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Effect of intercropping, fertilization on infestation of lima bean pod borer *Etiella zinckenella* (Treit.) (Lepidoptera: Pyralidae) on Cowpea and control it

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Abstract
Field experiments were conducted during 2020and2021 at the Plant Protection Research Station at Qaha region, Qalubiya Governorate, to study the effect of intercropping, fertilization on infestation of lima bean pod borer *Etiella zinckenella* on cowpea and evaluation of three chemical compounds to control it. Evaluation the efficiency of intercropping between cowpea and (Dill- Coriander- Jute mallow), the efficiency of fertilization Potakarb (K) and Folisil Calcium (Ca)at 300cm/100 L water were used. Also three chemical compounds [Egyxide plus (1000ml/100L water), Tebufenozide (75cm^3/100L water) and Deltalym (320cm^3/fed.)] were evaluated to control *E. zinckenella.*
The lowest mean numbers of population densities of *E. zinckenella* were (0.05 and0.05 larvae/30 Pods) and (0.36and0.3 larvae/30 Pods) occurred in the case of intercropping (Cowpea+Dill) during 2020and2021 seasons on Cowpea's green and dry pods, respectively.
Deltalym showed the highest reduction(%) in larval population after the first and second spray(86.6and89.4%)and(84and91.9%)during 2020and2021 seasons on Cowpea's green pods, respectively. whereas the reduction with the use of Tebufenozide showed maximum reduction in the first and second spray (61.5 and 65.8%) in the first season(63.2and64.4%)in the second one on Cowpea's dry pods.
Tebufenozide recorded the highest percent in total protein in cowpea grains during seasons 2020and2021. The highest yield of green pods was obtained in the intercropping of Cowpea+Dill in two seasons. The highest yield of dry pods was obtained in the case of treatment with Tebufenozide (635and600 kg/fed.) in the two seasons. The yield of dry pod resulting from the intercropping with Dill was highly protected from the infestation with postharvest insects in the two seasons.

Keywords: *Etiella zinckenella*, intercropping, fertilization, chemical compounds, storage

Introduction
Grain legumes are important source of proteins (up to 35%) for food and it can use as a substitute of animal protein in many countries especially the countries of the Third World where plant production is more important than animal production (Nelson *et al.* 1997) [13]. Additionally, to its importance in human food, cowpea is also useful for soil fertilization through symbiotic nitrogen fixation and also as a source of animal feed due to the quality of its leaves (Diouf, 2011) [8].
Cowpea (*Vigna unguiculata* (L)) is a member of the family Leguminosae. Out of 170 species within the genus, *V. unguiculata* is the formost important grain legume of the world (Akimbo, *et al*., 2006; Onwueme and Sinha, 1991) [5, 15].
Cowpea plants are subjected to attack by several insect pests, the foremost serious of there is the lima bean pod borer *E. zinckenella* (Oladiran and Oso, 1985 and Abdallah, *et al*.1994) [1]. The damage of *E. zinckenella* usually occurs on pods and also fed on seeds (Van Den Berg, *et al*. 1998) [21]. Thus, all pods are destroyed during the crop's reproductive stage resulting considerable loss of yield at harvest (Sukul, *et al*. 1989) [20].
The present experiment aimed at study the effect of intercropping, fertilization and evaluation of certain chemical compounds in the reduction of *E. zinckenella* infestation and also the study of all the effect previous factors within the infestation with post-harvest insects.

Material and Methods
This investigation was conducted at the Plant Protection Research Station at Qaha region, Qalubiya Governorate during of 2020 and 2021 seasons. The experiments were conducted to study the effect of intercropping, fertilization on infestation rate of cowpea pod borer in cowpea plants and evaluation of three chemical compounds to control the previous insect pest. The experimental area of about 330 m^2 was divided into 30 plots (11 m^2 for each).
The experimental area was cultivated by seeds of cowpea plants, *Vigna unguiculata* (L) (variety Kareem 7) in April, 1st in successive seasons 2020 and 2021.

Evaluation of the efficiency to
Intercropping
Three systems of intercropping were evaluated as follow:
- Cowpea + Dill
- Cowpea + Coriander
- Cowpea +Jute mallow

Fertilization
- Potakarb (Potassium citrate) (Soft Chem masr for Agricultural Development Company) used at 300cm^3/100 L water.
- Folisil Calcium [Eurofertilizantes Valencianos SL Plaza Calvo Sotelo 4-2 Plamta 03001 Alicante (Spain)] used at 300cm/100 L water.

Evaluation of chemical compounds:
- Egyxide plus (water soluble natural oil) (the Egyptian United Company) used at 1000ml /100L water.
- Tebufenozide (Mimic 20% SC) (Nippon Soda-C0.LTD- Jaban) used at 75cm^3/100 L water.
- Deltalym (Emamectin benzoate) 5% EC (Saudi Delta Chemical Industries - Saudi Arabia Company) used at 320cm^3/fed..

The experimental plots were laid out in a randomized complete block design and each treatment was represented by three plots. All the normal of agricultural practices were followed except for the pesticidal treatment. Sampling of cowpea pods started 56days after planting. Weekly samples (10pods/plot) were randomly taken from each plot and carried in paper bags and transferred to the laboratory for inspection and recording the number of *Etiella zinckenella* larvae. The crop yield of each treatment was weighted and estimated. Treatments were sprayed with the chemicals under study on June, 19th and July, 3rd in seasons 2020 and 2021 by using a 20 L. knapsack sprayer with one nozzle.
Inspections of plants were carried out before spraying and after 1, 3, 5, 7 and 14 days from application to evaluate the efficacy of pesticides on the reduction rates of the pest population.
The reduction percentage in the population after pesticides (% mortality) has been calculated according the equation of Henderson and Tilton (1955) formula as follow:

% Reduction of counts = 100 [1-(Cb / Ca X Ta / Tb)]

Where
Cb = count of insects in control before application
Ca = count of insects in control after application
Ta = count of insects in treatment before application
Tb = count of insects in treatment after application

Determination of protein content
Total N in cowpea grains was estimated according to Bremner and Mulvaney (1982). The crude protein content was obtained by multiplying the N content by the factor 6.25.

Statistical analysis
Statistical analysis was performed using SAS computer program and LSD (Least significant difference) was calculated to find out the significance in difference between the treatments of infestation of *E. zinckenella* on Cowpea (SAS Institute, 2003).

Seeds storage
After harvest, cowpea seeds were stored. 30 gm of seeds from each treatment were taken and divided into 3 replicates. These replicates were kept for 30, 45 and 60 days till the emergence of the progeny. Number of adults that emerged from each replicate was counted. The percentage of reduction in adult emergence of progeny was calculated according to the following formula:

$$\%\text{Reduction} = \frac{\text{no. of emerged adults in control} - \text{no. of emerged adults in treatment}}{\text{no. of emerged adults in control}} \times 100$$

Effect of intercropping and fertilization treatments on population densities of lima bean pod borer *E. zinckenella* during two seasons on Cowpea pods:
Data in Table (1) show the effects of intercropping cowpea with other plants (Dill, Coriander and Jute mallow) on the population densities *E. zinckenella*, in the two seasons. The intercropping with Dill recorded the lowest mean population densities followed by the intercropping with coriander and jute mallow but in general the intercropping led to a reduction in the insect population compared with control. This may be due to the odors

emitted from three plants which repellent the insects from the target host plants. Data agree with that of Karel *et al.* 1980 and also with Ahoaka–Atta *et al.* 1983 and Nampala *et al.* 2002.

As for the effect of adding fertilizers (Table, 1) these treatments caused decrease in population densities of insects either on the green or dry pods. The seasonal means member after the adding of Potakarb were (31.50 and 42.75 larvae) and (30.00 and 50.63 larvae) on green and dry pods, respectively during the two seasons. While Folisil calcium caused decrease recording 3.38 and 62.25 larvae. Also, the same trend was in the second season 2021.

This study has incontestable that cropping systems have an effect on pest incidence and also the associated harm in multifariously. These results square measure necessary for integrated management programs in cowpea. To be effective, intercropping and fertilization got to be a part of a pest management system that involves alternative management methods.

Table 1: Effect of intercropping and fertilization treatments on population densities of lima bean pod borer *E. zinckenella* during two seasons on Cowpea pods:

Date of Inspection	Treatments and total number of pest population/30 Pods											
	2020											
	Intercropping of cowpea with						Fertilization				Control	
	Dill		Coriander		Jute mallow		Potakarb		Folisil Calcium			
	green	dry	green	dry	green	dry	green	dry	green	dry	green	dry
10/6	0	0	9	66	24	54	129	126	6	96	204	234
17/6	0	0	6	30	15	30	30	99	0	81	255	195
24/6	3	45	6	30	12	0	30	15	15	144	216	237
1/7	9	0	6	24	24	15	63	81	6	108	225	222
8/7	0	21	0	30	0	9	0	9	0	51	246	249
15/7	0	6	0	30	0	3	0	6	0	0	279	255
22/7	0	0	0	24	0	15	0	0	0	0	189	270
29/7	0	15	0	27	0	30	0	6	0	18	240	258
Total	12	87	27	261	75	156	252	342	27	498	1854	1920
Mean	1.50	10.88	3.38	32.63	9.38	19.50	31.50	42.75	3.38	62.25	231.75	240.00
SD±SE	3.21±1.13	15.95±5.64	3.74±1.32	13.74±4.86	10.81±3.82	17.78±6.29	45.47±16.08	50.70±17.93	5.42±1.92	53.59±18.95	29.12±10.30	23.68±8.37
2021												
9/6	0	0	0	54	24	63	99	156	21	126	216	279
16/6	9	6	6	36	24	30	30	108	0	66	255	255
23/6	3	27	9	30	15	15	36	18	15	156	198	264
30/6	0	0	6	12	24	0	75	93	18	123	216	249
7/7	0	24	6	27	12	12	0	6	0	63	255	255
14/7	0	12	0	0	0	0	0	6	0	0	279	276
21/7	0	0	0	0	0	0	0	0	0	0	228	288
28/7	0	3	0	30	0	3	0	18	0	36	234	234
Total	12	72	27	189	99	123	240	405	54	570	1881	2100
Mean	1.50	9.00	3.38	23.63	12.38	15.38	30.00	50.63	6.75	71.25	235.13	262.50
SD±SE	3.21±1.13	10.99±3.89	3.74±1.32	18.59±6.57	11.16±3.95	21.90±7.74	38.59±13.64	59.60±21.08	9.45±3.34	58.98±20.86	26.40±9.33	17.78±6.29

fficacies of different compounds in reducing the population density of the Lima Bean Pod Borer, *Etiella zinckenella* during 2020 and 2021 successive seasons on Cowpea's green pods

Data of the effect of different compounds on the larval population of lima bean pod borer presented in Table (2) indicated that all treatments were significantly superior over the control. Deltalym showed maximum reduction in larval population after the first and second spray (86.6 and 89.4%) and (84 and 91.9%) during 2020 and 2021 seasons on Cowpea's green pods, respectively.

Results also showed that Tebufenozide and Egyxide plus were, clearly, less efficient against the Lima Bean Pod Borer than Deltalym after the first and second spray during 2020 and 2021 seasons on Cowpea's green pods, respectively.

Table 2: Efficacies of different compounds in reducing the population density of the Lima Bean Pod Borer, *Etiella zinckenella* during 2020 and 2021 seasons on Cowpea's green pods:

Chemical compounds	first spray				second spray			
	Days after spray			Mean Red.	Days after spray			Mean Red.
	3	7	14		3	7	14	
2020								
Egyxide plus	41.2	92.9	15.9	50	40.2	100	100	80.1
Tebufenozide	64.7	92.9	59.1	72.2	72.9	100	91.3	88.7
Deltalym	100	99	60.7	86.6	78.9	100	89.4	89.4
2021								
Egyxide plus	48.7	88.3	12.9	50	45.2	100	97.6	80.9
Tebufenozide	74.7	93	62.5	76.7	69.7	98.9	92.5	87
Deltalym	87.6	89.9	74.4	84	89.7	92.5	93.5	91.9

Efficacies of different compounds in reducing the population density of the Lima Bean Pod Borer, *Etiella zinckenella* during 2020 and 2021 seasons on Cowpea's dry pods:

Data of the effect of different compounds on the larval population of lima bean pod borer presented in **Table (3)** indicated that all treatments were significantly superior over the control.

Tebufenozide showed maximum reduction in larval population (61.5 and 65.8%) and (63.2 and 64.4%) after the first and second spray during 2020 and 2021 seasons on Cowpea's dry pods, respectively.

Egyxide plus and Deltalym were, clearly, come in the second category causing lower effect against the Lima Bean Pod Borer than Tebufenozide after the first and second spray during 2020 and 2021 seasons on Cowpea's dry pods, respectively. These results were in agreement with that of Oladiran and Oso (1985), Dhaka *et al.* (2011), Shaalan (2016), Shabana *et al.* (2019) and Abd El-Rahman and Abdel-wahab (2020), also data closed with that obtained by Abdou and Abdalla (2006) and Mahmoud (2011).

It could be concluded that application every two weeks of the compounds used in this study during podding and maturation stage of cowpea plants were necessary in controlling *E. Zinckenella* populations, and increase crop yield.

Table 3: Efficacies of different compounds in reducing the population density of the Lima Bean Pod Borer, *E. zinckenella* during 2020 and 2021 seasons on Cowpea's dry pods:

Chemical compounds	first spray				second spray			
	Days after spray			Mean Red.	Days after spray			Mean Red.
	3	7	14		3	7	14	
2020								
Egyxide plus	53.2	81.2	43.5	59.3	47.9	74.6	64	62.1
Tebufenozide	31	76.3	77.1	61.5	39	58.3	100	65.8
Deltalym	11.2	48	56	38.4	45.3	25.7	45.6	38.9
2021								
Egyxide plus	63.2	91.2	33.85	62.75	45.9	68.6	54	56.2
Tebufenozide	44.3	78.3	67.1	63.2	42.5	54.3	96.5	64.4
Deltalym	22.8	48	46	39	38.2	29.9	43.3	37.1

Effect of different treatments on cowpea grains protein in seasons 2020 and 2021:

Results given in Table (4) indicated that, the total protein in cowpea grains increased with all treatments compared with the control the two seasons of study. Tebufenozide recorded the highest percent in total protein in cowpea grains during seasons 2020 and 2021 were (14.31 and 16.49%), respectively, compared with the control (9.91 and 10.01%), respectively.

Table 4: Effect of different treatments on cowpea leaves protein in 2020 and 2021 seasons

Treatments		Protein %	
		2020	2021
Intercropping of cowpea with	Dill	11.31	13.1
	Coriander	7.87	9.09
	Jute mallow	7	8.41
Fertilization	Potakarb	10.06	11.62
	Folisil Calcium	8.75	9.87
Chemical compounds	Egyxide plus	12.62	14.36
	Tebufenozide	14.31	16.49
	Deltalym	11.31	12.75
control		9.91	10.01

Effect of different treatments on the yield (kg/fed.) in Cowpea:

As for the cowpea crop yield obtained after the different treatments, data in Table (5) indicated that, the yield significantly increased with all treatments compared with the control in seasons 2020 and 2021. The highest yield (green pods) was obtained after intercropping Cowpea + Dill (1750 and 2350 kg/fed.) scoring 42.86 and 61.70% increase than control which gave (1100 and 1000 kg/fed.) in seasons 2020 and 2021, respectively. The highest yield in the form of dry pods was obtained after the treatment by Tebufenozide (635 and 600 kg/fed.) giving 42.99 and 58.33% than control which gave (362 and 250 kg/fed.) in seasons 2020 and 2021, respectively.

Table 5: Effect of different treatments on the yield (kg/fed.) in Cowpea

Treatments		2020				2021			
		Green pods		Dry pods		Green pods		Dry pods	
		The yield (Kg/100 pods)	Rate of increase %	The yield (Kg/100 pods)	Rate of increase %	The yield (Kg/100 pods)	Rate of increase %	The yield (Kg/100 pods)	Rate of increase %
Intercropping with	Dill	1750[a]	42.86	540[e]	32.96	2350[a]	61.70	510[d]	50.98
	Coriander	1680[b]	40.48	500[g]	27.60	2100[b]	57.14	480[f]	47.92
	Jute mallow	1550[c]	35.48	550[d]	34.18	1650[c]	45.45	520[c]	51.92
Fertilization	Potakarb	1450[g]	31.03	530[f]	31.70	1560[d]	42.31	550[b]	54.55
	Folisil Calcium	1360[h]	26.47	480[h]	24.58	1240[h]	27.42	500[e]	50.00
Chemical compounds	Egyxide plus	1476[e]	32.25	600[b]	39.67	1500[g]	40.00	500[e]	50.00
	Tebufenozide	1485[d]	32.66	635[a]	42.99	1550[e]	41.94	600[a]	58.33
	Deltalym	1470[f]	31.97	580[c]	37.59	1540[f]	41.56	550[b]	54.55
control		1100[i]		362[i]		1000[i]		250[g]	51.92
LSD		2.57		1.71		3.00		3.43	

Effect of different treatments on the infestation with cowpea weevil *Callosobruchus maculatus* to stored seeds of Cowpea:

Concerning the effect of the prior field treatments on storability and cowpea weevil infestation after 60 days, Table (6 and 7) demonstrates that all treatments gave a considerable protection i.e., significant decreases in infestation of cowpea weevil compared with control. Cowpea + Dill gave the highest protection during the storage in the two seasons, giving reduction in the progeny which were (95.68 and 93.36%) the two season of study (2020 and 2021), respectively.

Table 6: Effect of different treatments on the infestation of cowpea weevil *C. maculatus* in stored seeds of Cowpea in 2020 season:

Treatments		No. of progeny after (days)			Mean No. of the Progeny after 60 days	Reduction in progeny %
		30	45	60		
Intercropping with	Dill	2	5	5	4	95.68
	Coriander	1	4	10	5	94.6
	Jute mallow	2	31	15	16	82.73
Fertilization	Potakarb	0	5	15	6.67	92.8
	Folisilb Calcium	0	42	60	34	63.31
Chemical compounds	Egyxide plus	1	40	20	20.33	78.06
	Tebufenozide	5	25	30	20	78.42
	Deltalym	40	50	70	53.33	42.45
control		70	88	120	92.67	

Table 7: Effect of different treatments on the infestation of cowpea weevil *C. maculatus* in stored seeds of Cowpea in 2021 season

Treatments		No. of progeny after (days)			Mean No. of the Progeny after 60 days	Reduction in progeny %
		30	45	60		
Intercropping with	Dill	2	4	13	6.33	93.36
	Coriander	4	10	12	8.67	90.91
	Jute mallow	1	35	26	20.67	78.32
Fertilization	Potakarb	5	9	15	9.67	89.86
	Folisil Calcium	8	52	59	39.67	58.39
Chemical compounds	Egyxide plus	7	38	34	26.33	72.38
	Tebufenozide	10	28	36	24.67	74.12

	Deltalym	56	67	82	68.33	28.32
control		66	90	130	95.33	

Conclusion

According to the obtained results, it is clear that the adding of fertilizers is very important, especially in time with the analysis of soil components. Also, the possibility of intercropping cowpea with other plants as dill or any of other aromatic plants may help in repelling insect pests. Also, the periodical investigation of plants to stop and determine the level of cowpea pod borer and take the decision of the use of chemical pest control in the case of the need to it.

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