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Population dynamics of the cabbage butterfly *Pieris rapae* (Lepidoptera: Pieridae) and its control in cabbage at Fayoum Governorate

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Abstract

The present work was carried out at the Experimental Farm, Fac. of Agric., Fayoum Univ., and aimed to shed some light on population fluctuations of the cabbage white butterfly, *Pieris rapae* L. (Lepidoptera: Pieridae), and its associated natural enemies and relation to some weather factors at Fayoum Governorate on cabbage (*Brassica oleracea* var. *capitata* L.) cultivated in four successive plantations during the 2019/2020 and 2020/2021 seasons. Natural enemies associated with *P. rapae*, are the lady beetle, *Coccinella undecimpuncta* L, (Coleoptera: Coccinellidae), the syrphid fly *Episyrphus balteatus* (De Geer) (Diptera: Syrphidae), and the braconid parasitoid, *Diaeretiella rapae* M'Intosh (Hymenoptera: Braconidae). Population fluctuations of *P. rapae* had one and two peaks in summer and winter plantations of the first season during 5th June, 16th December and mid-January, with 9, 15, and 14 individuals/30 leaves, respectively. In the 2nd season, its population recorded two and three peaks with 8, 7, 17, 18, and 22 individuals/30 leaves during 6th April, 5th June, 21st December, and 10th and 30th January for summer and winter plantations, respectively. The efficiency of bactericide (Dipel X) and chemical material (Runner 24% Sc) and plant extract used (garlic) were evaluated on *P. rapae* throughout the period. The results observed a high effect on populations *P. rapae* that treated by all used materials.

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) is an economically leafy vegetable crop belonging to the family Brassicaceae (Cruciferae). It is widely cultivated in tropical and temperate parts of the world. Cabbage is an important vegetable crop grown for its edible enlarged terminal buds. It contains protein, minerals, vitamins, amino acids, essential fatty acids, and dietary fibers. It also has a good amount of iron, calcium, and potassium, as well as vitamins C, B1, B2, and B3 (Abro *et al*., 1994; Ahmad *et al.,* 2007; Arthursm and Dara, 2018, and Purti and Rolania, 2022). The population of pest *P. rapae* differed markedly from location to location and between years, and *P. rapae* was the most abundant (Biever *et al.*, 1992), The cabbage white butterfly, *P. rapae*, is a dangerous pest of many foliar vegetable

crops, particularly cabbage (Atwa *et al*., 2009). *P. rapae* was reported as the most common Brassica pest. larval and pupal stages of *P. rapae* yielded five parasitoids including *Trichogramma buesi,* Voegele (Hymenoptera: Trichogrammatidae), Cotesia *glomerata* (L.) (Hymenoptera: Braconidae), *Hyposoter* sp. (Hymenoptera: Ichneumonidae), *Pteromalus puparum* (L.) (Hymenoptera: Pteromalidae), and *Brachymeria femorata* (Panzer) (Hymenoptera: Chalcididae) and two predators, *Paederus alfierii* Koch (Coleoptera: Staphylinidae), *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae), in cabbage fields (Embaby and Lotfy, 2015, and Tufail and Shafiq, 2010).

The efficiency of some insecticides on cabbage butterflies in the world and evaluate the potential effect of microbial control agent *B. thuringiensis* in suppressing the population of *P. rapae.* The commercial product Dipel 2X, when used as dust, scored the best results in controlling *P. rapae* attacking the winter cabbage (Salma *et al.,* 1991).

Materials and methods

1. Population fluctuation:

The study of survey and population fluctuations of *P. rapae* pest and natural enemies associated with cabbage plants was conducted at the farm of the Faculty of Agriculture, Fayoum University, during two seasons from 2019/2020 to 2020/2021. Two plantations were performed in each season, and each plantation was cultivated in a 350m^2 area with the sapany variety. The healthy and vigorous seedlings of 30 days old were transplanted in the main field at a spacing of 50cm on 27th March and 17th October in the 1st season and 27th March and 11th November in the 2nd season for the first and second plantations, respectively. The crop was fertilized with the recommended dose of NPK, and no insecticidal treatment was applied at any stage of the crop growth (Hågvar and Hofsvang, 1991).

2. Control studies:

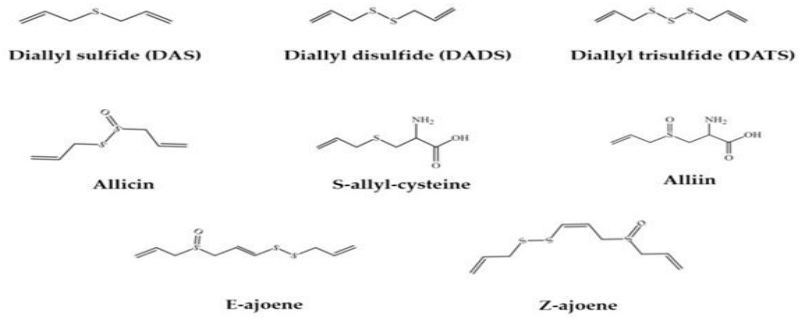
2.1. Plant extract materials tested:

These experiments were carried out in the open field to find out the effectiveness of some plant extracts, bio-insecticide, and insecticides on cabbage pests.

Garlic, *Allium sativum*

Active ingredients: Organic sulfides, saponins, phenolic compounds, and polysaccharides.

Chemical structures: the main organic sulfur compounds in garlic.

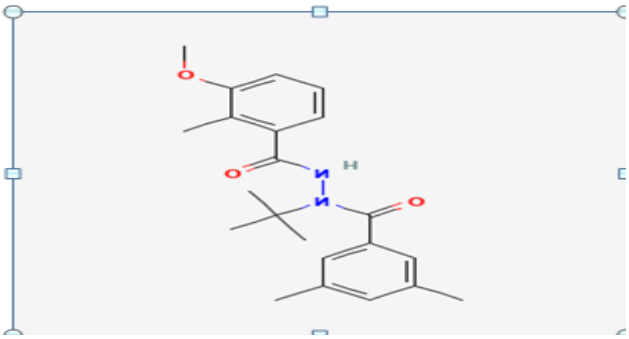


Crude extract preparation: Firstly, bulbs of fresh garlic which are free from diseases, were chosen. 25, 50, and 75g of chosen garlic were weighed using an electronic balance. Then, it grinds using an electric blender and distilled water, filtered using gauze. After that, the crude extracts were placed in bottles and stored in the freezer until use. Three concentrations were prepared by diluting the crude extracts with distilled water to obtain 25, 50, and 75g/L distilled water.

2.2. Entomopathogenic bacteria (Dipel X bactericide):

Active ingredient: *Bacillus thuringiensis* subsp. Kurstaki.
Three concentrations (0.350, 0.700, and 1.49 g/L distilled water) were used.

2.3. Chemical insecticide:
Trade name: Runner 24% SC
Active Ingredient: 240 g/L Methoxyfenozide



Chemical structure

Three concentrations (0.125, 0.25, and 0.500 cm insecticide/L water) were used.

3. Statistical analyses:

The data was analyzed by simple correlation and regression analysis. Simple correlation and regression between the population of the cabbage insect pests and means of the weather factors (Maximum, minimum temperatures, and % RH.) were determined by using the SPSS software program (Version 20).

Results and discussion

1. Population fluctuation of *Pieris rapae*:

1.1. First season, 2019/2020:

Data in Table (1) showed that in summer plantation, the population of *P. rapae* began low (1.0 egg/30 leaves) and continued around this rate, then recorded the first and only peak on 16th May with 3.0 eggs / 30 leaves. After that, the number decreased and disappeared completely from 5th June to the end of the plantation. Larvae appeared on cabbage plants on 6th April, and increased to record its peak with 9 larvae/30 leaves on 26th April, May at (37.7ºC, 16.6ºC, and 76% RH.). Then the population decreased gradually by the time to record 1.0 larvae/30 leaves at the end of inspection on 5th July 2019.

As shown in Table (1). The results in winter plantation showed that eggs population for the pest began low (2 egg/30 leaves) and fluctuated around this thin rate to reach the first peak (3.0 individuals/ 30 leaves) on 26th November After that, the number decreased and then increased again to record the second peak on 15th January 2020, and the second element, is larvae, was began low (4 larvae/30 leaves) in the first sample on 17th October 2019 and recorded the first peak (8 total/30 leaves) on 6th December 2019 at (28.4ºC-10.5ºC and 94% RH.) then the population decreased gradually by the time to record (6 total/30 leaves) at the end of the inspection on 25th January 2020.

On the other hand, the number of *P. rapae* recorded its peak in mid-January with 5.0 larvae/30 leaves in summer plantation. The total number of *P. rapae* stages increased gradually from the beginning of plantation to reach the first and highest peak (15 individuals/30 leaves) on 16th December. After that, the population decreased and increased again to record the second peak with 14 individuals/30 leaves during mid-January.

Table (1): Population fluctuations of *Pieris rapae* immature stages in summer and winter plantations during 2019 /2020 season at Fayoum Governorate.

Date of sampling	Summer plantation						
	No. of individuals /30 leaves				Weather factors		
	Eggs	Larvae	Pupae	Total	Temp. ◦C		RH. %
					Max.	Min.	
27/3	1	0	0	0	30.4	19.6	77
6/4	1	4	0	4	30.5	12.7	78
16/4	2	5	0	7	33.8	10.0	78
26/4	2	6	1	9	37.7	16.6	67
6/5	2	5	2	9	35.1	16.0	75
16/5	3	4	1	8	40.3	18.3	58
26/5	2	4	1	7	42.3	20.4	63
5/6	1	3	1	5	41.4	20.7	72
15/6	0	1	0	1	40.3	21.5	72
25/6	0	1	1	2	40.3	21.4	82
5/7	0	1	1	2	42.3	23.1	82
Total	14	34	8	54			
Winter plantation							
17/10/2019	2	4	0	6	35.1	14.4	86
27/10	2	4	0	6	35.0	14.5	89
6/11	2	5	0	7	35.0	15.1	88
16/11	1	5	2	8	32.5	11.8	85
26/11	3	7	2	12	30.0	10.4	83
6/12	3	8	1	12	28.4	10.5	85
16/12	3	8	4	15	24.1	10.2	91
26/12	1	7	3	11	25.0	8.0	94
5//1/2020	0	7	5	12	22.0	7.5	86
15/1	3	6	5	14	20.0	5.0	85
25/1	2	6	4	12	21.1	7.0	92
Total	22	67	26	115			

1.2. Second season, 2020/2021:

1.2.1. The first (Summer) plantation:

Data in Table (2) Showed that the total population in the summer plantation increased suddenly to record the first peak with 8.0 individuals/30 leaves on 6th April 2020. After that, it decreased gradually (For 50 days) and increased again to record the second peak on 5th June with 7 total/30 leaves. Then the population of all immature stages decreased until the end of inspection on 5th Jully 2020. In general, the population of *P. rapae* in the summer plantation was very low at the beginning of the plantation. The total immature stages (Egg, larvae, and pupae) until the end of plantation were (11, 27, and 9 individuals), respectively.

1.2.2. The Second (Winter) plantation:

Results in Table (2) for winter plantation demonstrated that the egg population of cabbage white butterfly had two low peaks on 21st December and 30th January, with 4 eggs/30 leaves for both peaks. For the larval stage, the population was recorded on cabbage plants at the first inspection and increased gradually to reach the first peak (11 larvae/30 leaves) on the 21st December, then decreased and rapidly increased to record the second peak on 10th January with 15 larvae/30 leaves. The highest and third peak (17larvae/30 leaves) was recorded on 30th January The total population began high with (6 total/30 leaves) on 20 th November and increased gradually to reach the first and lowest peak (17 individuals/30 leaves) on 21st December, then declined and increased suddenly to record another two peaks on 10th and 30th January The third peak was the highest, with 23 individuals/30 leaves. During this plantation, the peaks were recorded at the weather factor (20.3ºC, 6.5ºC, and 89% RH., 20.1ºC, 8.1ºC, and 99% RH., and 19.3ºC, 3.4ºc and 85% RH., respectively).

Generally, results of the two seasons showed that cabbage plant infestation with the larval stage reached the maximum after 40 days from planting, and then the infestation dropped gradually to reach the minimum rate at plant age 110 days. Also, the winter plantations were higher in *P. rapae* infestation than the summer plantations. It can be concluded that young, soft plants have the highest biological activities with the incidence of *P. rapae.*

Statistically, the total population was negatively correlated with minimum temperature and relative humidity and positively correlated with the maximum temperature in the summer plantation of the 1st season. The effect of maximum and minimum temperatures was significantly negative, while the effect of relative humidity was negative on the total population of *P. rapae* during both study seasons.

Table (2): Population fluctuations of *Pieris rapae* immature stages in summer and winter plantations during 2020 /2021 season at Fayoum Governorate.

Date of sampling	Summer plantation						
	No. of individuals /30 leaves				Weather factors		
	Eggs	Larvae	Pupae	Total	Temp. ◦C		RH. %
					Max.	Min.	
27/3/2020	0	0	0	0	33.2	13.0	75
6/4	2	6	0	8	33.0	12.7	76
16/4	1	6	0	7	37.0	17.0	70
26/4	1	4	0	5	40.0	17.0	63
6/5	2	2	1	5	39.0	19.0	76
16/5	0	3	1	4	39.0	17.3	76
26/5	1	4	1	6	41.0	18.1	67
5/6	1	6	0	7	40.0	20.3	76
15/6	1	2	2	5	40.3	19.4	77
25/6	1	2	2	5	40.4	20.5	77
5/7	1	2	2	5	43.5	22.2	72
Total	11	37	9	57			
Winter plantation							
11/11/2020	0	6	0	6	30.4	15.4	91
21/11	2	8	1	11	28.5	12.1	92
1/12	2	10	1	13	27.0	11.6	85
11/12	3	10	1	14	25.0	11.1	85
21/12	4	11	2	17	20.3	6.50	89
31/12	4	10	1	15	21.3	7.10	89
10/1/2021	3	15	0	18	20.1	8.10	99
20/1	2	14	1	17	20.1	6.60	88
30/1	4	16	2	22	19.3	3.40	85
9/2	3	17	2	22	18.0	3.40	90
19/2	2	10	4	16	17.5	3.00	89
Total	29	127	15	171			

3. Efficiency of some plant extract, natural products, bio and chemical insecticide against *Pieris rapae*:

3.1. Garlic extract:

The extraction of garlic loops was used at concentrations of 25, 50 g/L, and 75 g/L of water in the field during the summer season, and the dates of inspection were 1, 3,5, and 7 days after treatment. After 1day from treatment, all larvae of *P. rapae* died, and the effect of extraction was affected until the 7th day from treatment, recording 0.75, 1.7, and 3.3 individuals/10 leaves after 3, 5 and 7 days, respectively.

3.2. Runner 24% SC:

As mentioned above, the runner was used in three concentrations (0.125, 0.250, and 0.500cm/L). The effect of this insecticide was extended to the 3rd day after application only (Table 3).

3.3. Dipel 6.4% DF:

Cabbage treatment with 0.35, 0.70, and 1.4 g/L concentrations of Dipel 6.4% DF recorded 1.7, 1.3, 1.7, and 3.3 *P. rapae* larvae per ten leaves during 1, 3, 5, and 7 days after treatment. As mentioned in Table (3) this biocide is used in three concentrations (0.35, 0.70, and 1.4 g/L). The larvae of *P. rapae* that were treated with these biocides did not disappear completely to record (1, 3, 5, and 7days), respectively.

As shown in Table (3) the garlic extraction had a significant effect on larvae population of *P. rapae* in the field Compared with the control. The same result was recorded in the site either Runner or Dipel with significant differences.

Table (3): Latent effect of some plant extract. and insecticide on larvae population of *Pieris rapae* under field conditions at Darramad region at Fayoum Governorate.

Treatment	Concentration	Date of inspection			
		1day	3days	5 days	7 days
Garlic extraction	25 g/L	0	1	3	5
	50g/L	0	1	2	5
	75g/L	0	0	0	0
Total		0	2	5	10
Mean		0**c**	0.75**b**	1.7**b**	3.3**b**
Runner	0.125cm/L	3	1	2	2
	0.250cm /L	0	0	4	2
	0.500cm /L	0	0	4	3
Total		3	1	10	7
Mean		1.0**b**	0.3**b**	3.3	2.3**c**
Dipel 6.4%DF	0.35g/ l	1	2	3	6
	0.70g /L	2	2	2	2
	1.49g /L	2	0	0	2
Total		5	4	5	10
Mean		1.7**b**	1.3**c**	1.7	3.3**b**
Control	1	3	6	6	5
	2	4	4	5	7
	3	3	6	5	5
Total		10	16	16	17
Mean		3.3**a**	5.3**a**	5.3	5.7**a**

N.B: The data in the same column and took the same mark were significant.

The pest was observed in March and continued till December, causing severe damage to the cruciferous plants in the hills of Uttar Pradesh. *P. brassicae* was the major pest throughout the year, with maximum activity from February to October (Rai *et al.*, 1985).

The larvae were observed in the 4th week of the same month. The major egg peaks of the pest were recorded from mid-October to

mid-December, with a range of 0.5 to 2 eggs per plant, while no eggs were obtained during the period from May to August. Larval population ranged from 0.7 to 1.1 larvae per plant during early December and mid-January, while it disappeared during the months from May to June, showing that the relatively high temperature had a nonsignificant negative correlation with the population of eggs, while the relative humidity correlated negatively with populations of eggs and larval stages. The highest population densities of immature stages (Larvae and pupae) were recorded in October, November, January, and February (Ibrahim, 2020). *P. rapae* was found to be active in December (Abdel-Galil *et al*. 2021).

The above results agree with Salma *et al.* (1991), the potential effect of the microbial control agent *B. thuringiensis* in suppressing the population of *P. rapae* on different varieties of cabbage at three governorates in Egypt. The commercial product Dipel 2X, when used as a dust, scored the best results in controlling *P. rapae* attacking the winter cabbage. In Bulgaria, Mateeva *et al.* (1997), the species structure was indexed, and cabbage cultivars were classified according to their tolerance to insects. *Pieris brassicae* was controlled by plant extracts of *Delphinium elatum* and *Thermopsis lanceolata* (Fetoh and Azazy, 2004). Field experiments were conducted during 2003 to evaluate three biological control agents for the control of the cabbage worm, *Artogia Pieris rapae*, as a new approach to integrated pest management. Under laboratory conditions, the larvae and pupae of *A. rapae* were highly susceptible to Dipel 2x (The commercial formulation of *B. thuringiensis*, which exhibited highly toxic effects against *p. rapae* larvae.

In summary, population fluctuations are dominant. *P. rapae* showed variation in activity peak numbers with plantations and seasons. *P. rapae* had one or two peaks in summer and winter plantations for the first season. Observed that high-effect *P. rapae* populations that treated by all used materials, compared with the control.

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