



Chapter 11

Impact of insect pests and pesticides on fruit productivity in Kumaun Himalaya, Uttarakhand, India

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Abstract

Assessment of major insect pests, pesticides and their impact on the productivity of apple fruit crops were conducted in the fruit orchard of Khabrar village of district Nainital, Uttarakhand, during cropping season 2017-18. From the study area, an area of one acre was purposively selected to analyze the diversity of insect pests at regular time interval. Insect pests such as beetles, bugs, aphids and moths were the most dominant pests observed during the study period.

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Eight varieties of apple fruit trees are present in the Khabrar fruit orchards such as [*Malus domestica* (Borkh)]: Red Delicious; Golden Delicious; Prima; Ambri Kashmiri; Chaubatia Anupam; Red Spur; Oregon Spur and Red Delicious Buhra. Data was analyzed by using descriptive statistics by employing PAST software version 3.

Maximum diversity of insect pests was observed during the rainy season followed by spring season, autumn and winter season, respectively. The incidence of infestation rate was also calculated that depicts the maximum emergence of insect pests on the apple crops during the months of June, July and August. The observations made during the field work revealed the use of pesticides leads to the loss of important insect groups such as pollinators and predators. Therefore, this study recommended that there is an urgent need from concerned offices to improve apple organic farming system in the study area.

Keywords: Apple, Diversity, Insects, Orchard, Pesticides, Pests, Species.

Introduction

Temperate fruits are the most important tree fruits (apple, peach, plum, pear, apricot, walnut, cherry and kiwi) known in the world that are grown in temperate regions having a distant cold climates (Thind, 2001; Fetana and Lemma, 2014). Apples are major temperate fruit crops and grown over several years in the same habitat which serves as a permanent abode for the multiplication of various insect pests. Thousands of insect pests have been recorded from temperate fruit trees all over the world, of which, more than 600 pests are found on apples alone (Gupta and Pathania, 2017). Apple is one of the most widely cultivated temperate fruit tree in all the hilly areas of the world and India is ranked as the sixth largest world's apple producing country and second largest country in area.

Apple is considered as one of the most important and widely grown fruit crops in temperate zones of the world with regard to its acreage, production, economic returns, high nutritive value and popularity (Mir *et al.*, 2018). Apple is a highly remunerative crop and is grown in all temperate regions of the world. In India, apple is grown in Uttarakhand, Jammu and Kashmir, Himachal Pradesh and some parts of Arunachal Pradesh. However, the production and quality of apple is poor as compared to that of the developed countries because of several factors including insect and diseases. Although a large number of insect pests attacks to apple crops but some of them are very serious and need attention for their control (Sherwani *et al.*, 2016). Apple trees are prone to several insect pests and diseases depending on different local field conditions. It is a melancholy fact that the apple is attacked by a wide range of insect pests and diseases which at worst can reduce the crop to zero, and damage or even kill the tree.

Therefore, in the current study, occurrence and characterization of insect pests, pesticides and their impacts on the productivity of apple fruit tree crops were studied in Khabrar village of Nainital district, Uttarakhand.

Materials and methods

Study area

The present survey was conducted in the temperate fruit orchards of Khabrar village (29°25.942' N and 79°35.535' E) located in Nainital district of Uttarakhand state during the study period 2017-18. It is located in Ramgarh fruit block, 47 km away from the Nainital city, at an altitude of 2310 meters above sea level, within sight of the western peaks of the Himalayas. This fruit block is situated in open habitat at the top and receives low level of disturbances. Two types of fruit trees are present in this block such as Apple [*Malus domestica* (Borkh)] with eight varieties: Red Delicious; Golden Delicious; Prima; Ambri Kashmiri; Chaubatia Anupam; Red Spur; Oregon Spur and Red Delicious Buhra) and Pear [*Pyrus communis* (Linnaeus)] with only two varieties: Yog and Starkrimson Red. During the study period, the temperature varied from 7.5°C to 22°C and the relative humidity ranged from 34% to 95%, respectively. The selected study site is rich in scenic beauty, with magnificent views of the Indian Himalayas including India's second highest peak, Nanda Devi. Because of the hilly topography, agriculture in the area consists chiefly of potato fields and is bounded by fruit orchards on terraces cut into hilly sides surrounded by oak and coniferous forests (Figure 11.1).

Sampling and data analysis methodology

Calculation of infestation rate: The study was carried out in an apple orchards located at Khabrar village of Ramgarh temperate fruit block region Nainital district. To assess the environmental influence especially temperature and humidity on the incidence of insect pests observed in the months of May, June, July and August and the productivity of the same orchard was also assessed during 2017-18. The data regarding incidence of insect pests and productivity



Figure 11.1. A view of Khabrar village of district Nainital selected as study area.

was recorded and presented in the form of Figures. The infestation rate was calculated by using the formula adopted by Bandey *et al.* (2012) as under:

$$\text{Infestation rate} = \frac{\text{Total number of plants infested}}{\text{Total number of plants}} \times 100$$

Species composition and characterization of status of insect pests: To determine the composition and distribution of identified insect pests, species were arranged according to their families and an inventory was prepared. The status of insect pests were characterized into two main groups such as major and minor pests based on the nature of damage caused to apple trees during the study period. The insect pests that leads to heavy damage to the apple crops which lowers the economy of the fruits and weakens the health of fruit tree is categorized under major pests. The pests that do not cause much harm to the plant parts and economy of the fruit growers are characterized as minor.

Diversity analysis

Shannon- Wiener diversity Index: The species diversity will be calculated based on Shannon Wiener Index (H),

$$H'(S) = - \sum_{i=1}^S p_i \log p_i$$

Where, p_i = fraction of entire population made up of species i , S = total number of species encountered and i = proportion of species

Evenness index:

It was calculated as per Hill, i.e. $E = H / \ln S$. Where, S = total number of species and H = Index of species.

Margalef's Index: This index was used as a simple measure of species richness Margalef, Margalef's Index = $(S-1) / \ln N$, Where, S = total number of species, N = total number of individuals in sample and \ln = natural logarithm.

Results

Species composition and abundance

The study revealed the total of 623 individuals and 15 species of insect pests belonging to 10 families and three orders distributed over three orders listed in Table 11.1. Scarabaeidae was found to be the most dominant family during the study period represented by four species that constituted 26.66 percent, followed by Chrysomelidae and Pentatomidae (two species and 13.33% each), Elateridae, Aphididae, Diaspididae, Erebididae, Lasiocampidae, Saturniidae and Tortricidae each represented by single species that constituted 6.66 percent each, respectively (Figure 11.2).

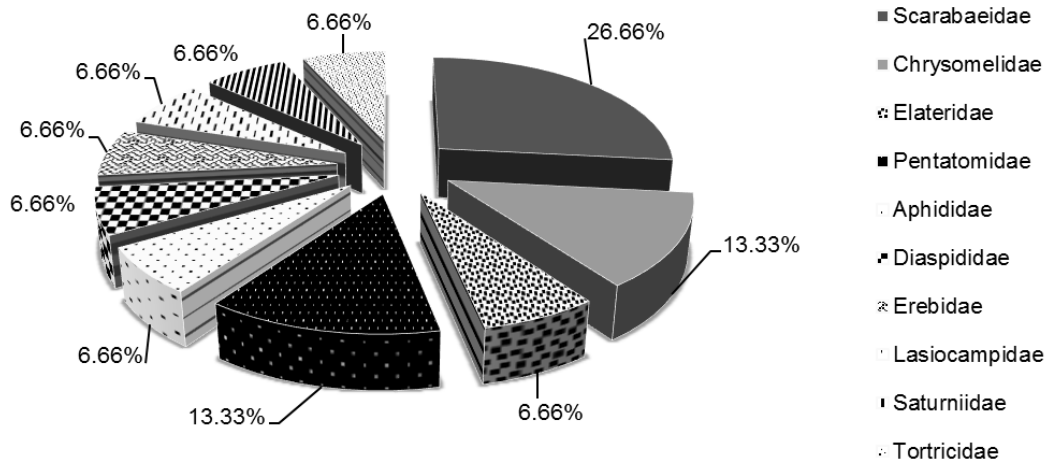


Figure 11.2. Percent contribution of different families of insect pests of apple crops recorded during the study period.

Across the entire study period, *Eriosoma lanigerum* Hausmann was the most dominant species constituting 12.68 percent of the total number of individuals recorded, followed by *Malacosoma indica* (Walker) (10.91%), *Erthesina fullo* (Thunberg) constituting 8.98 percent, *Brahmina coriacea* (Hope) (8.45%) and *Anomala lineatopennis* Blanchard (8.09%). On the other hand, *Adelocera* species constituting 3.69 percent, *Actias luna* (Linnaeus) (3.85%), *Dalpa dajugatoria* Lethierry (4.01%), *Lymantria concolor* Walker (4.17%) and *Quadraspidiotus perniciosus* Comstock constituting 4.49 percent to the total individuals were observed less abundant species during the entire study period.

Seasonal diversity of insect pests

A total 15 species of insect pests of apple crops recorded across the different seasons of the year, depicts that 14 species with 324 individuals constituted 52.06 percent were aggregated in the rainy season, followed by 12 species and 181 species (29.05%) in the spring season, eight species and 72 individuals (11.55%) in the autumn season and five species with 46 individuals that constituted 7.38 percent were encountered during the winter season. The Shannon diversity index indicated the maximum value of insect pests was calculated in rainy season (2.60) followed by spring season (2.36), autumn season (2.01) and winter season (1.49). The calculated value of evenness across different seasons of the selected fruit orchard was recorded high during the rainy season (0.965), followed by autumn season (0.934), winter season (0.889) and winter season (0.887). Species richness of insect pests was analyzed by using Margalef's index where the maximum value was examined in the rainy season (2.24), followed by spring season (2.11), autumn season (1.63) and winter season (1.04), respectively shown in Table 11.2.

Table 11.1. Species composition, relative abundance and status of different species of insect pests recorded from Khabrar village, Nainital.

S. No.	Species composition	Relative abundance (%)	Status
ORDER: COLEOPTERA			
Family: Scarabaeidae			
1.	<i>Anomala lineatopennis</i> Blanchard	8.09	Major
2.	<i>Brahmina coriacea</i> (Hope)	8.45	Major
3.	<i>Cotinis nitida</i> Linnaeus	6.58	Minor
4.	<i>Eupatorus</i> sp.	4.81	Minor
Family: Chrysomelidae			
5.	<i>Di cladispa</i> sp.	5.13	Minor
6.	<i>Galerucida cyanura</i> Hope	7.68	Minor
Family: Elateridae			
7.	<i>Adeloceras</i> p.	3.69	Major
ORDER: HEMIPTERA			
Family: Pentatomidae			
8.	<i>Dalpada jugatoria</i> Lethriery	4.01	Minor
9.	<i>Erthesina fullo</i> (Thunberg)	8.98	Major
Family: Aphididae			
10.	<i>Eriosoma lanigerum</i> (Hausmann)	12.68	Major
Family: Diaspididae			
11.	<i>Quadraspidotus perniciosus</i> Comstock	4.49	Major
ORDER: LEPIDOPTERA			
Family: Erebiidae			
12.	<i>Lymantria concolor</i> Walker	4.17	Major
Family: Lasiocampidae			
13.	<i>Malacosoma indica</i> (Walker)	10.91	Major
Family: Saturniidae			
14.	<i>Actias luna</i> (Linnaeus)	3.85	Minor
Family: Tortricidae			
15.	<i>Cydia pomonella</i> (Linnaeus)	5.61	Major

Characterization of status of insect pests

Based on the nature of damage caused by insect pests to apple crops, the total collected 15 species of insect pests were listed in two main categories viz. major and minor pests, respectively. Nine species were found to cause much harm to the apple fruit trees and thus lowers the economy of the fruits were categorized under the major pests that constituted 60 percent. On the other hand, six species were observed that do not cause much harm to different parts of the apple tree and economy of fruit growers were categorized as minor pests, constituted 40 percent of the total species recorded.

Table 11.2. Various diversity indices calculated for insect pests across different seasons during the study period.

Diversity indices	Rainy	Autumn	Winter	Spring	Total
Taxa_S	14	8	5	12	15
Individuals	324	72	46	181	623
Dominance_D	0.07668	0.1416	0.2514	0.1061	0.08056
Simpson_1-D	0.9233	0.8584	0.7486	0.8939	0.9194
Shannon_H	2.604	2.011	1.492	2.366	2.613
Evenness_e^H/S	0.9656	0.9342	0.8893	0.8879	0.9093
Margalef	2.249	1.637	1.045	2.116	2.176
Equitability_J	0.9867	0.9673	0.9271	0.9521	0.9649
Fisher_alpha	2.98	2.303	1.427	2.889	2.767

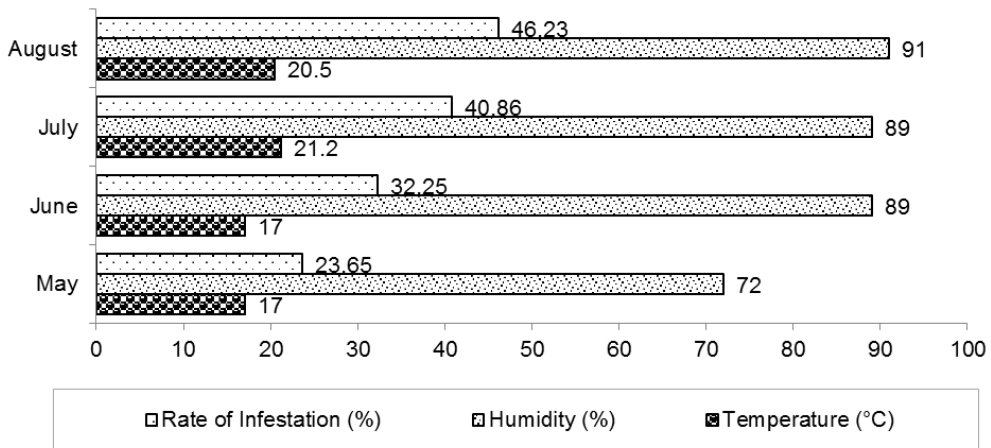


Figure 11.3. Incidence of insect pests on the apple crops during the study period.

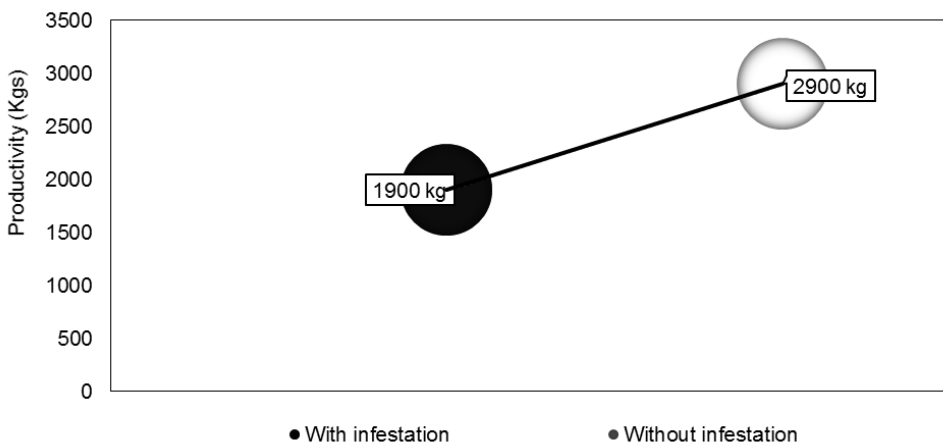


Figure 11.4. Productivity status from one acre apple orchard with and without infestation during the study period.

Analyzing infestation rate

The data pertaining to population buildup of different insect pests found infesting apple crops depicts that they remain dormant during the winter season. The emergence of insect pests of apple crops recorded started emerging during the onset of spring season and their population buildup was examined very high during the months of May, June, July and August because of favorable climatic conditions. The results of the rate of incidence of different insect pests exerted that during the month of May it was 23.65 percent under 17°C temperature and 89 percent humidity, whereas the rate of incidence of insect found during June was 32.25 percent under temperature 17°C and humidity 89 percent. The rate of incidence was 40.86 percent under 21.2°C temperate and humidity 89 percent for the month of July. The maximum rate of incidence of insect pests of apple fruit crops were examined in the month of August (91%) at 20.5°C temperature and 91 percent humidity, respectively (Figure 11.3). The data regarding the productivity in one acre of apple fruit orchard showed that with infestation the productivity was 1900 Kilograms (Kg), whereas the productivity was 2900 Kg where no infestation was occur shown in Figure 11.4.

Major pesticides used in study area

The pest problem has become a global concern among all the fruit growers of the world that affected the soundness and appearance of the fruits. During the present field observations, it was noticed that the fruit growers were seen more addictive to pesticides rather than the bio-control practices to control insect pests. The pesticides used by the farmers to get rid of insect pests were Chlorpyrifos 20 EC and Dimethonate 30 EC with dosage of 10 ml/100 liters of water during summer; Methyl-O-demeton 25 EC @ 80 ml/100 liters of water during the spring season that prevent infestation in summer; Carbofuran 3 CG@ 70 to 100g/ tree under the canopy area followed by hoeing of the soil in order prevent the infestation in root parts and Dicofol 18.5 EC@ 1.08 ml/ liter of water used as the summer spray. In spite of the pesticide use to control insect pests, other important insect groups such as pollinators and bio-control agents (predators) gets targeted leads to greater loss of the economically important insects and thus the loss of biodiversity. The population of such insect pests could be controlled by different practices such as proper planting management via pruning of fruit trees from time to time and removal of weeds that serve as alternate hosts of insect pests during off season, use of high yielding varieties, providing fertilizers supplement, efficient irrigation systems and integrated disease and pest management and use of clonal rootstocks.

Discussion

In comparison, Joshi and Joshi (1980) conducted the survey on different pests of fruit trees in Kumaun hills, where they reported numerous insect pests caused considerable damage to the these fruit trees hence reducing their productivity. The insect pest surveyed that infest apple fruit

crops of Kumaun hills include *Dorysthenes hugelii* Redtenbacher, *Cantharsius molossus* (Linnaeus), *Lucanus lunifer* Hope, *Melolontha* species, *Brahmina* species, *Eriosoma lanigerum* Hausmann, *Quadraspidiotus perniciosus* Comstock, *Lymantria obfusca* Walker and *Malacosoma indica* Walker. Brown (2003) studied the characterization of Stink bug (Pentatomidae) that caused depression on the surface of apple fruits.

Fetena and Lemma (2014) assessed the major apple pests in different apple varieties, of which green apple aphids, scale insects and green plant bugs were observed to feed on the leaves of the fruit plant. Sherwani *et al.* (2016) reported the incidence of major insect pests of apple trees in different orchards of Kashmir. The reported insect pests examined during the study period were San Jose Scale, Woolly Apple Aphid, Tent Caterpillar, European Red Mite, Codling Moth, Apple Root Borer, Apple Stem Borers, Gypsy Moth and Bark Beetle, respectively. The codling moth, *Cydia pomonella* (Linnaeus) is one of the key pests of apple fruit trees that directly affect the economy and cause severe damage to the apple trees (Pajac *et al.*, 2011; Shah Nawaz *et al.*, 2014; Mahzoum *et al.*, 2017). Gupta and Pathania (2017) investigated the diversity of hemipteran pests that feeds on apple crops in different districts of Jammu and Kashmir State of India. They reported the total of 12 species infesting apple crops from different apple growing areas of Jammu division, among which *Eriosoma lanigerum* Hausmann, *Quadraspidiotus perniciosus* Comstock and *Dalpada* sp. were found to be the most dominant insect pests during the study. Bandey *et al.* (2012) studied the diversity of apple pests and analyzed the infestation rate of insect pests that target the productivity in Jammu region of Jammu & Kashmir State. They selected three kanal gardens and analyzed the data that showed the productivity of apple fruits was reduced to 800 Kg (with infestation) from 1500 Kg (without infestation) during the study period.

Conclusion

The findings of the present study revealed the presence of 15 species of insect pests represented by 10 families and distributed over three orders. Coleoptera was found to be the most dominant order represented by seven species followed by Hemiptera and Lepidoptera with four species each. *Eriosoma lanigerum* Hausmann was the most dominant species constituting 12.68 percent of the total number of individuals recorded followed by *Malacosoma indica* (Walker) (10.91%), whereas *Adelocera* sp. constituting 3.69 percent and *Actias luna* (Linnaeus) (3.85%) were observed less abundant species during the entire study period. Across the different seasons, maximum Shannon diversity index value was found to be during the rainy season followed by spring, autumn and winter season, respectively. Nine species were noticed to inflict considerable damage to the plant parts hence were characterized as major pests, where remaining six species do not caused too much harm were regarded as minor pests.

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