked second for resistance of this insect. These results reveal that damage of *E. zinckenella* depended on soybean variety. These results are in accordance with those observed by Lam and Pedigo [22] who demonstrated that densely pubescent soybean of Clark isoline had the potential to resist bean leaf beetle feeding on pods than others. These results may be due to maturity group and growth habit of the tested soybean varieties (Table 1) that reflected on photosynthetic activities and accumulation of dry matter during growth and development stages.

Seed yield and its attributes of some soybean varieties

Data in Table (8) shows seed yield of tested soybean varieties and their attributes of during the two seasons. Soybean varieties differed significantly for all the studied traits in the two seasons. Giza 21 had the tallest plants (115.33 cm in the first season and 112.86 cm in the second one) compared to others. Giza 111 came in the second rank (108.27 cm in the first season and 110.93 cm in the second one) followed by Giza 35 (103.41 cm in the first season and 105.70 in the second season). Conversely, genotype Dr-101 had the shortest variety. This variation in plant height could be attributed to differences in genetic make-up of soybean varieties completed with growth environment. In general, internode elongation of soybean variety Giza 21 could be increased as a result of increasing use water and soil nutrients better than others and ultimately increase its plant height. The present findings are in partial agreement with the result of Noureldin *et al.* [23] who reported that Giza21 is the tallest variety as compared with others. Also, Abdel-Wahab [24] found that genotype Dr–101 was the shortest in comparison with other soybean genotypes. Moreover, Safina *et al.* [25] stated that soybean genotype Dr-101 was the shortest one.

Table 8: Seed yield and yield attributes of some soybean varieties (2017 and 2018 seasons).

Traits	plant height (cm)	Branches per plant (no.)	Pods per plant (no.)	Seed yield per plant (g)	100-seed weight (g)	Seed yield per ha (ton)
2017 season						
Giza 21	115.33	3.41	91.96	33.72	17.52	3.37 S
Giza 22	87.08	4.81	129.71	40.52	18.86	3.61 S
Giza 35	103.41	5.47	113.53	38.74	18.15	3.42 MR
Giza 111	108.27	4.93	166.16	40.04	16.83	3.56 MR
Crawford	101.33	3.33	120.77	31.02	15.98	2.13 S
Dr-101	71.39	2.93	71.42	29.87	19.32	1.85 R
L.S.D.0.05	6.62	1.37	19.58	3.43	1.18	0.22
2018 season						
Giza 21	112.86	3.36	89.24	31.16	17.01	3.30
Giza 22	85.61	4.70	126.02	38.87	18.42	3.54
Giza 35	105.70	5.34	110.88	35.41	17.74	3.37
Giza 111	110.93	4.81	162.46	37.53	16.35	3.50
Crawford	104.57	3.30	116.63	30.22	15.66	2.06
Dr-101	74.78	2.79	66.18	27.68	19.04	1.78
L.S.D.0.05	7.07	1.48	21.25	3.84	1.02	0.15

With respect to the number of branches per plant, soybean variety Giza 35 had higher values of a number of branches per plant (5.47 in the first season and 5.34 in the second one) than others. Soybean variety Giza 111 came in the second rank (4.93 in the first season and 4.81 in the second one) followed by a soybean variety Giza 22 (4.81 in the first season and 4.70 in the second one). Conversely, soybean genotype Dr-101 had lower values of number of branches per plant (2.93 in the first season and 2.79 in the second one) than others. These results may be attributed to the fact that soybean variety Giza 35 benefited greatly from environmental climatic resources which reflected positively on more photosynthetic activities and accumulation of dry matter during growth and development stages. These results are in parallel with those observed by Abd El-Mohsen *et al*. [26] who found that the highest of number of branches plant per plant was achieved in Giza 111 compared to others. Finally, Abdel-Wahab [24] reported that Dr–101 showed significant fewer values of a number of branches per plant than Giza 111 and Giza 22.

With respect to number of pods per plant, Giza 111 was superior to other soybean varieties (Table 8). Giza 111 had the highest number of pods per plant (166.16 in the first season and 162.46 in the second one). Giza 22 came in the second rank (129.71 in the first season and 126.02 in the second one) followed by Crawford (120.77 in the first season and 116.63 in the second one). Conversely, genotype Dr-101 had lower values of number of pods per plant (71.42 in the first season and 66.18 in the second one) than others. These data may be due to leaves of Giza 111 had anatomical and physiological characteristics that resulted in higher efficiency of photosynthetic process and lower lima bean pod borer infestation to provide a good opportunity for yield improvement than others. Similar results were observed by Naroz *et al*. [13] who indicated that Giza 111 had a higher number of pods/plant than others.

With respect to seed yield per plant, Giza 22 and Giza 111 had higher values of seed yield per plant (Table 8). Giza 22 recorded 40.52 g in the first season and 38.87 g in the second one) and Giza 111 recorded 40.04 g in the first season and 37.53 g in the second one than others. Giza 35 came in the second rank (38.74 g in the first season and 35.41 g in the second one) followed by Giza 21 (33.72 g in the first season and 31.16 g in the second one). Conversely, genotype Dr-101 had lower values of seed yield per plant (29.87 g in the first season and 27.68 g in the second one) than others. These results may due to plants of soybean varieties Giza 22 and Giza 111 were more efficient in utilizing solar energy as a result of acceptable percentage of N in their leaves (Fig. 3) and consequently more dry matter accumulation in different parts of soybean plant organs during growth and development stages. It is important tonote that leaves of soybean variety Crawford that had the highest N percentage (Fig. 3) and the lowest pubescence density (Fig. 4 and Table 7) permitted many insects and viruses to attack this variety which formed a good environment for lima bean pod borer prevalence within plants of this variety. Seed yield is a function of yield attributes and thereby increase in seed yield per plant was the cumulative effect of increase in numbers of branches per plant and pods per plant. It is known that the seed reached its maximum dry weight at physiological maturity [27].

With respect to 100-seed weight, soybean genotype Dr-101 was superior to other soybean varieties (Table 8). Soybean genotype Dr-101 had higher values of 100-seed weight (19.32 g in the first season and 19.04 g in the second one) than others. Soybean variety Giza 22 came in the second rank (18.86 g in the first season and 18.42 g in the second one) followed by soybean variety Giza 35 (18.15 g in the first season and 17.74 g in the second one). Conversely, soybean variety Crawford had lower values of number of pods per plant (15.98 g in the first season and 15.66 g in the second one) than others. These results could be due to maturity group and growth habit of plants of soybean genotype Dr-101 (Table 1) had the longest period of soybean growth during available normal climatic conditions from pollination to seed filling stage as a result of the lowest N content in their leaves (Fig. 3) and the highest pod pubescence density (Fig. 4 and Table 7) as compared with others.

With respect to seed yield per ha, soybean varieties Giza 22 and Giza 111 had higher values of seed yield per ha than others (Table 8). Soybean variety Giza 22 recorded 3.61 ton in the first season and 3.54 ton in the second one, as well as, soybean variety Giza 111 recorded 3.56 ton in the first season and 3.50 ton in the second one than others. Although soybean varieties Giza 22 and Giza 111 were susceptible and moderately resistant, respectively for *E. zinckenella* infestation but their seed yields did not reach economic damage. Soybean variety Giza 35 came in the second rank (3.42 ton in the first season and 3.37 ton in the second one) followed by soybean variety Giza 21 (3.37 ton in the first season and 3.30 ton in the second one). Conversely, soybean genotype Dr-101 had lower values of seed yield per ha (1.85 ton in the first season and 1.78 ton in the second one) than others. These results could be attributed to interaction between infestation percentages of *E. zinckenella* and soybean variety determined economic damage in soybean productivity. It is known that most soybean varieties differ in their yield attributes where Hassan *et al.* [28] indicated that Giza 22 variety surpassed all tested cultivars in numbers of pods and seeds, as well as, seed yield per plant followed by soybean variety Giza 35. They added that soybean variety Giza 111 had the heaviest weight of 100 seeds followed by soybean varieties Giza 22, Giza 35 and Crawford. In another study, Kandil *et al*. [29] stated that Giza 21 variety significantly superior to soybean varieties H30, H32, H2L12, Giza 22 and Giza 111 in seed yield and its components in both seasons. Also, Safina *et al*. [25] found that there were significant differences among the studied soybean genotypes for seed yield and its attributes.

Conclusion

It can be concluded that the use of host plant resistance offers a promising possibility for *E. zinckenella* control under field conditions. Plant breeders should be selected soybean varieties that have desirable resistance levels for *E. zinckenella*. *E. zinckenella* prefers plants of soybean varieties Crawford, Giza 35 and Giza 22. However, genotype Dr101 had resistant of this insect, did not present a high damaging potential to yield of all soybean varieties, also soybean genotype Dr-101 recorded the lowest percentage of weight seed losses in both seasons.

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