Ecological parameters affecting density of some insect pests and associated predators on *Phaseolus vulgaris* plants

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Abstract

This investigation was carried out to evaluate the population dynamics of *Aphis craccivora* and *Ophiomyia phaseoli* on common bean *Phaseolus vulgaris* with regard to their natural enemies at Giza Governorate, Egypt. *A. craccivora* and *O. phaseoli* were two economic pests on the main crops in the agricultural fields of El- Mansuryia, village- Giza Governorate.

The findings showed that during two seasons (2020/21 and 2021/22), 6 insect pests belonging to 5 families under 4 orders and 2predators were surveyed. They were*; Aphis craccivora*, Order: Hemiptera: Aphididae, *Ophiomyia phaseoli*, Order: Diptera: Agromyzidae, *Thrips tabaci*, Order: Thysanoptera: Thripidae, *Bemisia tabaci*, Order: Diptera: Aleyrodidae, *Melanogromyza phaseoli* Order: Diptera: Agromyzidae as insect pests and *Spodoptera litoralis*, Order:Lepidoptera: Noctuidae, as insect visitors. However, *Coccinella undecimpunctata* Order: Coleoptera: Coccinellidae and *Chrysoperla carnea* Order: Neuroptera: Chrysopidae as a predator. The effect of daily max., Temp., daily min. Temp., and rang R.H%, plant age and other ecological parameters on population fluctuation of *A. craccivora* and *O. phaseoli* were tested. These two pests *A.craccivora* and *O. phaseoli* had three peaks during 1st and 2nd seasons. The mean numbers of tested insect pests were higher during second season than the first season. The first appearance of *A. craccivora* and *O. phaseoli* was at the 4th week of December, late January and 1st March in two successive years, these insects are dangerous insect pests in common bean plants fields. The combination effect of climatic factors, plant age and natural enemies on *A. craccivora* and *O.phaseoli* population fluctuation was presented as explained variance which was 81 and 89% of *A. craccivora* and 83 and 73% of *O. phaseoli* in the first and second seasons, respectively.

Keywords: kidney bean, fields, polesta cultivar

1. Introduction

Common bean is *Phaseolus vulgaris* one of the most essential and profitable vegetable crops worldwide, and in Egypt. *P. vulgaris* is the most significant grain legume for direct human consumption, with a production more than doubles that of chickpea, the next most significant grain legume (Ragab *et al*. 2015) [13]. Leguminous plants belong to the family Leguminaceae, are usually used as a common good source of protein, complex carbohydrates for human and many of domestic animals. They are also an excellent source of vitamins, minerals, and other nutritious elements. Nevertheless, as reported by Safe *et al*. (2018) [15], they contain some harmful substances such tannins, folic acid, and protease inhibitors.

A. craccivora, *O. phaseoli* nymphs and adults of the two main insect pests, in addition to causing yellowing, wilting leaves, fresh beans, fresh bean pods, and shedding leaves, seriously damage plants from the seedling to pod bearing stage and, in cases of severe infestations, reduce growth rates and productivity. Furthermore, the honeydew that certain aphis species generate promotes the establishment of sooty mould, which impedes photosynthesis and reduces the vigor of plants. According to Souleymane *et al*. (2013) [19], pest sucking-sap insects cause harm to a variety of vegetables and are the source of honeydew.

The present work aimed to study of certain insect pests and its associated predators on *Phaseolus vulgaris* plants.

2. Materials and methods

2.1. Study area

This work was carried out at the experimental farm of Faculty of Agriculture, AL-Azhar Univ, Nasr City, Cairo, Egypt. The field experiments were planned and conducted to study the population dynamics of *Aphis. craccivora* and *Ophiomyza. phaseoli* infesting common bean plants *Phaseolus. vulgaris* (Polesta cultivar) at El- Mansuryia village, Giza Governorate, Egypt, to survey insect pests infesting common bean plants during two successive seasons (2020-21 and 2021-22).

2.2. Sampling techniques

The experiment area (1/2 feddan) (2100 m^2) was divided into four plots (each part 525 m^2); each plot was divided into three replications (175 m^2) and cultivated with common bean. Four plants were chosen in Randomized Complete Block Design (CRCBD). Direct counting of major pests and insects was calculated. The most common insect pests were identified and directly counted under field conditions. Data were recorded weekly from late December, 2020-21 until the end of April, 2021-22. Samples were taken randomly in the early morning at weekly intervals.

2.3. Meteorological data

Records of daily maximum and minimum Temp. and R.H % were obtained from the Central Laboratory for Agriculture Climate (CLAC), Dokki, Giza, Egypt to study the effect of weather factors on the population fluctuation on the insect pests. The data were subjected to the analysis of variance and Duncan's Multiple Range Tests (DMRT) (SAS, 2003) [16].

3. Results and discussion

3.1. Survey of insects occurring on *phaseolus. vulgaris (*Polesta cultivar*)*

Data presented in Table (1) show a list of insect species reordered on *P. vulgaris* plants. Six insect pest species and two predators belonging to seven families, 6 orders during the two successive seasons were surveyed. These were; *A.craccivora*, *O.phaseoli*, *B.tabaci*, *M.phaseoli* and *T. tabaci*, *S. littoralis*. The predators were represented by *C. undecimpunctata* and *Chrysoperla. carnia* as well as the prevailing climatic factors (daily maxi and mini-Temp. and R.H %). The obtained results are consistent with those of Abrol *et al.* (2006) [3] in India, who found that red kidney beans, a significant cash crop, are attacked by eight kinds of insect pests that inflict significant harm. The hairy caterpillar, *S. obliqua*, *O. phaseoli*, *C.chinensis*, *A signatus*, and *C. coerculea* were among them. *Thrips*, *S. dorsalis*, *A. craccivora* and *A. signatus* and *C. coerculea* were the two most harmful pests among all those discovered for the first time in the crop and the nation. Also, according to the findings of Emosairue *et al.* (2004) [9] in Nigeria**,** gave a list consisted of 37pest species and 4natural enemies on cowpea. The insect species encountered on the yield were distributed as follows: order: Coleoptera,14 species constituting 34.2% of all species identified; order: Heteroptera, 10 species (24.4%); order: Homoptera 8 species (19.5%); order: Orthoptera, 4 species (9.8%); order: Lepidoptera, 3species (7.3%); order: Thysanoptera, 1 species (2.4%) and order: Dictyoptera, 1 species (2.4%).

Table 1: Scientific names of insect pests and associated predators recorded on common bean plants during 2020/21& 2021/22 seasons at El-Mansuryia village, Giza governorate, Egypt

Order	Family	Scientific name	Status
Thysanoptera	Thripidae	*Thrips tabaci*	Pest
Hemiptera	Aphididae	*Aphis craccivora*	Pest
	Aleyrodidae	*Bemisia tabaci*	Pest
Diptera	Agromyzidae	*Ophiomyia phaseoli*	Pest
		Melanogromyza phaseoli	Pest
Lepidoptera	Noctuidae	*Spodoptera litoralis*	Visitor
Coleoptera	Coccinellidae	*Coccinella undecimpunctata.*	Predator
Neuroptera	Chrysopidae	*Chrysoperla carnea*	Predator

3.2. Population dynamics of *Aphis craccivora* on *Ophiomyza, Vulgaris*

The data in Tables 2 and 3 indicated that *A. craccivora* appeared on the *P. vulgaris* variety with mean numbers of 10.75 and 11.16 insects per week at the season, respectively. The population number of insects increased to give the highest first peak at the end of December. In the 4th week of January, the insect population reached its second peak, were of 23.67 and 29.24 insects for the two seasons, respectively. In the first week of March, this insect reached its 3th peak, with weekly numbers of 32.89 and 34.96 (individuals/sampling) for the two seasons, respectively. The data (in Tables 2 and 3) proved that the second season harbored more numbers 281.44 (insects) of *A. craccivora* than that obtained on first season (211.21 insects). The obtained data are in agreement with findings of El-Defrawi *et al*. (2000) [8] in Egypt, who observed that the population density of the cowpea aphid, *A. craccivora* had two main periods of activity, highest counts were recorded during the third week of December and February in first season, and during the fourth week of December and third week of March in the second season. *Aphis craccivora* (Koch) (Hemiptera: Aphididae) recorded the highest total number, and *Ophiomyia phaseoli* recorded the lowest total number. According to Abdou *et al.* (2019) [2], the aphid, *A. craccivora* was the species with the highest total number of observations throughout the spring seasons in both 2017 and 2018, while *O. phaseoli* had the lowest total number; there was no clear difference between the two seasons. *Aphis craccivora* causes yield loss by directly infesting leaves, stems, and roots, according to findings similar to those described by Singh *et al.* (2014) [18]. Also, El -Gindy (2002) [7] who mention that both of *A. craccivora* and *A. gossypii* has two generations of bean plants. Ibrahim (1999) [11] in Egypt, found that *P. vulgaris* plants are attacked by several insect pests and the most main insect pests are *A. crassivora*.

3.3. Population dynamics of *O. phaseoli* on *P. vulgaris* plants

Data presented in Tables 2 and 3 show that *O. phaseoli* appeared on *P. vulgaris* plants in the 4th of December. During two successive seasons, the weekly insect population counts were 7.08 and 8.09 insects, respectively. The population of insects increased to reach its maximum 1st peak during the 4th week of December, the insect population increased gradually to give the highest peak in 1st week of December with weekly numbers of 9.77 and 10.45 insects. Insect numbers fell until the 3th week of January in the two consecutive seasons, the number of insects climbed to reach its highest second peak in the 4th week of January, with weekly numbers of 9.88 and 12.03 insects, respectively. However, this insect was recorded at the 3th peak in the 1st week of March with weekly numbers of 13.12 and 13.47 insects, respectively. The data in Tables 2 and 3 proved that second season harbored more numbers 135.85 insects of *O. phaseoli* than the first season was128.89 (individuals/sampling). These results agree with the findings of Sachan *et al.* (2008) [14] and Selem *et al.* (2016) [17] researched the bean fly *O. phasoeli* in India from 2000 to 2003, but the significant insect pest that harmed *P. vulgaris* during that time was *P. vulgaris* (November-February). Abdou *et al.* (2019) [2] who stated that the highest total number recorded by *A. craccivora*, and the lowest total number recorded by *O. phaseoli*. The highest total number recorded during spring seasons during both 2017 and 2018, represented by *A.* and the lowest number was of *O. phaseoli*. Also, according to the findings of Bassiony (2019) [6], *P. vulgaris* was typically infested by 241 larvae per 25 leaflets of *L. trifolii*, with the second of February seeing the highest infection levels. Similar findings were reported by Bassiony (2019) [6] and Abdou *et al.* (2019) [2] who found that the mean number of predators fluctuated during September and increased gradually to reach its maximum during October and November and then decreased towards the end of the season.

Table 2: Population fluctuation of *Aphis craccivora and Ophiomyia phaseoli* and associated predators on *phaseolus. vulgaris* cultivar during 2020/2021 seasons at El- Mansuryia village- Giza governorate, Egypt

Inspection date	*A. craccivora*	*O. phaseoli*	*C. carnea*	*C. undecim punctate*	Climatic factors		
					Max	Min	Rang R. H. %
24/12/2020	10.75	7.08	6.50	5.57	20.35	10.16	54.66
31/12/2020	16.95	9.77	8.22	6.33	22.90	8.34	61.12
07/01/2021	9.33	8.24	6.00	6.60	19.61	8.56	59.19
14/01/2021	15.29	7.80	7.84	5.46	22.40	12.04	57.30
21/01/2021	11.29	8.96	7.13	7.60	20.13	9.59	57.81
28/01/2021	23.67	9.88	7.63	10.22	20.62	8.33	65.25
04/02/2021	10.79	8.88	9.41	13.91	20.07	9.48	62.51
11/02/2021	16.64	7.88	10.50	10.02	24.58	12.29	63.27
18/02/2021	9.99	9.60	11.41	9.30	18.38	7.79	65.63
25/02/2021	12.73	9.28	10.81	11.01	21.71	10.23	70.98
04/03/2021	32.89	13.12	12.42	10.04	25.16	10.71	57.29
11/03/2021	15.03	8.84	9.50	10.94	24.07	13.18	62.81
18/03/2021	10.19	7.32	8.61	6.08	24.09	14.84	48.52
25/03/2021	8.03	6.24	7.29	5.57	22.89	10.46	55.53
01/04/2021	7.64	6.00	6.60	5.58	28.33	13.71	51.17
Total	211.21	128.89	129.87	124.23			
Means	14.08	8.59	8.66	8.28			

Table 3: Population dynamics of *A.craccivora* and *O.phaseoli* and associated predators on *Phaseolus. vulgaris* during 2021/2022 seasons at El-Mansuryia village- Giza governorate, Egypt

Inspection date	*A. craccivora*	*O. phaseoli*	*C. carnea*	*C. undecim punctate*	Climatic factors		
					Max	Min	Rang R. H. %
24//122021	11.16	8.09	7.70	6.17	23.02	10.00	36.34
31/12/2021	22.76	10.45	8.72	7.52	21.34	8.13	45.02
07/01/2022	18.88	9.12	7.20	7.90	23.95	10.66	45.14
14/01/2022	19.88	7.28	7.34	6.26	24.06	10.84	36.61
21/01/2022	17.64	8.35	8.84	9.70	18.22	6.14	40.77
28/01/2022	29.24	12.03	13.34	11.02	20.51	6.31	41.22
04/02/2022	18.48	10.28	10.91	13.10	23.02	9.00	34.84
11/02/2022	18.48	8.27	12.00	11.10	25.29	10.27	41.12
18/02/2022	19.72	8.47	12.31	10.10	18.96	6.47	43.11
25/02/2022	21.44	10.41	10.91	14.10	19.01	6.91	44.99
04/03/2022	34.96	13.47	22.92	12.54	21.34	8.13	45.02
11/03/2022	18.52	10.24	9.00	8.02	25.70	9.48	39.36
18/03/2022	15.80	9.21	7.11	7.00	23.16	8.74	45.95
25/03/2022	9.88	7.15	6.79	6.02	25.35	12.09	39.93
01/04/2022	4.60	3.03	2.10	6.61	26.53	9.48	39.40
Total	281.44	135.85	147.19	137.16			
Mean	35.18	16.98	18.40	17.15			

3.4. The effect of biotic and abiotic factors on the population fluctuations of insect pests on common bean

Generally, fluctuations in the weather factors, the amount of food supply, the number of natural enemies, or all three are what lead to population changes. These biotic and abiotic elements usually have an impact on an insect pest's capacity for reproduction and survival**.** The present work suggests that there are daily maxi and mini temp., R.H%, plant age and two natural enemies, including: *C. undecimpunctata* and *C. carnea* were associated with the *A. craccivora* and *O. phaseoli* samples on the *P. vulgaris* crop.

3.4.1. *Aphis craccivora*

As shown in Table 4 the effect of climatic factors (daily mean of max. & min. Temp., and R.H%) and plant age on the population density of *A. craccivora* and natural enemies on *P. vulgaris* plants during two successive seasons, (2020-21) and (2021-22) in agricultural fields in Mansouriya village, Giza governorate. Simple correlation had an insignificant effect ($p>0.05$) on the aphid population during 1st season, except two predators the effect of the significant on the aphid population. While in the 2nd season daily max, Temp., and natural enemies showed significant effects on the aphid population. Un-significant negative "b" values in the first season except the daily mean max, Temp., daily mean. R.H% and plant age 2 whereas in the second season the factors change the insect population means numbers with un-significant negative except the effects of daily mean., R.H% with un-significant values and *C. carnea* which showed significant effects. The combined effect of all studied factors on aphid population was presented as explained variance (EV%) which was 81 and 89% in 1st and 2nd season, respectively.

Table 4: Statistical analysis of the effect of certain ecological factors on the population of *A. craccivora* during 2020/2021 season on *P. vulgaris* cultivar at El-Mansuria village- Giza governorate

Years	Source of variation		Simple correlation		Partial regulation				
			r	p	b	p	F	P	Ev %
2020/2021	Daily max. Temp.		-0.170	0.541	-0.110	0.541	3.57	0.069	83%
	Daily min. Temp.		-0.421	0.113	-0.340	0.113			
	Daily mean. R.H%		0.450	0.085	0.136	0.085			
	Plant age	Age 1	-0.150	0.576	0.510	0.624			
		Age 2	-0.280	0.301	0.151	0.329			
		Age 3	-0.371	0.163	-0.008	0.180			
		C. carnia	0.661	0.007	0.006	0.888			
		C. undicium punctata	0.531	0.038	0.004	0.842			
2021/2022	Daily max. Temp.		-0.481	0.067	-0.441	0.067	2.03	0.201	73%
	Daily min. Temp.		-0.420	0.116	-0.550	0.116			
	Daily mean. R.H%		0.360	0.181	0.240	0.181			
	Plant age	Age 1	-0.180	0.517	-0.830	0.268			
		Age 2	-0.280	0.308	0.371	0.136			
		Age 3	-0.360	0.186	-0.011	0.079			
		C. carnia	0.801	0.003	0.341	0.098			
		C. undicium punctata	0.601	0.018	0.121	0.761			

4.5.2. *Ophiomyia phaseoli*

As shown in Table 5, the effect of climatic factors (daily mean of max. & min. temp., and daily mean of R.H%) and plant age on the population density of bean fly and natural enemies on *P. vulgaris* plants during two successive seasons in agricultural fields in Mansuryia village, Giza governorate. Simple correlation had an insignificant effect (P> 0.05) on the bean fly population during 1st and 2nd seasons except the two-predator showed significant effects on the bean fly population *O. phaseoli*. The combined effect of combination of all studied factors on aphid population is presented as explained variance (EV%) with values of 83 and 73% in 1st and 2nd seasons, with the same insignificant positive b values in both seasons except daily mean of max. temp., daily mean of R.H% and plant age 3 in the first season and daily mean of max. & mini temp., plant age 2 in the second season, of R.H%, respectively. These results are closely related with those obtained by Wains *et al*. (2010) [20] who reported that *A. craccivora* population density was positively associated with maxi as well as mini temp., while it showed a negative correlation with R.H%).The environmental factors are thought to be limiting parameters for the growth and fertility of whitefly while on the other hand, the *B. tabaci*, population fluctuations decreased when the temperature was below 15° C°, (Amaar *et al.* (2014) [5] and Selem *et al.* (2016) [17].

Table 5: Statistical analysis of the effect of certain ecological factors on the population of *O. phaseoli* during 2020/2021 season at El- Mansuryia village- Giza governorate, Egypt

Years	Source of variation		Simple correlation		Partial regulation				
			r	p	b	p	F	P	Ev %
2020/2021	Daily max. Temp.		0.190	0.492	0.494	0.492	3.29	0.081	81%
	Daily min. Temp.		-0.110	0.675	-0.369	0.657			
	Daily mean. R.H%		0.211	0.431	0.250	0.431			
	Plant age	Age 1	-0.070	-0.880	-1.664	0.735			
		Age 2	-0.150	0.575	0.443	0.530			
		Age 3	0.230	-0.426	-0.024	0.401			
		C. carnia	0.520	0.051	-0.560	0.235			
		C. undicium punctata	0.541	0.021	-0.300	0.727			
2021/2022	Daily max. Temp.		0.520	0.046	-1.440	0.046	6.61	0.016	89%
	Daily min. Temp.		-0.480	0.064	-1.940	0.057			
	Daily mean. R.H%		0.401	0.136	0.820	0.136			
	Plant age	Age 1	-0.201	0.459	-1.100	0.817			
		Age 2	-0.331	0.219	-0.520	0.464			
		Age 3	-0.420	0.111	-0.030	0.266			
		C. carnia	0.870	0.001	1.380	0.006			
		C. undicium punctata	0.610	0.010	-0.340	0.659			

Conclusion

Our findings and comparisons to previously published data regarding two pests lead us to the conclusion that timely crop monitoring is necessary, in order to avoid the pest from crossing the economic threshold. Furthermore, *P. vulgaris* is a crucial crop for Egypt's vegetable industry, thus it needs to be safeguarded from these dangerous pests. Due to the plant's late age and resulting decline in nutritional content, which is essential for the development of both nymph and adult insects, it is apparent that the density of insects decreases after the third peak. Also, using all these information should help to develop an Integrated Pest Management (IPM) approach for four species of insects that are recognized as polyphagia's insect pests globally.

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