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Annual Variation in Population of the Bean Fly Leaf miner, *Melanagromyza phaseoli* (Tryon), Generation Numbers and Related Injury in Common Bean Fields

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Abstract

Four experiments were conducted at Embaba, Giza Governorate by planting beans four times during 2011, 2012 and 2013 to assess the annual variation in population of *Melanagromyza phaseoli* attacking bean plants *Phaseolus vulgaris* (L.) in relation to certain climatic factors, synchronization of plant age with insect counts, generation numbers, and injury on plants. Obtained results cleared that adults and larvae of this fly attack plants as soon as seedlings emergence in all growing seasons. In spring 2011, adult females reached highest counts 1.17, 1.17 and 1.1 individual/sweep at 12th April, 10th May and 7th June, respectively. Their larvae reached highest 2.2 and 15.33 larvae/leaf at 26th April and 31st May. The highest tunnels number during season was 26.87 tunnel/leaf. In summer 2011, larvae reached highest counts 1.4, 29 and 2.3 larvae/leaf at 5th July, 23rd August and 20th September at temperature 27.17, 29.84 and 27.97°C and relative humidity 54.14, 54.57 and 57.71%, respectively. During summer 2012, both adults and larvae reached its highest three times, larvae were 1.9, 4.87 and 7.2 larvae/leaf. Tunnels number was 11.07/leaf in highest case. Leaf miner population was rather low during winter 2012/2013.

Capabilities of insect to produce progeny and to injure plants were discussed. Insect produced three generations/growing season. Temperature and relative humidity revealed their presence inside the optimum range for the insect activity. Plant age had positive relationship with larvae counts in spring and summer seasons. Management program must be directed against insect during period 39-74 day of plant age.

Keywords: Annual variation; *Melanagromyza phaseoli*; Generation numbers; Related injury; *Phaseolus vulgaris*

Introduction

Common bean, *Phaseolus vulgaris* (L.) regard among the most important legume crops in Egypt. It is infesting by bean fly *Melanagromyza Phaseoli* (Tryon) (Agromyzidae); this insect is devastating for its feeding on young plants or young leaves as soon as seedlings emergence [1-3]. Adult females puncture both upper and lower surface of leaves to lay eggs or to feed [4]. Larvae feed as leaf miner and also as stem borer [1,3]. Damage by leaf miner represented in mining, wilting and followed by drying of leaves [5]. In field studies, it is important to follow up the population growth of insect, define the insect counts necessary to apply control measures, timing of insect counts with plant phenology; and select the appropriate sampling technique [6].

In Egypt, Giza governorate this insect was ignored and did not receive any attention from researchers until became dangerous on bean plants. So the objective of this study was to assess the annual variation in larvae and adults population of *M. phaseoli* among different growing seasons in relation to certain climatic factors, synchronization of plant age with insect counts, generation numbers and the related injury on plant due to insect activity.

Material and Methods

Experiments preparation

Four experiments were conducted at Embaba district, Giza Governorate, Egypt. Two experiments were done during 2011 by planting beans at spring and summer, the third one in summer 2012; and fourth experiment at winter 2013. An area about 3 Karats (1/8 feddan) (feddan=4200 m^2) was prepared in each experiment and planted by common bean Giza 6 at dates 24th March 2011, 23rd June 2011, 18th July 2012 and 13th December 2013. Experimental area was divided into three equal parts to use as replicates. Conventional agricultural practices were followed and chemical control was entirely avoided.

Sampling methods

Standard sampling methods were used to estimate leaf miner population according to Pohronezny and Waddil [7]; Gangrade and Kogan [2]; Johnson et al. [8]; Pohronezny et al. [9]; adult flies are very active, cannot estimated accurately on leaves or foliage, therefore sweep net method was used to make 30 double strokes above plants, captured adults were killed in cyanided jar and counted. As well as larvae population was estimated on foliar samples of 30 leaves/experiment every week (10 leaves/replicate), samples were picked up randomly from leaves of the middle level on plants, which harbored the highest density of larvae [10]. Alive larvae were counted using binocular microscope. Tunnels numbers were recorded.

Calculations and statistical analysis

Daily records of temperature and relative humidity during the experimental periods were obtained from the Central Laboratory for Agricultural Climate. Weekly means of two climatic factors used to calculate the simple correlation and regression values according to Gomez and Gomez [11]. Captured adults/sweep; larvae and tunnels numbers/leaf; and percent of infested leaves/sample were calculated.

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Number and duration of insect generations were calculated according to method of Audemard and Miliare [12] and Jacob [13].

Results and Discussion

Assessment the insect population and related injury

Spring experiment: Data in Table 1 cleared that adult of *Melanagromyza phaseoli* had three peaks of activity and reached its highest counts 1.17, 1.17 and 1.1 individuals/sweep at 12th April, 10th May and 7th June, respectively. Larvae reached its highest counts twice 2.2 and 15.33 larvae/leaf at 26th April and 31st May when temperature was 19.47 and 27.91°C; and relative humidity was 53.43 and 43.86% respectively. The highest number of tunnels was 26.8 tunnel/leaf appeared timing with the presence of highest counts of larvae (15.33 larvae/leaf) at 31st May. Highest percent of infested leaves during the season growth was 100% at 31st May.

It is worth to mention that adult fly was catched during the season growth by grand mean 0.745 individuals/sweep; and produced larvae estimated by means 2.7 larvae/leaf; these larvae tunneled and injured leaves by 5.3 tunnels/leaf. This mean that each sampled leaf harbored actual infestation estimated by 2.71 larvae and harbored supposed infestation on leaves=5.35 tunnels (larvae)/leaf wherever each larva mine one tunnel; this tunnel still presented on leaves and did not disappear after larvae developed into another stages and emerged out. Percent of infested leaves was 59.72%.

Summer experiments: Data in Table 2 cleared that adult fly reached its highest counts four times in summer 2011 (2, 0.93, 1.13 and 0.8 individuals/sweep). Larvae had three peaks of activity, reached its highest with more abundant and dominant counts in this season, threating the crop (1.4, 29 and 2.3 larvae/leaf) at 5th July, 23rd August and 20th September, when temperature was 27.17, 29.84 and 27.97°C and relative humidity was 54.14, 54.57 and 57.71%, respectively. The highest number of tunnels (56 tunnels/leaf) appeared timing with the presence of highest counts of larvae (29 larvae/leaf) at 23rd August.

Highest percent of infested leaves/sample during growth season was 93.33% at 6th and 20th of September. Finally, adults captured by mean 0.81 individual/sweep during summer 2011, produced larvae (actual infestation) by mean 4.44 larvae/leaf; these larvae fed, injured and mined leaves by 7.5 tunnels/leaf; so supposed infestation=7.5 larvae (tunnel) leaf; this actual or supposed infestation resulted in 81.96% infestation on sample leaves.

Data in Table 3 cleared that adults reached its highest counts three times in summer 2012, with counts 1.5, 1.23 and 1 individual/sweep. Larvae revealed a trend of activity similar with their mothers and reached its highest counts 1.9, 4.87 and 7.2 larvae/leaf at 7th August, 28th August and 2nd October, when temperature was 30.38, 29.78 and 27.39°C and relative humidity was 57.43, 55.0 and 55.57%, respectively. The highest number of tunnels was 11.07 tunnels/leaf related to the activity of highest counts of larvae (7.2 larvae/leaf). The highest percent of infested leaves/sample was 100% appeared twice during season growth.

Captured adults was estimated by mean 0.79 individuals/sweep during summer 2012, produced progeny=2.38 larvae/leaf; injured and mined leaves by mean 4.58 tunnels/leaf (supposed infestation) Resulted infestation was 82.36% on sampled leaves.

Winter experiment: Data in Table 4 cleared that adult fly reached its highest counts three times (1.3, 1.0 and 0.9 individual/sweep at 28th January, 25th February and 18th March of 2013. But larvae counts in this season was lower than its counts in three previous seasons, it is reached its highest (1.17 larva/leaf) at 21st January in conditions of 14.39°C and 56.86%. Highest number of tunnels during winter 2013 was 2.7 tunnel/leaf. The highest percent of infested leaves/sample was 70%.

During the experimental seasons, it was observed that the captured adults had near values 0.745, 0.81, 0.79 and 0.76 individual/sweep at spring, summer 2011, summer 2012 and winter 2013 (Tables 1-4), respectively. In spite of this, produced larvae differed in its counts, it was 2.71 (larvae/leaf in spring 2011 and duplicated in summer of the same year (4.44 larvae/leaf); and back to 2.38 larvae/leaf in summer 2012; and was minimized (0.46 larvae/leaf) in winter 2013. So that, larvae counts regard the limited parameter for insect in causing its injury on plants. Tunnels number showed similar trend as the larvae counts; but it was dominated and higher than larvae counts, because the larvae completed its development and emerged out tunnels in spite of the still presence of these tunnels; tunnels number changed from 5.301 to 7.5 tunnel/leaf; and from 4.58 to 1.06 tunnel/leaf in spring, summer 2011; and in summer 2012, winter 2013 respectively. Such results are in agreement with results of Assem [1] who found that lowest activity of *M. phaseoli* was recorded in winter. El Gendi et al. [10], El-Khouly et al. [14] and Abou-El-Haggag and Salman [15] who found that larvae of *Liriomyza trifolii* has three peaks of activity per season. They also agree with results of Assem [1], El-Bessomy [16]; Omar and Faris [17] who revealed that larvae of *M. phaseoli* primary mine between leaf

Sampling Date	Plant age (days)	Insect Counts		Related Injury		Climatic factors	
		Adults/sweep	Larvae/leaf	Tunnels no./ leaf	%infested leaves	Temperature (°C)	R.H%
April 5	11	0.57	0.13	1	20	19.89	56.29
12	18	1.17	0.33	1.5	23.33	20.06	52.43
19	25	0.9	1.8	1.6	46.67	23.71	37.43
26	32	1.03	2.2	1.9	66.67	19.47	53.43
May 3	39	0.5	0.2	2	73.33	24.3	47.43
10	46	1.17	0.2	2.47	80	23.26	51.14
17	53	0.63	0.73	1.27	60	22.16	50.57
24	60	0.37	1.13	6.4	40	25.41	46.43
31	67	0.7	15.33	26.87	100	27.91	43.86
June 7	74	1.1	6.87	14.4	93.33	26.61	54.0
14	81	0.5	2.33	2.8	73.33	28.37	46.86
21	88	0.3	1.23	1.4	40	27.34	54.43
Total Mean		8.94 0.745	32.48 2.71	63.61 5.301	716.66 59.72		

Table 1: Mean counts of bean fly *Melanagromyza phaseoli* related injury on bean plants and climatic factors during spring 2011 at Giza Governorate.

Sampling date	Plant age (days)	Insect counts		Related injury		Climatic factors	
		Adults/sweep	Larvae/leaf	Tunnels no./leaf	%infested leaves	Temperature (°C)	R.H%
April 5	11	2	1.4	1.62	77	27.17	54.14
12	18	0.97	1.27	3.13	86.67	29.06	55.0
19	25	0.7	1.2	2.33	86.67	29.99	55.57
26	32	0.43	1.13	1.53	86.67	30.03	57.43
August 2	39	0.93	0.8	1.9	73.33	29.57	61.57
9	46	0.4	0.73	1.83	60	29.34	60.14
16	53	1.13	1.53	4.3	80	28.17	60.71
23	60	0.7	29	56	80	29.84	54.57
30	67	0.7	15	15	70	28.93	56.43
September 6	74	0.5	1.53	2.3	93.33	28.53	59.57
13	81	0.6	2.2	4.0	87	28.0	61.57
20	88	0.8	2.3	3.43	93.33	27.97	57.71
27	95	0.7	2.13	4	86.67	27.27	55.43
October 3 2011	102	0.77	1.93	3.67	86.67	22.64	65.0
Total Mean		11.33 0.81	62.15 4.44	105.04 7.5		1147.38 81.96	

Table 2: Mean counts of bean fly *M. phaseoli* related injury on bean plants and climatic factors during summer 2011 at Giza Governorate.

Sampling date	Plant age (days)	Insect counts		Related injury		Climatic factors	
		Adults/sweep	Larvae/leaf	Tunnels no./leaf	%infested leaves	Temperature (°C)	R.H%
July 31	11	1.5	0.9	1.0	27	30.51	58.71
August 7	18	1.3	1.9	2.2	80	30.38	57.43
14	25	0.8	1.75	2.3	90	32.14	47.29
21	32	1.23	1.25	1.7	76.66	29.90	53.71
28	39	0.8	4.87	6.87	87	29.78	55.0
September 4	46	0.6	1.5	2.0	80	28.96	59.0
11	53	0.37	0.45	2.07	60	28.24	59.29
18	60	0.57	1.2	3.47	86.66	27.88	51.71
25	67	1.0	5.4	8.1	100	26.73	58.0
October 2	74	0.7	7.2	11.07	90	27.39	55.57
9	81	0.67	2.2	7.9	96.66	26.17	59.0
16	88	0.47	2.0	4.9	96.66	26.41	57.71
23	95	0.3	0.3	5.9	100	26.06	63.43
Total Mean		10.31 0.79	30.92 2.38	59.48 4.58		1070.64 82.36	

Table 3: Mean counts of bean fly *M. Phaseoli* related injury on bean plants and climatic factors during summer 2012 at Giza Governorate.

Sampling date	Plant age (days)	Insect counts		Related injury		Climatic factors	
		Adults/sweep	Larvae/leaf	Tunnels no./leaf	%infested leaves	Temperature (°C)	R.H%
December 24	11	0.1	0	0	0	15.23	51.29
31	18	0.5	0	0	0	14.75	73.0
January 7 2013	25	0.8	0.3	0.6	30	14.58	64.14
14	32	0.8	0.8	2.8	60	12.39	69.29
21	39	1.13	1.17	1.1	63.64	14.39	56.86
28	46	1.3	0.5	1.0	60	15.88	54.14
February 4	53	0.7	0.9	1.6	70	14.28	60.43
11	60	0.7	0.5	2.7	70	16.18	54.43
18	67	0.8	0.6	2.1	70	15.22	33.0
25	74	1	0.7	1.5	70	16.94	54.57
March 4	81	0.7	0.3	1.1	70	18.45	56.86
11	88	0.5	0.2	0.8	60	18.21	53.29
18	95	0.9	0.3	0.8	60	21.13	45.43
25	102	0.7	0.2	0.9	50	19.09	51.43
Total Mean		10.63 0.76	6.47 0.46	14.77 1.06		733.64 52.4	

Table 4: Mean counts of bean fly *M. Phaseoli* related injury on bean plants and climatic factors during winter 2013 at Giza Governorate.

Experimental Season	1st generation period	2nd generation period	3rd generation period
Spring 2011	From April 1st to 19th April (3 weeks)	From 19th April to 24th May (5 weeks)	From 24th May to 21st June (4 weeks)
Summer 2011	From 5th July to 19th July (3 weeks)	From 19th July to 16th August (4 weeks)	From 16th August to 31st October (7 weeks)
Summer 2012	From July 31st to 21st August (4 weeks)	From 21st August to 25th September (5 weeks)	From 25th September to October 31st (4 weeks)
Winter 2013	From December 31st to January 31st (6 weeks)	From February 1st to 18th February (3 weeks)	From 18th February to 25th April (5 weeks)

Table 5: Number of generations and duration periods of *Melanagromyza phaseoli* on bean plants during 2011, 2012 and 2013.

Experimental Season	Plantage		Temperature		Relative humidity	
	r	b	r	b	r	b
Spring 2011	0.39	0.07	0.51	0.37	-0.27	-0.22
Summer 2011	0.125	0.034	0.22	0.93	-0.36	-0.88
Summer 2012	0.18	0.014	-0.021	-0.23	-0.13	-0.07
Winter 2013	-0.03	-0.0003	-0.43	-0.063	-0.08	-0.007

Table 6: Simple correlation (r) and regression (b) for leaf miner larvae with certain studied factors.

layers, consuming chloroplasts and reducing photosynthesis followed by decreasing yield.

Number of insect generations

Accumulated weekly counts of larvae showed three generations for *M. Phaseoli*. Table 5 revealed that insect had 3 generations/growing season. In spring season, they occupied 3,5 and 4 weeks, respectively, in summer season 2011, occupied 3,4 and 7 weeks, in the following summer they occupied 4,5 and 7 weeks; in the following summer they occupied 4,5 and 4 weeks; in winter season, occupied 6,3 and 5 weeks, respectively. This agrees with results of El-Khouly et al. [14] and Omar et al. [18] who found that larvae of *Liriomyza* spp passed by three generations each season [19].

Synchronization of larvae population with studied factors

The relations between plant age, temperature; relative humidity and annual variation in larvae population of *M. phaseoli* on bean plants, was shown in Table 6. Plant age had positive relationship (correlation) with larvae counts in spring 2011, summer 2011 and summer 2012 where r=0.39, 0.125 and 0.18, respectively; but negative correlation was obtained (r=-0.03) in winter 2013. This agree with results of Salem [20] who found that infestation by *Melanagromyza cunctans* on soybean plants began as the seedlings emergence and continued until the harvest time, captured adults, larvae counts and tunnels numbers were increased with the plant age until 13 weeks (91 days) of plant age. Abd El-Salam et al. [19] mentioned that leaf miner cause damage to faba bean plants during all life stages.

Statistical analysis revealed that weekly mean temperature had insignificant effect on larval population in four experimental seasons (Table 6); also relative humidity had negative and insignificant effect this refer that both temperature and relative humidity was inside the optimum range for the larval activity. These findings agree with results of El-Khouly [14] who found that temperature and relative humidity had insignificant effect on larvae population of *L. congesta.*

On the basis of aforementioned results, larvae of this insect reached its maximum counts during the experimental seasons at range from 1.13 to 29 larvae/leaf; when temperature ranged from 25.41 to 29.84°C; and relative humidity from 43.86 to 60.71% and plant age was between 39-74 days. This refers that this period (39-74 day of plant age) was the most favorable and attractance for (leaf miner infestation; with the range of temperature 25.41-29.84°C and relative humidity 43.86-60.71%, so management program must be directed into insect during this period of plant age or during this ranges of climatic factors [20].

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