Effects of Abiotic Factors on Pest Population of Diamond backmoth, *Plutella xylostella* (Plutellidae: Lepidoptera) on Cauliflower: A Review

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Abstract

Cauliflower is most important vegetable crop of India. Its helps to farmers to increases their yield and income also helped to growing economic wealth. But at the same time it’s attacked by several factors like abiotic factors (temperature, relative humidity, rainfall) and biotic factors (insect pest and disease). Diamondback moth is a very destructive and serious pest of cauliflower that could damages 52% yield. The abiotic parameters are unpredictable and hence can affect both in quality and quantity of the cabbage production. These different abiotic parameters are directly influence the incidence of the cabbage insect pests. The present study of review to evaluate the seasonal incidence of diamondback moth in cabbage crop and impact of weather parameters on its population dynamics.

Keywords: Cauliflower, Diamondbackmoth, Abiotic factors, Seasonal incidence.

1. Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* Linn) is one of the most important vegetable crop in India and worldwide. It belongs to family Brassicaceae. Cauliflower is the third major producing vegetable in India. The area under cauliflower, in India is 453 thousand hectares with a production of 8668 metric tonnes and in Punjab the area, production and productivity of cauliflower is 14.97 thousand ha, 279.67 thousand tonnes and 18560 kg/ha, respectively during 2018-19 (NHB, 2019).

Cauliflower serving 100 g of raw cauliflower provides 25 calories of energy, 5 g of carbohydrates, 0.3 g of fats, and 1.9 g of proteins. It has a high content of vitamin C (48.2 mg), moderate levels of several B vitamins and vitamin K (15.5 μg). Cauliflower contains several phytochemicals, common in the cabbage family, that are under preliminary research for their potential properties, including isothiocyanates and glucosinolates (NHB 2019). Cauliflower is mostly used for culinary purpose in curries, pickles, etc. From nutritional point of view it is an important source of minerals, vitamins, protein, carbohydrate and dietary fibres (Chatfield 1984).

India loses about 30% of its crops due to pests and diseases each year (Deeplata Sharma and Rao, 2012). Cauliflower crop is attacked by a number of insects viz, Tobacco caterpillar (Spodoptera litura), Diamond back Moth (Plutella xylostella), cabbage leaf Webber (*Crocidolomia binotalis*), aphids (*Brevicoryne brassicae*) and *Lipaphis erysimi,* painted bug (*Bagrada cruciferarum*) and flea beetle (*Phyllotreta cruciferae*) from sowing to harvest (Rao and Lal, 2005). In India, 37 insects' pests were recorded in cabbage, (Lal 1975, Bhatia and Verma, 1993). The production of cauliflower has been reduced by several factors, including insect pests, such as diamondback moth (*plutella xylostella*), aphids (*Brevicoryne brassicae,* (Innaeus) *Lipaphis erysimi* (Kaltenbach) and Myzuspersicae (Sulzur), cabbage worms and beetles of flea (Phyllotreta.) Butterfly (*Pieris bracecae)* and diseases such as black rot and stick root Nyambo. The diamondback moth is a highly destructive insect pest of *B. oleracea* throughout the world and is the parasite of most widespread insects of all insects Lepidoptera (You and Wei, 2007 and Shelton, 2001).

Most often growers resort to prophylactic and scheduled applications of chemical insecticides (Weinberger and Srinivasan, 2009). Consequently, problems like resurgence, resistance, residues, replacement, destruction of nontarget organisms and environmental pollution have been on the rise. DBM has become very difficult to manage because of the development of high levels of resistance to several groups of organophosphorus, carbamate, and pyrethroid insecticides. Sole reliance on insecticides has facilitated rapid build-up of resistance in the multivoltine DBM, which undergoes 20 generations a year in the tropics (Talekar and Shelton, 1993). To overcome resistance in DBM to insecticides, farmers often increase the doses of insecticides when insecticides alone account for between 30 and 50% of the total cost of production. Health problems with farmers were also common in states where these crops are grown (Sherma *et al.,* 2017). The production of cauliflower is low because this crop suffers from both the biotic and abiotic stresses. Cauliflower is a winter vegetable and requires cold and moist climate. It is grown mainly in Punjab, Uttar Pradesh, Bengal and Karnataka. The yield of cauliflower is adversely affected by many bottlenecks including insect pest, diseases, environmental stresses, nutritional imbalance etc. Insect pests are of prime importance as they cause serious economic damage to cauliflower crop. Natural enemies play a very important role in keeping pest populations under control. Insects can multiply very rapidly and in the absence of natural enemies, insect populations "explode". The wide spread use of insecticides has led to the elimination of natural enemies, thus paving the way to attain status of most noxious pests of various cole crops in India (Holopainen and Gershenzon 2010 and Vos *et al.,* 2001). Biotic (herbivorous insects, fungi, pathogens) and abiotic (temperature, drought, salt) plant factors commonly occur simultaneously in the natural environment

2. Diamondbackmoth (*Plutella xylostella*)

DBM has its origin either in the Mediterranean region or in South Africa in 1890. In India, DBM was reported in 1914 on cruciferous vegetables and is now the most devastating pest of cole crops in the states of Punjab, Haryana, Himachal Pradesh, Delhi, Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra and Karnataka. (Kumar *et al.,* 2007 and Mahala *et al.,* 2005) said that the diamondback moth, Plutella xylostella (L.) is the most destructive cosmopolitan pest. Krishnamoorthy (2002) had reported that there is 52% loss in yield due to the attack of diamondback moth.

Sachan and Gangwar (1980) was studied the vertical distribution of this pest from the higher altitude ranges of Mehalayas. Dhaliwal *et al.* (2010) was reported that the diamondback moth, *P. xylostella*, has consistently remained the most destructive insect pest of crucifer vegetables worldwide. Major outbreaks of *P. xylostella* are more likely in the fields that are sprayed frequently and heavily with insecticides. The absence of effective natural enemies and fast development of insecticide resistance are believed to be the major causes of increasing pest status of P. xylostella in most parts of the country. This insect is resistant to many classes of insecticides and causes 50 to 80% loss in marketable yield. An outbreak of DBM on cauliflower was reported in Aligarh during September to first fortnight of October 2006. The infestation increased gradually from first fortnight of August and led to total loss of the crop. Climatic changes may lead to increase in severity of this pest in many regions of the country.

Verkerk and Wright, 1996 was reported that *Plutella xylostella* was recorded to be the major lepidopteran insect pest damaging different cauliflower varieties. Tsunoda was reported the occurrence of P. xylostella three decades ago from nearly 128 countries of the world (Tsunoda S. 1980). They were reported to cause alarming yield loss globally to an extent of 90 percent.

3. Abiotic Factor:

Among biotic stresses of agro-ecosystem, terrestrial flora played most vital role in the development of various stages of terrestrial insects, their oviposition and hatching success (Bownes *et al.*, 2013 and Lucas barbosa *et al.*, 2011). On the plants different insects feed like pollinator and other herbivorous. Plants showed various responses against different insect pests. Certain bivore induce plant volatile influence the carnivorous insects to attack on folivorous species

Sow *et al.*, (2013) said that integrated management of *P. xylostella* greatly depends on a comprehensive knowledge of the various weather parameters that affect its population dynamics. Rai *et al.* (2011) said that the abiotic stresses such as temperature, drought and salinity are the major environmental constraints affecting production and productivity of almost all horticultural crops. Conventional plant breeding has not been proved that much successful in addressing abiotic stress mitigation so far. The reason might be that the traits are controlled by a number of genes present at a quantitative trait locus (QTL). To combat the negative effects of various abiotic stresses, it is pre-requisite to identify potential candidate genes or QTLs (gene networks) associated with broadspectrum multiple abiotic stress tolerance. Various abiotic stresses including drought, high temperature, salinity, frost and flood, etc. adversely affect overall crop growth and productivity by affecting the vegetative and reproductive stages of growth and development. These stresses generally trigger a series of physiological, biochemical and molecular changes in the plants which often result in damage to the cellular machinery.

Zalucki *et al.* (2009) reported that timely forecasting the population dynamics is very helpful for shaping budgets of insecticides, hiring extra crop scouts and taking strategic decisions on which crops to grow. (Ayres and Schneider 2009) These climatic and weather changes not only affect the status of insect pests but also affect their population dynamics, distribution, abundance, intensity and feeding behaviour. Abiotic stresses can cause a decrease in yield of crops up to 50% resulting in very high economic losses (Vij and Tyagi, (2007). The minimization of these losses is one of the main objectives for plant and crop specialists (Mahajan and Tuteja, 2005) and since it is very difficult to control abiotic stress resulting from climate change and human activities, the development of stress tolerant crop genotypes is necessary.

The severity of the incidence of diamondback moth is greatly influenced by the prevailing climatic conditions which vary from region to region (Diaz et al 2004).. The basic information of the insect species of an agro-ecosystem and their population densities during the crop cycle is indispensable for planning well-timed measures for controlling phytophagous insects and minimizing economic losses for the producer. Seki *et al.*, (2003) reported the plant growth and productivity are limited by both biotic and abiotic factors.

(Thomashow, 1999; Smallwood and Bowles, 2002).Cold acclimation is defined as the exposure of plants to low non-freezing temperatures leading to significant positive effect on the cold tolerance of plants

Nechols *et al.*, 1999; Roy *et al.* (2002) said that the relationship between the life parameters of insect pest and its adaptations to climatic conditions play an important role in the management of the insect pest as its help in prediction the population dynamics, development timing, dormancy, migration and reproduction (Harrison et al 2006) said that global changes are responsible for wide range of anthropogenic and natural environmental variation. Intensity of change in climatic ecosystem noted by meteorological science has showed a direct and indirect affect on the prey and host relationship, their immune responses and rate of development, their fecundity and various physiological functions (Yamamura et al 1998 and 2006). Abiotic disturbances particularly upper and lower thermal affects check the insect multiplication, diapauses, emergence, flight and the dispersal rate

Low temperature is one of the main abiotic stresses that affects plant growth and production globally (Pearce and Fuller, 2001). It limits the geographical distribution of agronomic species and significantly decreases the yield of several crops around the world. It is important to study frost damage mechanisms and to breed for cold tolerant cultivars since the many crops must survive exposure to occasional sub-zero temperatures (Deane, 1994).

4. Effects of Abiotic factors on pest population of DBM.

Seasonal abundance of the *P. xylostella* and corresponding yield of cauliflower and cabbage are greatly influenced by weather parameters (Wagle *et al.*, 2005; Venkateswarlu *et al.*, 2011).

4.1 Temperature

According to Aiswarya *et al.*, (2018) the population of *plutella xylostella* reduced gradually when the weather parameters viz. maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, bright sunshine hours and rainfall during the peak period of incidence were 29.6°C, 8.8^{0}C, 75 per cent, 24 per cent, 9.8 hours and 0.0 mm, respectively.

Bhagat and Yadu (2018.) reported that larval population of diamondback moth had non significant negative correlation with maximum temperature and non significant positive correlation with minimum temperature (r = -0.005 and r = 0.24 respectively), whereas, non significant positive correlation with relative humidity and rainfall (r = 0.105 and r = 0.05 respectively), whereas negative correlation with sunshine hours (r = - 0.31).

The finding of Aysheshim et al. also showed that the population of diamondback moth had positive non-significant relation with the maximum temperature and justified partial agreement with the present finding. Meena and Singh also reported that the minimum temperature showed positive relation with the larval population of diamondback moth which corroborates the present findings. Shirai (2000) reported that temperature above 33o C greatly affect egg laying and larval development of the *P. xylostella* whereas the developmental time of pupae decrease with the increase of temperature.

Minimum population 0.32 per cent recorded on second fortnight of Febuary and maximum population 5.98 per cent recorded on third fortnight of March (Jat, 2017). A study on the correlation studies indicated a significant positive correlation between larval population of diamondback moth and. the relative humidity (R.H), total rainfall and sunshine hours (SSH) had negative correlation with the larval population of diamondback moth. Sharma *et al.* (2017) recorded Peak population of diamond back moth (DBM) was recorded on 1st March and 23rd February with13.60 and 14.33 larvae /plant during 2011-12 and 2012-13 respectively. Sonika Sharma *et al.* (2017) recorded the diamond back moth population was maximum in the first and second week of February (5th and 6th SW) recorded the infestation of *Plutella xylostella*, diamondback moth started from the 5th standard week (0.88 larvae plant-1) and reached peak (18.68 larvae plant-1) in a 14th standard week. *P. xylostella* occurred between June and November, and the largest peaks of abundance were observed between August and September, when low temperatures and rainfall were recorded (Marchioro, L.A. Foerster 2016)

The maximum and minimum temperature showed significant positive correlation with larval population of diamondback moth whereas, non-significant correlation with relative humidity and rainfall (Patra *et al.*, 2013). Marchioro and Foerster (2012) reported that temperature plays a critical role in P. xylostella reproduction, and subtle differences in average temperature could have an impact on its population growth. The study of Venkateswarlu *et al.* (2011) who reported that peak incidence of diamond back moth was observed during 1st week of September. The population dynamics of insect pests and their associated natural enemies are greatly influenced by temperature as it set the limits of biological activities (Huffaker *et al.*, 1999, Ansari, 2010).

4.2. Rainfall

Ahmad *et al.* (2015) further investigated that temperature has positive correlation with population dynamics of *P. xylostella*, whilst rainfall negatively affect the population build up the said pest. of the *P. xylostella* due to weather parameters in both years of studies was 87-96% (R2). The finding of Ahmad *et al.* (2015) who reported that weather parameters can influenced the population dynamic of *P. xylostella* up to 90-

98% (R^2). Zada *et al.* (2014) also reported that *Cydia pomonella* population has greatly influenced by weather parameters Swat Pakistan,which ranges from 68-82% (R^2).

The intraction between larval feeding and temperature can represent an important factor determining the variability of volatile emmions by plants subjects to almost simultaneous factor. (Truong *et al.,* 2014). According to Patra *et al.* (2013) high temperatures favored the multiplication and development of *P. xylostella* while cold temperatures in November-February limited its population dynamics. As incidence of pest depends on host availability and climatic condition, therefore, incidence and peak infestation of pest vary from region to region.

Population of DBM is generally influenced by abiotic factors like, temperature, rainfall and humidity (Abraham and Padmanabhan 1968). The population became abundant during September to October and March to April. Heavy rain can destroy the moth population. High build-up of larval populations has been reported during February-March (late winter) and April-August (summer and mid rainy season).

4.3. Relative humidity

Humidity and temperature are among the vital abiotic factors that affect the population and biology of *P. xylostella* (Guo and Qin, 2010). Ahmad and Ansari (2010) reported that the population of the DBM showed increased in the month of August and September and then gradually declined. Hemchandra and Singh (2007) reported that higher temperature, lower relative humidity and lower total rainfall, seem to favour the pest population build up.

According to Loher et al. (2007) the growth and development of P. xylostella are significantly influenced by the prevailing weather variables,especially temperature and rainfall in the field. Shelton, (2001) reported that the hot and dry conditions are known to be conducive for *P. xylostella.*

The finding of the non-significant relation of diamondback with the relative humidity and sunshine hours is in conformity with the observations made by Bana et al. (2012). Goudegnon *et al.,* (1999) has been reported that the relative humidity has no significant effect and sunshine hours has negative and nonsignificant relation with the population fluctuation of diamondback moth. Jayarathnam (1977) found significantly high build-ups of larval populations during the rainy season (July- September) compared with other seasons.

Bhagat *et al.,* (2018) recorded that the infestation of diamondback moth started from the third week of November and reached peak (45.2 larvae /10 plants) in the first week of January. The maximum and minimum temperature showed significant negative correlation with larval population of diamondback moth whereas, non-significant correlation with relative humidity and sunshine hours.

The positive correlation of diamondback moth population with the maximum and minimum temperature was also reported by Venkateswarlu *et al.* (2011) but the findings of the same author that negative relation with the relative humidity and positive with sunshine hours is in contrast with the present findings as it has been observed that the relative humidity has no significant effect and sunshine hours has negative and non-significant relation with the population fluctuation of diamondback moth.

The survival rate and pupal development of *P. xylostella* is increased at higher relative humidity (Alsaffar et al., 1996). Kuwahara *et al.*, (1995) reported the population of *P. xylostella* remained constantly high round the year during the hottest weather conditions at a temperature range of about 29 to 310 C. During rainy season, population of *P. xylostella* remains low due to the killing of its immature stage but it is not a major factor to reduce its population during that period (Sow et al,. 2013). Kuwahara *et al.* (1995) reported that adaptation of *P. xylostella* is high at elevated temperate environmental conditions than the temperate one. Chen *et al.* (1990) stated that populations of *P. xylostella* in tropical regions can tolerate higher temperature than the ones in the temperate regions.

5. Conclusion

The correlation between population of P. xylostella and weather parameters (temperature (maximum and minimum), percent relative humidity, sunshine and rainfall) was found statistically non significant. These findings can be used by the farmers for developing a sound programme to counter the attack of P. xylostella in cabbage crop to minimize losses.

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