



Egyptian Journal of Plant
Protection Research Institute

www.ejppri.eg.net



Population dynamics of cabbage webworm, *Hellula undalis* and diamondback moth, *Plutella xylostella* (Lepidoptera:Crambidae : Plutellidae) at Fayoum Governorate

Abd-Elgayed, A. A.¹; Solaiman, R. H. ¹; Abd- Elwahab, Horia A. ²and Ghidan, Rasha M. ¹⁻²

¹Plant Protection Department, Faculty of Agriculture, Fayoum University.

²Plant Protection Research Institute, Agricultural Research Center, Dokki , Giza, Egypt.

ARTICLE INFO

Article History

Received:15 /4/2025

Accepted:9 /6/2025

Keywords

Cabbage, lipedopteran,
Hellula undalis,
Plutella xylostella and
population dynamics..

Abstract

The lepidopteran is an insect of great economic importance; it includes many species whose larvae feed on important agricultural crops and cause serious damage to the valuable products. Many species are also associated with forest vegetation and ornamental plants, posing serious damage as defoliators. During the field survey, different immature stages viz., eggs, larva, pupa, and adult, of the species *Hellula undalis* (Fabricius) and *Plutella xylostella* (L.) (Lepidoptera: Crambidae: Plutellidae), were collected in the field from detailed accounts on different life history aspects of the species. Results: *H. undalis* larvae were recorded on cabbage plants in summer plantations during 16th April and 27th March of the 1st and 2nd seasons and fluctuated in their density until harvesting crops. It had only one peak with 44 and 33 individuals/30 leaves for the 1st and 2nd seasons, respectively. The pest completely disappeared during winter plantations. Diamondback moths were found on cabbage crops in summer and winter plantations, but they were abundant in winter plantations during both study seasons. In the winter plantation, the total population recorded two peaks during 16th November and 16th December with 8 and 14 individuals/30 leaves in the first season, and 10th and 30th January with 36 and 38 individuals/30 leaves in the second season.

Introduction

The objective of the experiment was to assess the efficacy of insect pests on cabbage, with a primary concentration on lepidopteran larvae, *Plutella xylostella* (L.) (Lepidoptera:Plutellidae), and its associated natural enemies were investigated in the major *Brassica oleracea* var. capitata. The potentially injurious lepidopterous pests were imported cabbage worm, *Pieris rapae* L. (Lepidoptera: Pieridae), *P. xylostella* L., and

cabbage semilooper, *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae) (Chalfant *et al.*, 1979 and Shelton *et al.*, 1982). *Hellula undalis* (Fabricius) (Lepidoptera: Crambidae) larvae mine in leaves and stems, bore into the growing shoots, and many larvae attack the same plant in the field. Young seedlings are generally killed by infestation. Young larvae appeared unable to survive under winter conditions, but there does not appear to be a winter diapause for

this pest (Harakly, 1973). The outbreaks of DBM sometimes cause crop losses of more than 90% (Verkerk and Wright, 1996). *H. undalis* occurred on cabbage crops from April to October, but its population was very low. The damage is most severe between transplanting and the heading stage of cabbage, even though the larvae are present in the field throughout the crop (Singh and Lal, 1999). DBM larvae and pupae were collected from the cabbage. The lepidopteran larval population on the cabbage plants comprised 41% diamondback moth and 15% cabbage webworm (Atwal and Dhaliwal, 2002). The larvae of *H. undalis* feed on the developing shoot, causing a reduction in marketable heads production. This insect is one of the major pests infesting cabbage and is distributed worldwide. It also infests other cruciferous vegetables, cauliflower, knolkhol and beetroot, causing substantial loss by webbing the leaves and boring into the stem, stalk, or leaf veins (Ojha *et al.*, 2004). *H. undalis* larvae population has two peaks in the first year and three peaks in the second year, with the highest abundance during August, September, and October (El-Dabi *et al.*, 2006).

Cabbage crops were attacked by several species of insect pests, including *Pieris brassicae* (L.) (Lepidoptera: Pieridae), *P. xylostella*, the tobacco caterpillar, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae), and *H. undalis*. *P. xylostella* is the most destructive species of these pests (Ahuja *et al.*, 2012).

Materials and methods

1. Population fluctuation of lepidopterous insects:

The study of population fluctuations of these pests and predators 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 350m² area with the Sapawy variety. The healthy and vigorous seedlings of 30 days old were transplanted in the main field. At spacing 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.

Cabbage plants were sampled at ten-day intervals starting from 10 days after transplanting. On the first four sampling dates, counts were taken from thirty randomly selected plants. The observations on the numbers of lepidopterous immature stages for each species were recorded by observing the plants and counting their numbers. Because of the leaf size increase, lepidopterous species were sampled by taking a total of thirty cabbage leaves from thirty separate plants. Sampling was stratified according to plant structure (10 upper, 10 middle, and 10 lower-positioned leaves). All immature stages of lepidopterous species (Eggs, larvae, and pupae, and pupal cases) were found on the cabbage leaves by gripping the leaf petiole and carefully lifting it upward until the entire lower and upper leaf surfaces could be viewed. After that, leaves were placed in paper bags and transferred to the laboratory for counting immature stages and adults by using a binocular stereomicroscope (Sivapragasam and Chua, 1997).

Counted cabbage lepidopterous insect pests /30 leaves were used for studying the population fluctuation of the pest in relation to some weather factors (Average temperatures and relative humidity). The data of weather factors, including maximum and minimum temperatures, and relative humidity, were obtained from the meteorological station at Fayoum Governorate. Immature stages of lepidopterous pests were collected from the

cabbage field and kept individually in Petri dishes in the laboratory up to the emergence of the complete following stage. The immature stages were provided with fresh cabbage leaves for feeding.

Results and discussion

1. Population fluctuation of *Hellula undalis*:

1.1. First season, 2019 /2020:

Data in Table (1) One discussed the larvae of *H. undalis*, as they are the most harmful stage on the cabbage during summer plantations. The counts began with zero population (0.0 larvae/ 30 leaves) on 27th March 2019 and appeared on cabbage plants after two weeks from inspection on 16th April with 4.0 larvae / 30 leaves. The population

increased gradually to reach its peak with 40 larvae /30 leaves on 5th June (41.4°C, 20.7°C, and 72% R.H.), then it declined until the harvesting crop. Pupae stages appeared on the cabbage plant for the first time on 16th May and recorded only one peak with 4 pupae on 5th June. The total population for immature stages (larvae and pupae) increased gradually from 16th April to 5th June to reach only one peak with 44 individuals/30 leaves. Then the population declined until the end of the inspection. Generally, the total number of *H. undalis* larval and pupal stages in the summer plantation was 173 larvae and 19 pupae. On the other hand, all stages of the pest completely disappeared during the winter plantation in 2019/2020 season.

Table (1): Population fluctuations of *Hellula undalis* immature stage 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.	
27/3/2019	0	0	0	0	30.4	19.6	77
6/4	0	0	0	0	30.5	12.7	78
16/4	0	4	0	4	33.8	10.0	78
26/4	0	7	0	7	37.7	16.6	67
6/5	0	9	0	9	35.1	16.0	75
16/5	0	18	3	21	40.3	18.3	58
26/5	0	30	4	34	42.3	20.4	63
5/6	0	40	4	44	41.4	20.7	72
15/6	0	23	3	26	40.3	21.5	72
25/6	0	21	3	24	40.3	21.4	82
5/7	0	21	2	23	42.3	23.1	82
Total	0	173	19	192			
Winter plantation							
17/10/2019	0	0	0	0	35.1	14.4	86
27/10	0	0	0	0	35.0	14.5	89
6/11	0	0	0	0	35.0	15.1	95
16/11	0	0	0	0	32.5	11.8	92
26/11	0	0	0	0	30.0	10.4	83
6/12	0	0	0	0	28.4	10.5	94
16/12	0	0	0	0	24.1	10.2	91
26/12	0	0	0	0	25.0	8.0	94
5/1/2020	0	0	0	0	22.0	7.5	86
15/1	0	0	0	0	20.0	5.0	85
25/1	0	0	0	0	21.1	7.0	92
Total	0	0	0	0			

1.2. Second season, 2020/2021:

As shown in table (2) The population in the second plantation (summer) began low at the beginning of the plantation in the first sample (2 individuals/30 leaves) on 27th March for the larval stage, then increased gradually by the time to record the first and lowest peak (12 larvae/30 leaves) on 26th April, then the larval population declined and rapidly increased again to record the highest and second peak on 5th Jun. with 33 larvae/30 leaves at 40.0°C, 20.3°C, and 76% RH.

Finally, the population decreased gradually until the end of the inspection. Concerning the total population of larvae and pupal stages, a similar trend is observed to that of the larvae population, recording two peaks in the total period of plantation. As mentioned in the first and second seasons 2019/2020 - 2020/2021 in winter plantation, the population of *H. undalis* immature stages was not recorded from the first inspection until the end of the plantation.

Table (2): Population fluctuations of *Hellula undalis* immature stage 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	2	0	2	33.2	13.0	75
6/4	0	2	0	2	33.0	12.7	76
16/4	0	4	0	4	37.0	17.0	70
26/4	0	12	0	12	40.0	17.0	63
6/5	0	11	1	12	39.0	19.0	76
16/5	0	12	1	13	39.0	17.3	76
26/5	0	20	1	21	41.0	18.1	67
5/6	0	33	0	33	40.0	20.3	76
15/6	0	12	2	17	40.3	19.4	77
25/6	0	10	2	12	40.4	20.5	77
5/7	0	10	2	12	43.5	22.2	72
Total	0	116	9	125			
Winter plantation							
11/11/2020	0	0	0	0	30.4	15.4	91
21/11	0	0	0	0	28.5	12.1	92
1/12	0	0	0	0	27.0	11.6	85
11/12	0	0	0	0	25.0	11.1	85
21/12	0	0	0	0	20.3	6.5	89
31/12	0	0	0	0	21.3	7.1	89
10/1/2021	0	0	0	0	20.1	8.1	99
20/1	0	0	0	0	20.1	6.6	88
30/1	0	0	0	0	19.3	3.4	85
9/2	0	0	0	0	18.0	3.4	90
19/2	0	0	0	0	17.5	3.0	89
Total	0	0	0	0			

Table (3). Simple correlation (r) and regression (b) analysis of variance between population of *Hellula undalis*, and max., min. temperatures and % RH during 2019/2020 and 2020/2021 seasons.

Season	Parameter	Max. temp. °C			Min. temp. °C			% RH.		
		Correlation	Regression		Correlation	Regression		Correlation	Regression	
		r	b	Sig.	R	b	Sig.	R	b	Sig.
2019/2020	Larvae	0.877**	0.790	0.23	0.670*	0.127	0.650	-0.276	-0.007	0.974
	Pupae	0.846**	0.629	0.065	0.687*	0.245	0.396	-0.364	-0.142	0.515
	Total	0.879**	0.776	0.224	0.676*	0.138	0.605	-0.289	-0.023	0.910
2020/2021	Larvae	0.560	0.389	0.772	0.557	0.197	0.869	-0.047	0.037	0.940
	pupae	0.661*	1.647	0.090	0.690*	--		0.303	0.735	0.050
	Total	0.630*	0.664	0.592	0.631*	0.007	0.995	0.011	0.169	0.711

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

As shown in Table (3), statistically, the relationship between maximum temperatures, minimum temperature, and population of all parameters (larvae, pupae, and total population) was highly significant and positive, while the relative humidity was negatively correlated with larvae, pupae, and total population in the 1st season. In the second season, the effect of maximum and minimum temperatures was significantly positive on pupae and total population, while it was insignificantly positive on the population of larvae. Relative humidity was insignificantly positive with pupae, total population, and insignificantly negative with the population of larvae.

2. Population fluctuations of *Plutella xylostella*:

2.1. The first season, 2019 /2020:

Data in Table (4) showed that *P. xylostella* was found in both summer and winter plantations, but it was most abundant in winter plantations. Generally, the population of this pest was very low in all inspection periods of the summer plantation. In the winter plantation, the individuals of *P. xylostella* immature stages were not noticed on cabbage plants in the first sample inspection. Then, the population of the larval stage increased gradually to record the lowest and first peak (4.0 larvae /30 leaves) on 16th November

2019 at 32.5°C ,11.8°C, and 92% RH. After that, it decreased and increased again to reach the second highest peak with 9.0 larvae/30 leaves on 26th December at weather factors 25.0°C, 8.0°C, and 94% RH. Then, larva numbers declined until the end of the plantation. Concerning the total population, it was found that the pest had two peaks in winter plantation. The first peak was recorded on 16th November. With 8.0 individuals/30 leaves, the highest and second peak (14 individuals/30 leaves) was on 26th December.

2.2. Second season 2020 /2021:

Results in Table (5) indicated that during the summer days, the larvae and pupae numbers of *P. xylostella* were low in the summer plantation compared with those in winter plantations. In the summer plantation, the population of larval and pupal stages recorded two peaks on 26th April and 5th June. The first peak recorded 7.0 larvae/30 leaves on 26th April (40.0°C, 17.5 °C, and 63% RH). Then, the number of larvae decreased gradually and increased again to record 6 larvae /30 leaves on 5th June (40.0 °C, 20.0 °C/ 76% RH.). On the other hand, the total population recorded two peaks; the first peak occurred on 26th April with 9.0 individuals/30 leaves, while the second peak (8.0 individuals/30 leaves) was recorded on 5th June. After that, the

population remained high until the end of the plantation on 5th July 2020.

Concerning winter plantation, results showed that the individuals of *P. xylostella* were high in the second year (2020- 2021), The larval population began low and increased gradually to record the first peak with 31 larvae/30 leaves on 10th January; then the population declined and increased suddenly to reach the second peak with 33

larvae on 5th June and continued until the end of the plantation. With the same trend of larval stage fluctuation, the total population recorded two peaks with 36.0 and 38.0 individuals/30 leaves on the 10th and 30th of January. In general, the pest count was high in this season until the end of the crop, and into the winter season of the previous season.

Table (4): Population fluctuations of *Plutella xylostella* immature stage 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.	
27/3/2019	0	0	0	0	30.4	19.6	77
6/4	0	2	0	2	30.5	12.7	78
16/4	0	2	0	2	33.8	10.0	78
26/4	0	1	0	1	37.7	16.6	67
6/5	0	0	0	0	35.1	16.0	75
16/5	0	0	0	0	40.3	18.3	58
26/5	0	1	0	1	42.3	20.4	63
5/6	0	1	1	2	41.4	20.7	72
15/6	0	0	0	0	40.3	21.5	72
25/6	0	1	1	2	40.3	21.4	82
5/7	0	0	0	0	42.3	23.1	82
Total	0	8	2	10			
Winter plantation							
17/10/2019	0	0	0	0	35.1	14.4	86
27/10	0	1	0	1	35.0	14.5	89
6/11	0	2	4	2	35.0	15.1	95
16/11	0	4	4	8	32.5	11.8	92
26/11	0	3	4	7	30.0	10.4	83
6/12	0	7	4	11	28.4	10.5	94
16/12	0	9	5	14	24.1	10.2	91
26/12	0	9	4	13	25.0	8.0	94
5/1/2020	0	9	4	13	22.0	7.5	86
15/1/	0	8	3	11	20.0	5.0	85
25/1	0	7	3	10	21.1	7.0	92
Total	0	59	35	80			

Table (5): Population fluctuations of *Plutella xylostella* 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	0	2	0	2	33.0	12.7	76
16/4	0	3	1	4	37.0	17.0	70
26/4	0	7	2	9	40.0	17.0	63
6/5	0	5	1	6	39.0	19.0	76
16/5	0	3	0	3	39.0	17.3	76
26/5	0	3	0	3	41.0	18.1	67
5/6	0	6	2	8	40.0	20.3	76
15/6	0	5	1	6	40.3	19.4	77
25/6	0	8	3	11	40.4	20.5	77
5/7	0	8	5	13	43.5	22.2	72
Total	0	50	15	65			
Winter plantation							
11/11/2020	0	4	0	4	30.4	15.4	91
21/11	0	6	3	9	28.5	12.1	92
1/12	0	10	4	14	27.0	11.6	85
11/12	0	12	5	17	25.0	11.1	85
21/12	0	13	5	18	20.3	6.5	89
31/12	0	25	7	32	21.3	7.1	89
10/1/2021	0	31	5	36	20.1	8.1	99
20/1	0	30	5	35	20.1	6.6	88
30/1	0	33	5	38	19.3	3.4	85
9/2	0	30	4	34	18.0	3.4	90
19/2	0	31	5	36	17.5	3.0	89
Total	0	215	48	263			

As shown in Table (6), statistically, the effect of maximum and minimum temperatures was significantly negative on larvae and total population, while it was insignificantly negative of the pupal stage. The relative humidity was positively

correlated with larvae, pupae, and total population in both summer and winter plantations of the first season. Concerning the second season, the effect of maximum and minimum temperatures was significantly positive on larvae, pupae, and

total population in summer plantation, while it was not significantly negative in winter plantation. The population of larvae, pupae, and the total population were insignificantly positively correlated with

relative humidity in both summer and winter plantations, except for that of pupae in the winter plantation, where the correlation was insignificantly negative.

Table (6): Simple correlation (r) and regression (b) analysis of variance between population of *Plutella xylostella* and max., min. temperatures and % RH during 2019/2020 and 2020/2021 seasons.

Season	plantation	Parameter	Max. temp. °C			Min. temp. °C			% RH.		
			Correlation	Regression		Correlation	Regression		Correlation	Regression	
			r	b	t	r	b	t	r	B	T
2019/2020	Summer plantation	Larvae	-0.313	0.459	0.270	-0.667*	-	0.031	0.186	0.296	0.321
		Pupae	0.348	0.440	0.401	0.348	0.061	0.899	0.251	0.401	0.297
		Total	-0.111			-0.406			0.262		
	Winter plantation	Larvae	-0.899**	-	0.094	-0.849**	-	0.971	0.162	0.280	0.079
		Pupae	-0.464	0.917	0.794	-0.428	0.018	0.853	0.312	0.395	0.858
		Total	-0.855**	0.304	0.362	-0.821**	0.218	0.695	0.112	0.246	0.227
2020/2021	Summer plantation	Larvae	0.811**	-	0.613	0.900**	1.231	0.098	0.055	-	0.747
		Pupae	0.648*	0.352	0.307	0.770**	1.720	0.095	0.061	0.083	0.478
		Total	0.774**	1.011	0.401	0.879**	1.470	0.068	0.059	-	0.571
	Winter plantation	Larvae	-0.903**	-	0.353	-0.870**	-	0.754	0.119	0.155	0.563
		Pupae	-0.693*	0.682	0.175	-0.642*	0.224	0.405	-0.158	-	0.308
		Total	-0.917**	1.633	0.231	-0.880**	0.962	0.918	0.086	0.322	0.751

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

H. undalis insects were abundant during late summer and autumn in cabbage and cauliflower fields (Harakly, 1973). *H. undalis* larvae mine in leaves and stems, bore into the growing shoots, and many larvae attack the same plant in the field. Young seedlings are generally killed by the infestation. Young larvae appeared unable to survive under winter conditions, but there does not appear to be a winter diapause for this pest (Lee, 1986). *H. undalis* occurred on cabbage crops from April to October, but its population was very low (El-Dabi *et al.*, 2006). The larval population has two peaks in the first year and three peaks in the second year, with the highest abundance during August, September, and October (Venugopal *et al.*, 2017), and there is a non-significant

negative correlation of relative humidity with the *H. undalis* population. The weather parameters, viz., maximum temperature, minimum temperature, and relative humidity during the peak of *H. undalis* and the period of incidence were 28.9°C, 11.5°C, and 75% RH., respectively (Aiswarya *et al.*, 2018). Infestation of cabbage head borer was the highest in the 1st week of April. Also, the relative morning humidity had a significantly positive correlation with the population of the pest (Mane *et al.*, 2020), and the larval population had a highly significant negative correlation with maximum and minimum temperature and relative humidity, suggesting that daily minimum and maximum temperatures ranging from 18.3 to 18.1°C and 33.4 to 36.8°C, respectively,

are favored for insect multiplication (Bharodiya *et al.*, 2023).

In this partial, the diamondback moth activity started in September and increased gradually up to January. The population peak was recorded by February and remained high until mid-March (Sachan and Srivastava, 1972); the first larvae were recorded in mid-October. The highest densities of larval and pupal stages were recorded during the period from mid-November to mid-January (Mohan, 1994); the infestation of *P. xylostella* started in the 3rd week of November and increased to record its peak in the 1st week of January. The diamondback moth is the most destructive pest of brassicas worldwide (Bana, 2012). In this respect, the diamondback moth had the highest densities of larval and pupal stages recorded during the period from mid-November to mid-January, with 1-2.2 and 0.5-0.8 individuals per plant for larvae and pupae, respectively. The relative humidity correlated negatively with larval and pupa populations (Alishah, 1987). There is a negative correlation between the population of *P. xylostella* and mean relative humidity. Bhardwaj (2002) mentioned that the larval population of *P. xylostella* negatively correlated with maximum temperature and positively correlated with minimum temperature. The high temperature causes rapid development of DBM and many generations per year (Goud *et al.*, 2006), the high temperature causes rapid development of DBM and many generations per year, increasing the rate of resistance development (Furlong *et al.*, 2013). *P. xylostella* population had a positive correlation with temperature and negative correlation to relative humidity and rainfall (Maity *et al.*, 2018). Diamondback moth abundance differed

significantly between seasons (Ngowi *et al.*, 2019).

H. undalis larvae were recorded on cabbage plants in summer plantations and fluctuated in their density until harvesting crops. The pest completely disappeared during winter plantations. Statistically, the relationship between maximum temperature, minimum temperature, and population of all parameters. Diamondback moth *P. xylostella* was found on cabbage crops in summer and winter plantations, but it was abundant in winter plantations during both study seasons.

References

- Ahuja, B. B.; Usharani, A.; Srinivas, P.; Singh, R. V.; Sharma, P. and Bamawale, O. M. (2012): Development of farmer led integrated management of major pests of cauliflower cultivated in rainy season in India. J. Agri. Sci., 4(2): 79- 90. DOI:10.5539/jas. v4n2p79
- Aiswarya, V. A.; Bhosle, B. B. and Bhede, B. V. (2018): Population dynamics of major lepidopteran insect pests of cabbage. Int. J. Curr. Microbial App. Sci., Special Issue, 6: 236-239.
- Alishah, A. (1987): Ecology, behaviour and integrated control of cabbage insect pests in Tasmania Thesis Ph.D. University of Tasmania, Bibliography, pp. 391-435.
- Atwal, A. S. and Dhaliwal, G. S. (2002): A textbook on Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana, pp.177-434.
- Bana, J. K.; Jat, B. L. and Bajya, D. R. (2012): Seasonal incidence of major pests of cabbage and their natural enemies. Indian J. Ent., 74 (3): 236-240.
- Bhardwaj, V. (2002): Effect of insecticides on diamondback moth, *Plutella xylostella* (L.) and its natural enemies on cauliflower. M.Sc. (Agri.)

- Thesis, CSK Himachal Pradesh Krishi Vishva Vidyalaya, Palampur., pp. 23-25.
- Bharodiya, D. A.; Pandya, H. V. and Jena, M. K. (2023):** Seasonal incidence of head borer, *Hellula undalis* Fabricius and coccinellid predators in cabbage and their correlation with weather parameters. International Journal of Environment and Climate Change, 13 (9):1679-1688.
DOI:10.9734/IJECC/2023/v13i92398
- Chalfant, R. B.; Denton, W. H.; Schuster, D. J. and Workman, R. B. (1979):** Management of cabbage caterpillars in Florida and Georgia by using visual damage thresholds. Journal of Economic Entomology, 72: 411-413.
- El-Dabi, M.; Roda, H.; Shalan S.; Nagla, F. and Reyad, A. (2006):** population fluctuations of the cabbage webworm *Hellula undalis* Fabricius in cabbage and cauliflower fields. Plant Protection Res. Inst. Agric. Res. Center. Min. Agric. Giza, Egypt, 31(8): 5479-5486.
DOI: 10.21608/jppp.2006.235242
- Furlong, M. J; Wright D. J. and Dosdall, L. M. (2013):** Diamondback moth ecology and management: Problems, progress, and prospects. Annual Review of Entomology, 58(1):517-541. doi: 10.1146/annurev-ento-120811-153605.
- Goud, R.; Rao, S. and Chiranjeevi, R. K. (2006):** Influence of weather parameters on the population build-up of diamondback moth, *Plutella xylostella* (L.) infesting cabbage. Pest Management in Horticultural Ecosystem, 12(2):103-106.
- Harakly, F. A. (1973):** Biological studies on the cabbage web- worm, *Hellula undalis* Fabr. Bull. Soc. Ent. Egypte., 52(5): 191-211.
- Lee, H. S. (1986):** Seasonal occurrence of the important insect pests on cabbage in southern Taiwan. Journal of Agricultural Research of China, 35(4): 530-542.
- Maity, L.; Padhi, G. and Samanta, A. (2018):** Population dynamics and management of diamondback moth *Plutella xylostella* (L.) in cabbage ecosystem of West Bengal. International Journal of Chemical Studies, 6(1): 381-385.
- Mane, P. D.; Singh, B. B.; Kumar, M. and Singh, P. K (2020):** Seasonal incidence of major pests of cabbage in Nalanda district of Bihar. Journal of Entomology and Zoology Studies, 8(6): 2003-2005.
- Mohan, C. N. (1994):** Seasonal incidence of DBM: *Plutella xylostella* and its parasitoids in Nilgiri. Jr. of Biological Control, 8(2):77-80.
- Ngowi, B. V.; Tonnang, H. E. Z.; Khamis, F.; Mwangi, E. M.; Nyambo, B.; Ndegwa, P. N. and Subramanian, S. (2019):** Seasonal abundance of *Plutella xylostella* (Lepidoptera: Plutellidae) and diversity of its parasitoids along altitudinal gradients of the eastern Afrotropical. Phytoparasitica, 47:375-391.
<https://doi.org/10.1007/s12600-019-00732-3>
- Ojha, P. K.; Singh, I. P.; and Pandey, N. K. (2004):** Seasonal incidence of insect pests of cauliflower and population build-up under Agro. climatic Zone-1 of Bihar. Pestology, 28(3): 16-18.
- Sachan, J. N. and Srivastava, B. P. (1972):** Studies on seasonal incidence of insect pests of cabbage. Indian journal of Entomology, 34:123-127.
- Shelton, A. M.; Andaloro, J. T. and Barnard, J. (1982):** Effects of cabbage looper, imported cabbageworm, and diamondback moth on fresh market and processing cabbage. Journal of

Economic Entomology, 75(4): 742-745.
DOI:10.1093/jee/75.4.742

Singh, S. S. and Lal, H. (1999): Integrated pest management in cole crops. Progressive Horticulture, 31(3/4):123-130.

Sivapragasam, A., and Chua, T. H. (1997): Natural enemies for the cabbage webworm, *Hellula undalis* (Fabr.) (Lepidoptera: Pyralidae) in Malaysia. Res. on Pop. Ecol., 39(1): 3-10. doi:10.1007/bf02765244

Venugopal, U.; Ashwani, K.; Prasad, D. S. H. and Rajesh, B. (2017): Seasonal

incidence of diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* var. capitata L.) under Allahabad condition. Journal of Entomology and Zoology Studies, 5(6):2477- 2480.

Verkerk, R. H. J. and Wright, D. J. (1996): Multitrophic interactions and management of the diamondback moth: A review. Bulletin of Entomological Research, 86 (03): 205-216. DOI:10.1017/S0007485300052482