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Seasonal Incidence of Head Borer, *Hellula undalis* Fabricius and Coccinellid Predators in Cabbage and Their Correlation with Weather Parameters

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Authors' contributions

This work was carried out in collaboration among all authors. Author DAB designed, performed, analysed and visualised the experiment. Author MKJ wrote, reviewed and edited the manuscript, did data visualisation. Author HVP did data visualisation and supervised the study. All authors read and approved the final manuscript.

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ABSTRACT

The investigation was conducted to study the seasonal incidence of cabbage head borer, *Hellula undalis* Fabricius at Regional Horticultural Research Station Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India during 2021-22. The incidence of *H. undalis* on cabbage commenced from 48th Standard Meteorological Week (SMW) with its peak in the second SMW and then decreased gradually until 10th SMW, *i.e.*, end of the crop growth

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period. The *H. undalis* larval population had highly significant negative correlation with maximum and minimum temperature and evaporation. There was 88.78 per cent association of the *H. undalis* population with significant weather parameters. Only coccinellid predators *viz*., *Coccinella transversalis* Fabricius and *Cheilomenes sexmaculata* Fabricius, were noticed in cabbage ecosystem during the crop growth period and none of the parasitoids were reported. The initial occurrence of coccinellids was noted during 48th SMW and the population increased gradually in successive weekly counts and reached the peak during second SMW and thereafter, population declined gradually until 10th SMW. The maximum and minimum temperature had significant negative correlation with the population of coccinellid beetles. The variation in abundance of coccinellids was contributed by significant abiotic factors by 85.30 per cent.

Keywords: Cabbage; Coccinellid predators; Hellula undalis; seasonal incidence; weather parameters.

1. INTRODUCTION

"India is the largest producer of vegetables after China in the world and is known as the vegetable and fruit basket" [1]. "Cabbage, *Brassica oleracea var. capitata*, belongs to the family Cruciferae and is widely cultivated in tropical and temperate parts of India and other parts of the world. Cruciferous vegetables have an important place among *Rabi* crops grown in India. In India, the total cultivated area of cabbage is 418 thousand hectares with the production of 9.72 million metric tons (MT) during the year 2022" [2]. Cabbage has also curative, antidiabetic, anticancerous, and anticarcinogenic properties [3]. The typical flavour in cabbage is due to glycoside "Sinigrin" which contains Sulphur [3,4]. "It is subjected to attack by a large number of insect-pests throughout its growth phase which limit the production. More than 27 species of insect-pests have been reported to infest cabbage in India" [5]. "The various pests infesting cabbage include cabbage head borer *H. undalis*, aphids, *Lipaphis erysimi*, *Brevicoryne brassicae* Linnaeus and *Myzus persicae* Sulzer, tobacco caterpillar, *Spodoptera litura*, diamondback moth, *Plutella xylostella*, cabbage leaf webber, *Crocidolomia bionotalis*, painted bug, *Bagrada cruciferarum* and flea beetle, *Phyllotreta cruciferae"* [6-10]. The *H. undalis* is one of the major pests infesting cabbage and distributed worldwide. It also infests other cruciferous vegetables, cauliflower, knol-khol and beetroot [11]. "The *H. undalis* caterpillars cause substantial loss by webbing the leaves and boring into stem, stalk or leaf veins. They also bore into the cabbage head making it unfit for consumption. The damage results in webbed leaf holes in cabbage head with faecal matter" [8,12,13]. The knowledge of the seasonal incidence of *H. undalis* and coccinellid beetles at different growth stages of cabbage will be helpful in evolving proper management schedule. However, there is scarcity of information available on the seasonal incidence of *H. undalis* and coccinellid beetles particularly in this agroclimatic zone. Keeping these facts in mind, the present investigation was undertaken seasonal incidence of *H. undalis* and coccinellid predators in cabbage ecosystem.

2. MATERIALS AND METHODS

The present investigation was carried out at Regional Horticultural Research Station Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University (NAU), Navsari, Gujarat, India during *Rabi* 2021-22. The soil of the experimental plot was clay in texture, and with pH 7.4. Geographically, Navsari is situated at 72° 54' East longitude and 20° 57' North latitude and at an altitude of 11.98 m, above the mean sea level. The climate was typically tropical and monsoonic. The average rainfall of the tract was about 1500 mm. The field was cross ploughed with a tractor drawn cultivator. It was followed by harrowing and planking to obtain a well pulverised experimental field. The weeds and crop residues, left out from the previous sown crop, were removed. Cabbage seeds of the *variety*, Golden acre, were sown in a plugged chamber in the green house. The seedlings were transplanted in 72 m^2 area on 11th November, 2021 with a spacing of 60 cm × 45 cm. The crop was fertilized with the recommended dose of 200:00:50 kg N, P, and K per hectare (NAU recommendation). The crop was free from the application of pesticides. Appropriate and uniform agronomical operations were followed.

The observations on numbers of *H. undalis* larvae were recorded at weekly interval since transplanting following the method developed by Mane et al. [13]. The observations were taken by thoroughly observing the plants and counting the

numbers of larvae of *H. undalis* per plant. The numbers of coccinellid beetles were also recorded at weekly interval. The data on weather parameters viz., maximum and minimum temperature, morning and evening relative humidity, wind speed, rainfall and sunshine hours *etc.* were obtained from meteorological observatory of NAU. The data was analyzed by simple correlation and regression analysis.

3. RESULTS AND DISCUSSION

3.1 Seasonal Abundance of *H. undalis* in Cabbage Ecosystem

The incidence of *H. undalis* occurred from 48th SMW (2.90 larvae/plant). The larval population gradually increased and attained the peak during second SMW (5.98 larvae/plant) and then decreased to 0.37 larvae/plant at the end of the crop growth period, *i.e.*, 10th SMW. The reduction in larval population was observed from early head formation stage of cabbage (Table 1 and Fig. 1).

The present findings are more or less similar to those of Alam [14] who observed "the initial occurrence of larvae nearly about 18-22 days after transplanting or in 49th SMW at Varanasi". Patel and Shukla [15,16] observed "the initial occurrence of pests between 21-28 days after transplanting during 50th SMW at Raipur and Udaipur, respectively". Bhagat et al. [17] recorded "the incidence after one month of transplanting". The peak population of 14.09 larvae/ plant was observed by Maity et al. [18] on 10 WAT at West Bengal. Goud et al. [6] found the peak population during the last week of January *i.e.,* at 85 days after transplanting at Hyderabad. Gaikwad et al. [19] recorded "the maximum diamondback moth larval population of 7.82 larvae/plant in 2nd SMW in cauliflower at Parbhani". Aiswarya et al. [20] revealed that "the initial population of diamondback moth larva was observed during 47th SMW with peak incidence of 5.20 larvae/plant at 51th SMW during *rabi* season at Parbhani, Maharashtra". Mishra et al. [21] reported major activity period of diamondback moth on cauliflower from 35th to 39th SMW with peak incidence in 39th SMW (7.32 larvae/plant) during late-*kharif* season at Dhule. Baker et al. [22] reported that the mean larval populations remained below 3.0 larvae per plant in cabbage ecosystem. Oduor et al. [23] recorded the diamondback moth population not exceeding 6 larvae/plant.

According to Lasota and Kok [24], "the minimum larval population of 0.70 larvae/plant was observed at the end of the crop growth period during last week of February". Harcourt et al. [25] recorded "the least population of diamondback moth might be due to the non-availability of hosts at the end of crop season or when the moths emerged, they were no longer attracted to cabbage as it reached harvesting maturity by then". Venugopal et al. [26] recorded the minimum diamondback moth larva on second fortnight of February on cabbage at Allahabad. These findings are also concurrent with the present findings.

Table 1. Seasonal abundance of *H. undalis* on cabbage since transplanting in different SMW

Observation period	WAT	SMW	Mean larvae/plant
11th – 17th Nov	1	46	0
18th – 24th Nov	2	47	0
25th – 01st Dec	3	48	2.90
2nd - 9th Dec	4	49	3.35
10th - 16th Dec	5	50	4.10
17th – 23rd Dec	6	51	4.85
24th - 30th Dec	7	52	5.20
31st Dec – 6th Jan	8	1	5.67
7th – 13th Jan	9	2	5.98
14th - 20th Jan	10	3	5.43
21th – 27th Jan	11	4	4.26
28th Jan – 3rd Feb	12	5	3.75
04th – 10th Feb	13	6	3.15
11th - 17th Feb	14	7	2.49
18th – 24th Feb	15	8	1.28
25th – 3rd March	16	9	0.93
4th – 10th March	17	10	0.37

WAT – Week(s) After Transplanting

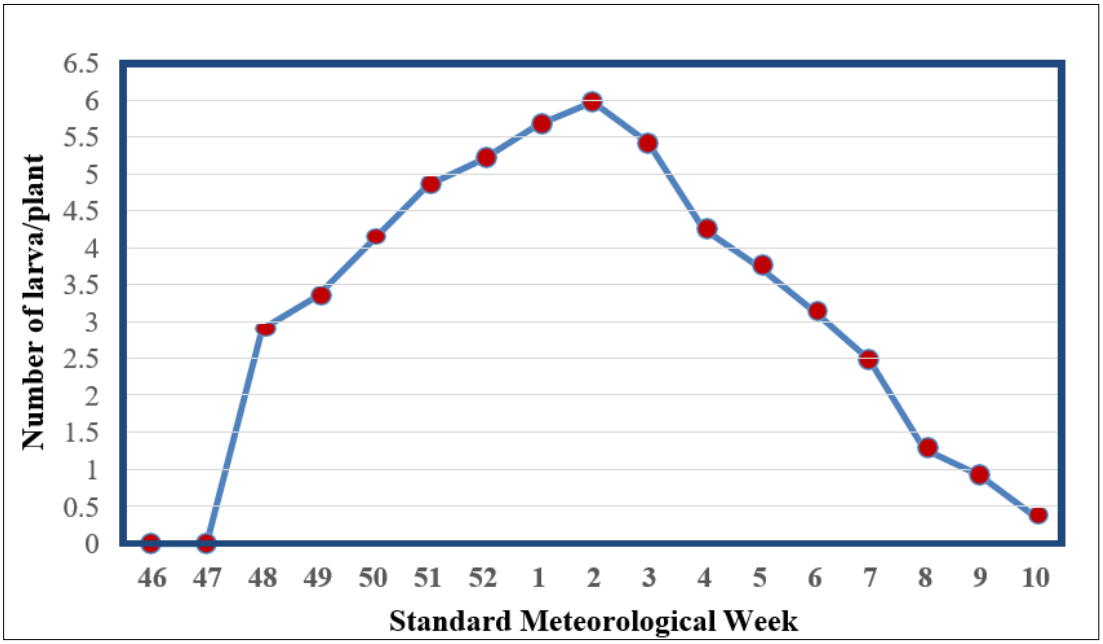

Fig. 1. Seasonal abundance of *H. undalis* infesting cabbage in different SMW

The *H. undalis* population exhibited highly significant negative correlation with maximum temperature (r = –0.793), and significant negative correlation with minimum temperature (r = -0.572) and evaporation (-0.542). It indicated that the rise in temperature led to decline in the larval population. The morning (r = 0.406) and evening relative humidity (r = 0.422) had nonsignificant positive correlation with the population of *H. undalis*. A comparison of temperature record with population growth suggested that daily minimum temperature ranging from 18.3 to 18.1ºC and daily maximum temperature between 36.8 and 33.4ºC favored insect multiplication. The absence of rain during crop growing season excluded the correlation of larval population with total rainfall (Table 2 and Fig. 2).

The present findings are close to those of Usha et al. [27] who observed a negative correlation of larval population with maximum and minimum temperature and sunshine hours. Poonam [28] observed that larval population was significantly negatively correlated with mean and maximum temperature but positively correlated with relative humidity. Bhalla and Dubey [29] suggested that daily maximum temperature between 21 and 36°C and daily minimum temperature ranged from 5 to 12°C favored insect multiplication during crop period. The present results regarding the correlation of larval population with weather parameters are also in conformity with the findings of Bana et al., Shukla, Sharma et al. and Jaishree [9,16,30,31]. Venugopal et al. [26] showed that there was a non-significant positive correlation of sunshine hours and non-significant negative correlation of morning relative humidity with the population of *H. undalis*. There was a negative correlation of *P. xylostella* population with mean relative humidity [32]. Goud et al. [6] recorded a negative correlation of larval population with maximum temperature and sunshine hours and positive correlation with minimum temperature. The positive correlation of larval population with temperature was suggested by Maity et al., Hemchandra and Singh, Patra et al., Jat et al., Jakhar and Singh [18,33,34,35,36].

"Regression studies on the effect of abiotic factors on the build-up of *H. undalis* population revealed that it was significantly influenced by weather factors like wind speed with their contribution being 88.78 per cent" [37].

Coefficient of determination (R^2) = 0.88
Regression equation: $\hat{Y} = 7.23 – 0.39X_4$

Table 2. Effect of weather parameters on population of *Hellula undalis* larvae in cabbage ecosystem

Weather parameter	Correlation coefficient (r)
Maximum temperature (°C)	-0.793**
Minimum temperature (°C)	-0.572*
Morning relative humidity (%)	0.406
Evening relative humidity (%)	0.422
Wind speed (km/hr)	-0.107
Sunshine hours (hrs/day)	-0.435
Evaporation	-0.542*

**Significant at the level of 0.05, **Significant at the level of 0.01*

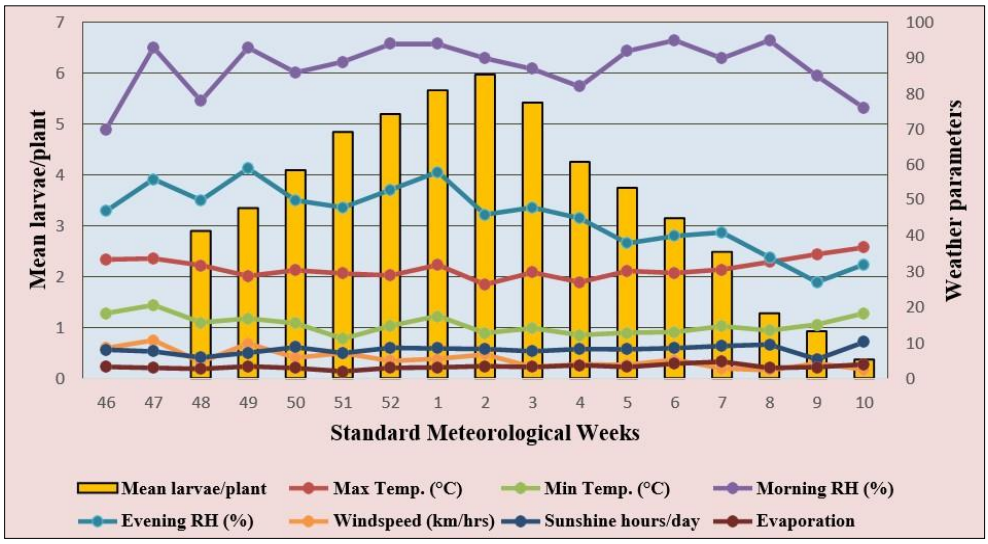

Fig. 2. Seasonal abundance of *H. undalis* in relation to weather parameters

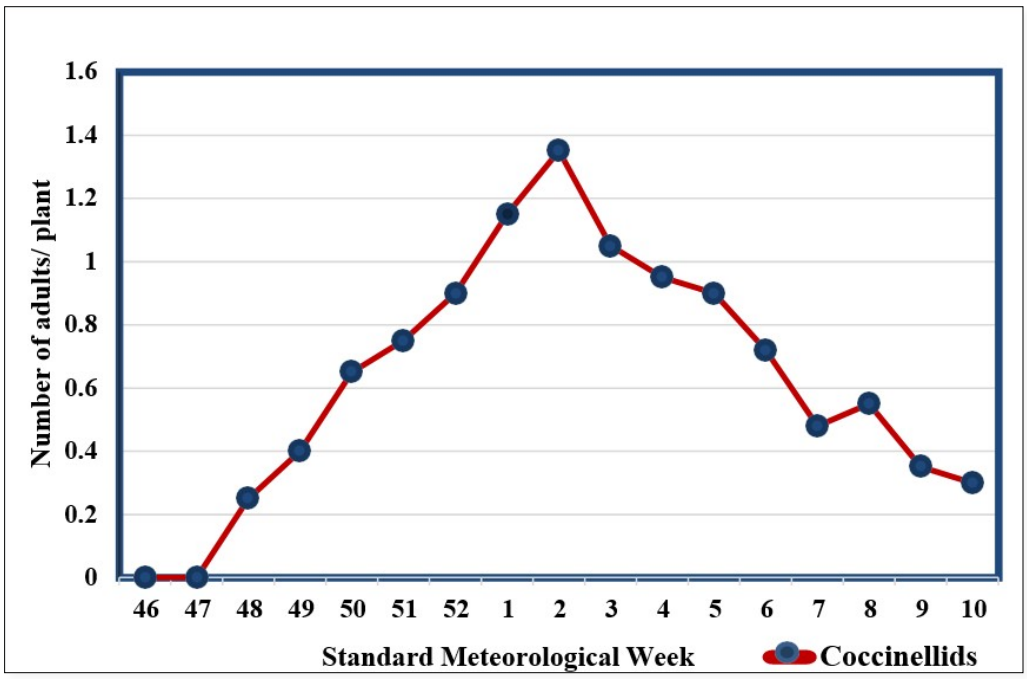

Fig. 3. Seasonal abundance of coccinellid beetles in cabbage in different SMW

The present findings are alike to those of Sonika et al. and Ahmad et al. [38,39] who revealed that the *P. xylostella* population was significantly influenced by weather factors with their contribution being 77.60 and 90-98 per cent, respectively. Nagesh [40] reported that none of the weather parameters individually showed a significant correlation with diamondback moth population, yet maximum temperature, minimum temperature, relative humidity, wind speed, sunshine hours and rainfall together explained 64.93 per cent of the variation in larval population. According to Goud et al. [6] the cumulative effect of weather parameters on the population build-up of diamondback moth was to an extent of 28.11 per cent which is deviated from the present results. This may be due to the differences in variety, species, composition of leaf and prevailing environmental conditions.

3.2 Seasonal Abundance of Coccinellid Beetles in Cabbage Ecosystem

"Among the natural enemies of insect pests of cabbage, the coccinellid predators were found in the field and none of the species was recorded parasitizing the moths. Coccinellid predators *viz*., *Coccinella transversalis* (Fabricius) and *Cheilomenes sexmaculata* (Fabricius) were noticed in cabbage ecosystem during the course of study" [37].

The results revealed the absence of predators for first two weeks after transplanting the crop. The initial incidence of coccinellids occurred in 48th SMW with an initial population of 0.25 adults/plant. The population increased gradually in successive weekly counts and reached the peak of 1.35 adults/plant in second SMW and thereafter, the population gradually declined to 0.30 adults/plant during the 10th SMW (Table 3 and Fig. 3).

Earlier, Debbarma et al. [41] noticed "the coccinellid predators *viz*., *Coccinella sexmaculata, Scymnus* sp., *Coccinella septumpunctata* (Fabricius) and *Brumoides suturalis* (Fabricius) during the survey conducted in Dindigul and Theni districts of Tamil Nadu on cauliflower". Jakhar and Singh [36] revealed that "the ladybird beetle, *C. septempunctata* was recorded as the major natural enemy predator in cauliflower ecosystem and the population was first noticed in the 4th SMW (8.6/ ten plants) and reached the maximum in the 11th SMW (20.2/ ten plants) at maximum and minimum temperature of 26.3 and 13.0 ºC, respectively". Sharma et al. [30] also recorded the presence of coccinellid predator, *C. septempunctata* as major natural enemy in the cabbage ecosystem which fed on the aphids. Jat et al. [35] found that the population of *C. septempunctata* touched its peak (2.10 adult/plant) during 6th SMW with initial incidence on 52nd SMW and *C. sexmaculata* was observed from first week of January to last week of February. Patra et al. [34] noticed the occurrence of coccinellids from seedling stage and continued till harvesting of crop. These findings are concurrent with the present findings.

Table 3. Seasonal abundance of coccinellid beetles in Cabbage ecosystem in different SMW

Observation period	SMW	Mean Adults/plant
11th – 17th Nov	46	0
18th – 24th Nov	47	0
25th – 01st Dec	48	0.25
2nd - 9th Dec	49	0.40
10th - 16th Dec	50	0.65
17th – 23rd Dec	51	0.75
24th - 30th Dec	52	0.90
31st Dec – 6th Jan	1	1.15
7th – 13th Jan	2	1.35
14th - 20th Jan	3	1.05
21th – 27th Jan	4	0.95
28th Jan – 3rd Feb	5	0.90
04th – 10th Feb	6	0.72
11th - 17th Feb	7	0.48
18th – 24th Feb	8	0.55
25th – 3rd March	9	0.35
4th – 10th March	10	0.30

Table 4. Effect of weather parameter on population of coccinellid beetles in cabbage ecosystem

Weather parameter	Correlation coefficient (r)
Maximum temperature (°C)	-0.692**
Minimum temperature (°C)	-0.636**
Morning relative humidity (%)	0.446
Evening relative humidity (%)	0.114
Wind speed (km/hr)	-0.313
Sunshine hours (hrs/day)	-0.313
Evaporation	-0.415

**Significant at the level of 0.05, **Significant at the level of 0.01*

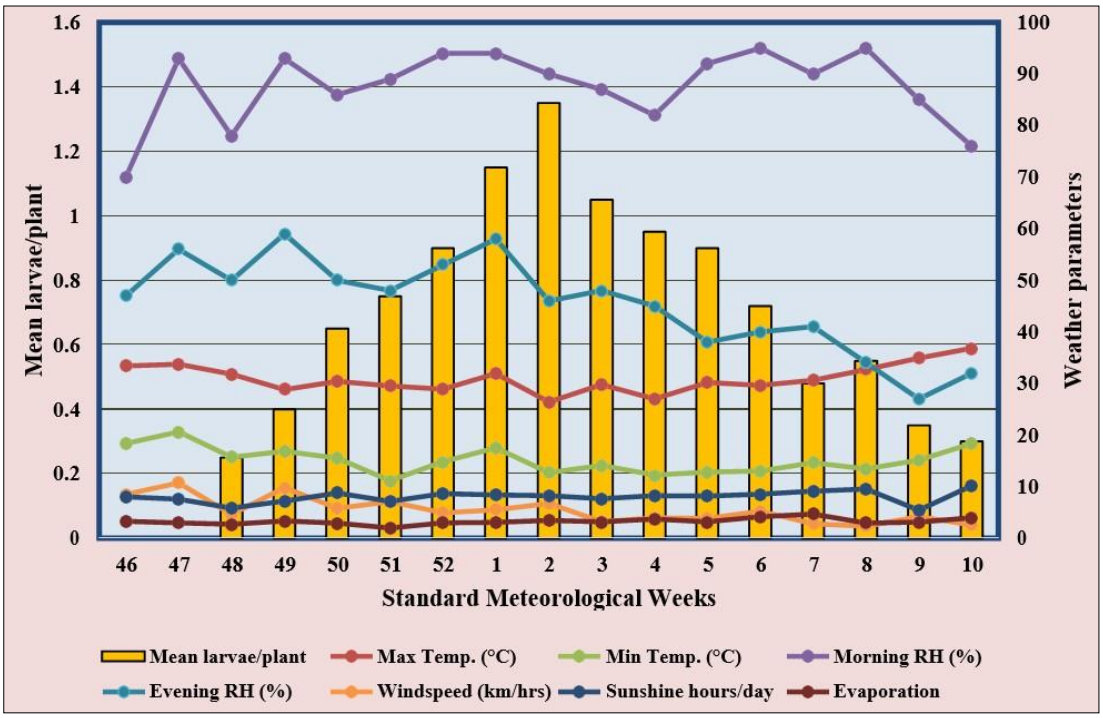

Fig. 4. Seasonal abundance of *H. undalis* in relation to Temperature, Relative Humidity, Wind speed, Sunshine hours and Evaporation

The data in Table 4 and Fig. 4 revealed that the population of coccinellid beetles had highly significant negative correlation with maximum temperature (r = –0.692) and minimum temperature (r = – 0.636).

Similarly, Sharma et al. [30] revealed that the population of *C. septempunctata* had non-significant correlation with maximum and minimum temperature, relative humidity and sunshine hours. Jhakar and Singh [37] reported that the population of *C. septempunctata* had significant positive correlation with maximum and minimum temperature (r = 0.71 and r = 0.66, respectively). Jat et al. [35] found that *C. sexmaculata* population exhibited a negative correlation (r = –0.102) with mean temperature and positive correlation with mean relative humidity (r = 0.053) during *rabi* season.

Regression studies on the effect of abiotic factors on the build-up of *H. undalis* population revealed that the *H. undalis* population was significantly influenced by weather factors like wind speed with their contribution being 85.30 per cent.

Coefficient of determination (R^2) = 0.85
Regression equation: $\hat{Y} = 2.46 – 0.09X_4$

4. CONCLUSION

The incidence of *H. undalis* on cabbage commenced from third week after transplantation of cabbage seedlings with its peak during early

head formation stage and then decreased gradually until the end of crop growth period. The *H. undalis* larval population had significant negative correlation with maximum and minimum temperature and evaporation. Only coccinellid predators *viz*., *C. transversalis* and *C. sexmaculata* were noticed in cabbage ecosystem during the crop growth period and none of the parasitoids were reported. The initial occurrence of coccinellids was noted after two weeks of transplanting and the population increased gradually in successive weekly counts and reached a peak during early head formation stage and thereafter, population declined gradually. The maximum temperature and minimum temperature had significant negative correlation with the population of coccinellid beetles. These may vary with the changing environmental conditions even in the same variety of the crop in the succeeding years.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Negi S. Supply chain efficiency: An insight from fruits and vegetables sector in India. Journal of Operations and Supply Chain Management. 2014;7(2):154-167.
2. Ministry of Agriculture and Farmers Welfare (India). Production volume of cabbage in India from financial year 2015 to 2021, with an estimate for 2022 (in million metric tons) [Graph]. In Statista; 2022.
   Retrieved from:https://www.statista.com/statistics/1043933/india-production-volume-of-abbage/)
3. Joseph MA, Moysich KB, Freudenheim Jo K, Shields PG, Bowman ED, Zhang Y, Marshall JR and Ambrosone CB. Cruciferous Vegetables, Genetic polymorphism in glutathione - transferases M1 and T1, and prostate cancer risk. Nutrition and Cancer. 2004;50(2):206-213.
4. Mini C and Krishnakumary K. Leaf vegetables. Agrotech publishing academy, Udaipur. 2005;81-93.
5. Bhatia R and Verma AK. Insect pest complex of cabbage in Himachal Pradesh. Journal of Insect Science. 1993;6(2):297-298.
6. Goud R, Rao SRK and Chiranjeevi. Influence of weather parameters on the population build-up of diamond back moth, *Plutella xylostella* (L.) infesting cabbage. Pest Management in Horticultural Ecosystem. 2006;12(2):103-106.
7. Varalakshmi P, Rao AP, Madhumathi T, Krishanaiah PV and Rao SV. Occurrence of pest complex on cauliflower. Journal of Agriculture. 2006;53(3):181-183.
8. Patait DD, Shetgar SS, Subhan S, Badgujar AG and Dhurgude SS. Seasonal abundance of lepidopteron pests infesting cabbage in relation to weather parameters. Indian Journal of Entomology. 2008; 70(3):255-258.
9. Bana JK, Jat BL and Bajya DR. Seasonal incidence of major pests of cabbage and their natural enemies. Indian Journal of Entomology. 2012;74(3):236-240.
10. Bhure KY, Pandya HV, Patel SD, Darandle SA, Saiyad MM and Patel NG. Incidence and abundance of major insect-pests of cabbage (*Brassica oleracea var. Capitata* Linnaeus) in relation to weather parameters. Multilogic Science. 2014; 4(11):175-179.
11. Ojha PK, Singh IP and Pandey NK. Seasonal incidence of insect pests of cauliflower and population build up under agro climatic Zone-1 of Bihar. Pestology. 2004;28(3):16-18.
12. Yadav N, Agrawal N and Yadav R. Influence of weather parameters on the population of different cabbage pests in organic cabbage field. Journal of Entomology and Zoology Studies. 2019; 7(3):551-553.
13. Mane PD, Singh BB, Kumar M and Singh PK. Seasonal incidence of major pests of cabbage in Nalanda district of Bihar. Journal of Entomology and Zoology Studies. 2020;8(6): 2003-2005.
14. Alam T. Studies on the population dynamics of diamondback moth (*Plutella xylostella* Linnaeus) in cauliflower and its management with novel and ecofriendly insecticides. Ph.D. Thesis, Banaras Hindu University. 2015;56 – 62.

15. Patel P. Studies on diamondback moth, *Plutella xylostella* (L.) with special reference to its management through new chemical insecticide on cabbage crop. M.Sc. (Agri.) Thesis, Indira Gandhi Agricultural University, Raipur. 2002;87-88.
16. Shukla A. Bio efficacy of some insecticides and development of eco safe management technology against *Plutella xylostella* along with its population dynamics in cabbage (*Brassica oleracea* var. capitata). Ph.D. (Agri.) Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur. 2002;61- 168.
17. Bhagat P, Yadu YK and Sharma GL. Seasonal incidence and effect of abiotic factors on population dynamics of diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea var. capitata* L.) crop. Journal of Entomology and Zoology Studies. 2018;6(2):2001-2003.
18. Maity L, Padhi G, Samanta A. Population dynamics and management of diamond back moth *Plutella xylostella* (L.) in cabbage ecosystem of West Bengal. International Journal of Chemical Studies. 2018; 6(1):381-385.
19. Gaikwad AD, Bhede BV, Bokan SC and Bhosle BB. Seasonal incidence of major insect pests, natural enemies on cauliflower and their correlation with weather parameters. Journal of Entomology and Zoology Studies. 2018; 6(5):952-956.
20. Aiswarya VA, Bhosle BB and Bhede BV. Population dynamics of major lepidopteran insect pests of cabbage. International Journal of Current Microbiology Applied Science. 2018;6:236- 239.
21. Mishra A and Singh SVS. Efficacy of some plant extracts against diamondback moth (*Plutella xylostella*) on cabbage. Annals of Plant Protection Science. 2014;3(8):797-798.
22. Baker PB, Shelton AM, Andaloro JT. Monitoring of Diamondback Moth (Lepidoptera: Yponomeutidae) in cabbage with pheromones. Journal of Economic Entomology. 1982;75(6):1025–1028.
23. Oduor GI, Lohr B and Seif AA. Seasonality of major cabbage pests and incidence of their natural enemies in Central Kenya. The Management of Diamond back Moth and Other Crucifer Pests. 1997;37-43.
24. Lasota JA and Kok LT. Seasonal abundance of imported cabbage worm (Lepidoptera: Pieridae) cabbage looper (Lepidoptera: Noctuidae) and diamondback moth (Lepidoptera: Plutellidae) on cabbage in South western Virginia). Journal of Economic Entomology. 1989;82(3): 811-818.
25. Harcourt DG, Backs RH and Cass LM. Abundance and relative importance of caterpillars attacking cabbage in Eastern Ontario. Canadian Entomologist. 1955; 87:400- 406.
26. Venugopal U, Ashwani K, Prasad DSH and Rajesh B. Seasonal incidence of diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea var. capitata* L.) under Allahabad condition. Journal of Entomology and Zoology Studies. 2017;5(6):2477- 2480.
27. Usha C, Bhalla OP and Sharma KC. Biology and seasonality of the diamondback moth, *Plutella xylostella* (L.) and its parasitoids on cabbage and cauliflower. Pest Management in Horticultural Ecosystem. 1997;3(1): 7-12.
28. Poonam J. Insect-pest complex of cabbage and their management. Thesis M.Sc. (Agri.), CSK Himachal Pradesh Krishi Vishva vidyalaya, Palampur. 1999; 56- 58.
29. Bhalla OP, Dubey JK. Bionomics of the diamond back Moth in the North western Himalaya. DBM in North western Himalaya. Diamond back Moth Management Proceedings of the First International Workshop, Tainan, Taiwan. 1986;55-61.
30. Sharma S, Kooner R, Arora R. Insect Pests and Crop Losses. In: Arora R, Sandhu S. (eds) Breeding Insect Resistant Crops for Sustainable Agriculture. Springer, Singapore; 2017.
31. Jaishree B. Studies on insect pests of cabbage with special reference to seasonal incidence and management of diamond back moth. M.Sc. (Agri.) Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur. 2017;42-56.
32. Bhardwaj V. Effect of insecticides on diamond back moth, *Plutella xylostella* (L.) and its natural enemies on cauliflower. M.Sc. (Agri.) Thesis, CSK Himachal Pradesh Krishi Vishva Vidyalaya, Palampur. 2002;23-25.

33. Hemachandra O, Singh TK. Population dynamics of DBM, *Plutella xylostella* (L) on cabbage agroecosystem in Manipur. Indian Journal of Entomology. 2007; 59:154-161.
34. Patra S, Dhote VW, Alam SKF, Das BC, Chatterjee ML and Samanta A. Population dynamics of major insect pests and their natural enemies on cabbage under new alluvial zone of West Bengal. Journal of Plant Protection Science. 2013;5(1):42- 49.
35. Jat GC, Lekha R, Jat SK and Yadav PC. Effect of weather parameters on the incidence of major insect pests of cabbage. Indian Journal of Agricultural Sciences. 2017;9(16):4133-4135.
36. Jakhar M and Singh SK. Study of seasonal abundance of diamondback moth and natural enemies in cauliflower, crop and their relation with the environmental factors. Journal of Entomology and Zoology Studies, 2018;6(6):1250-1252.
37. Anjali GP, Pandya HV. Investigations on population dynamics of diamondback moth, Plutella xylostella Linn. and natural enemies on cabbage, Brassica oleracea var. capitata Linn. Journal of Entomology and Zoology Studies 2019; 7(4): 1209-1212
38. Sonika S, Ahmad H, Sharma D, Ganai SA, Kour R, Khaliq N and Norboo T. Studies on seasonal incidence and field efficacy of insect growth regulators against diamondback moth, *Plutella xylostella* (L.) infesting cabbage, *Brassica oleracea var. capitata* (L.). Journal of Entomology and Zoology Studies. 2017;5(5):1921-1925.
39. Ahmad B, Saljoqi AR, Saeed M, Ullah F, Khan IA. Population dynamics of *Plutella xylostella* (L.) in cauliflower and its correlation with weather parameters at Peshawar, Pakistan. Journal of Entomology and Zoology Studies, 2015; 3(1):144-148.
40. Nagesh M. Efficacy and persistence of certain insecticides against diamond back moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea var. capitata* L.). Ph.D. (Agri.) Thesis, Indian Agricultural Research Institute, New Delhi. 1997;50-52.
41. Debbarma A, Jayaraj J, Chandramani P, Senthil N, Ananthan M and Prabakaran K. A survey on occurrence and diversity of insect pests of cauliflower in Dindigul and Theni districts of Tamil Nadu, India. International Journal of Current Microbiology and Applied Science. 2017; 6(9):2495-2505.

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