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Impact of Imidacloprid on Insect pests on citrus fruit and deciduous fruit trees in National Centre for Fruit Development, Kirtipur, Nepal

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All over Nepal, deciduous fruits and citrus fruits have higher productivity economic value. However, the yield of these crops has declined significantly and pest infection is one of the causes. In this study, insects had been collected and identified as beneficial and harmful from five species of deciduous trees that include Apple, Peach, Pear, Japanese Guava, and Plum. Furthermore, identification of insects has also been studied in six other species of citrus trees including Mandarin Orange, Trifoliate Orange, Pomelo, Kumquat, Sweet Orange, and Kaffir Lime at the National Centre for Fruit Development.

Before the uses of insecticides, 26 species of insects from deciduous trees and 30 insect species from citrus trees have been collected. When the same tree species were introduced with Imidacloprid insecticide and water in the ratio of 1:1000 ml, 13 insects in deciduous trees and 16 insects in citrus trees were collected after use of 30 days. In both types of trees, there were fewer numbers of beneficial and harmful insects that have been noticed, which implies that imidacloprid greatly impacted the survival of both pollinators or other beneficial insects and pests. High impacts had been observed in *Citrus limotta*, as a smaller number of beneficial insects captured in comparison to the deciduous fruits tree. Ladybug beetle (Family: Coccinellidae), hoverflies (Family: Syrphidae) and Ant (Family: Formicidae) were some of the beneficial insects captured along with some scale and vector insects (Family: Chloropidae, Muscidae, Chloropidae, and Pipanculidae). Also, both the deciduous and citrus fruit showed a significant association between Imadacloprd and insects, with a p-value of 0.3039 and 0.4752 respectively.

Keywords: *Beneficial, destructive, imidacloprid*

INTRODUCTION

Deciduous and citrus fruits are the most demand fruits and successfully grown in mid and hilly region from Eastern to Far-Western Nepal. Globally, there are around 10,000 species of insects invade crops and 7,800 species from 49 families on the scale insects (Coccidea), 1800 species of weeds and some 80000-100000 plant diseases caused by bacteria, viruses, fungi and algae (Diwaker et al. 2008 and Morales et al. 2016). Most of the pest is represented by members of Lepidoptera, Coleoptera, Diptera and Hemiptera that affect the fruit quality and productions (Agnello et al. 2009).

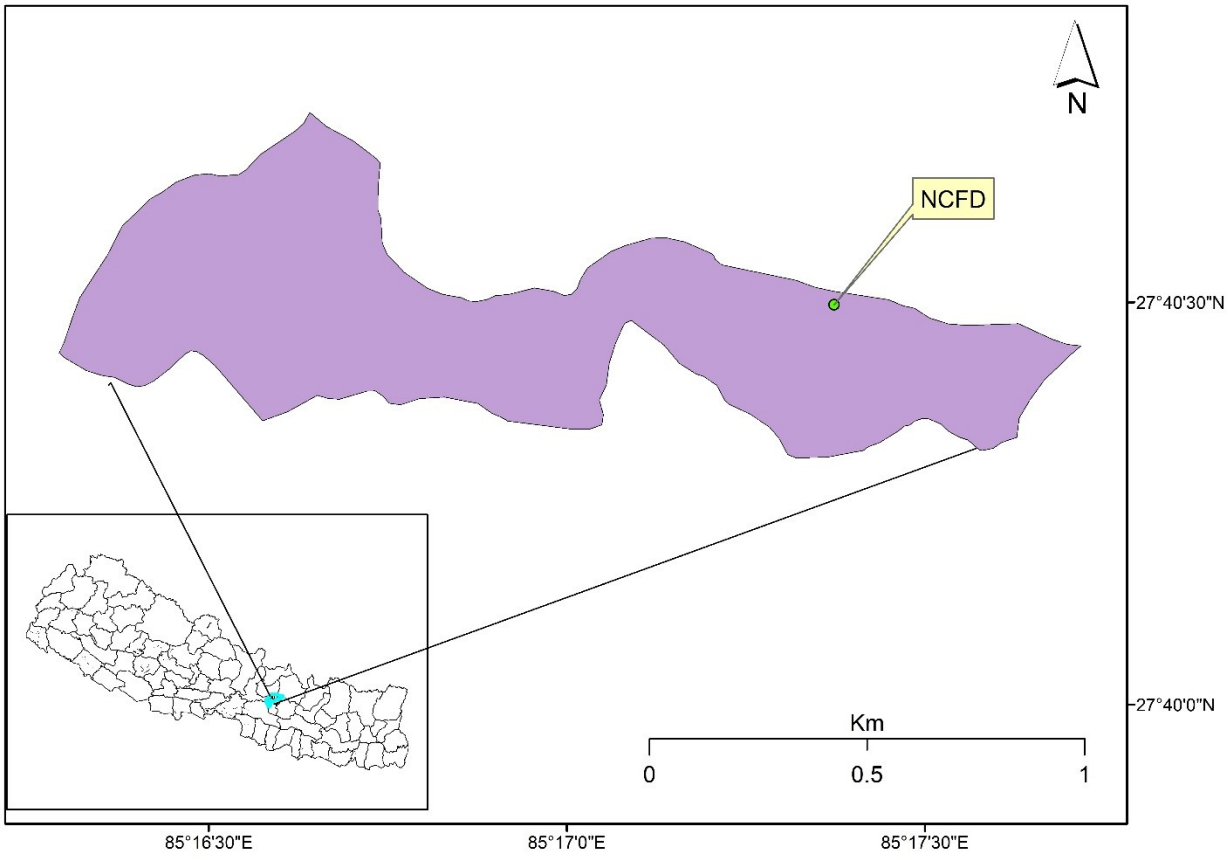
Pseudococcus citri, Pseudococcus bakeri, Pseudococcus citrophilus and Pseudococcus longispinus are the major pests found in the citrus plant, sometime *Pseudococcus ryani* and *Ceroputo arctostaphylii* are accidental pests on the citrus plant (Clausen 1915). In Nepal mostly citrus plant is affected by *Taxoptera aurantia* and *Throscrhiza citrii* (MOAD 2015). Aphids like Aphis pomi prefer newly develop leaves (Paulson, Hull and Biddinger 2005) and the green peach aphid causes direct damages to both leaves and stems, resulting in leaf curl, shoot stunning and overall devitalization of the tree and reduces the fruit quality (Pascal et al. 2002).

Imidacloprid is systematic insecticides having an insecticidal action (Abbink et al. 1991) that is extremely effective against some species of biting insects (Elbert et al. 1991) by affecting insects nervous systems (Abbink 1991).

Study area

National Centre for Fruit Development lies 5km south of Kathmandu at an altitude of 1,320 above the mean sea level. FDD is the central technical body responsible for the overall development of temperate fruits, coffee, tea and ornamental crops in Nepal.

This research Centre is operated with the objective of production of qualitative food, providing the quality of foods with aim of providing proper nutrition, making self-reliance in temperate fruit, export trade to the qualitative product, production of raw materials for the fruit industry, and providing job opportunities.



Data Collection Method:

Firstly, insects were collected in February before the uses of Imidacloprid and at the end of May after the uses of insecticides (fruiting time) from citrus and deciduous tree, by two tactics: nets wipe for flying insects (Wilson 1999) and visual collection. Visual collecting is used to collect scale insects, which is a particularly useful and common collecting strategy(Kozár and Miller 2016). All parts of the deciduous and citrus trees were examined. The underside of leaves, particularly in concealed areas near the veins good sites for the scales. The insecticides were used in April at the ratio of 1:1000ml of imidacloprid and water, with 30 days of interval.

Thus, collected specimens were preserved on the 70% ethanol and then stored in a refrigerator. The samples were taxonomically identified by using various resources including 'How to know the insects (Bland 1978, Jhonson 2006). I used a cozy magnifier and microscope (Hantor 2019) - a smartphone that is used in observing minute insects. Thus, collected data were analyzed using R software (Team 2016).

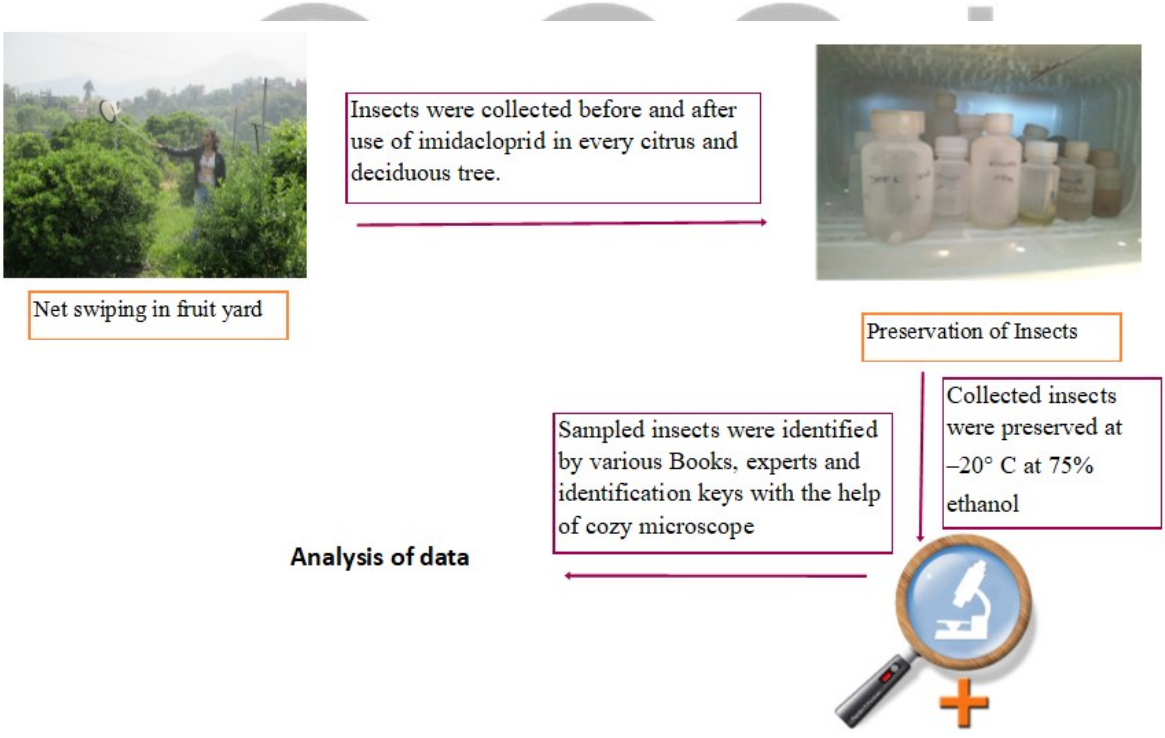


Figure 1: Model showing the procedure taken during data sampling to data analysis

Designing model

Qualitative models of National Centre for fruit Development for the impact of imidacloprid for beneficial, destructive and scale insects. The symbols + and – are used as connecting expressions to show the causal relationship between the associated ideas, describing either positive or negative interaction between them depending on conditions (Modelling by Bhumika Acharya and Meena Saru).

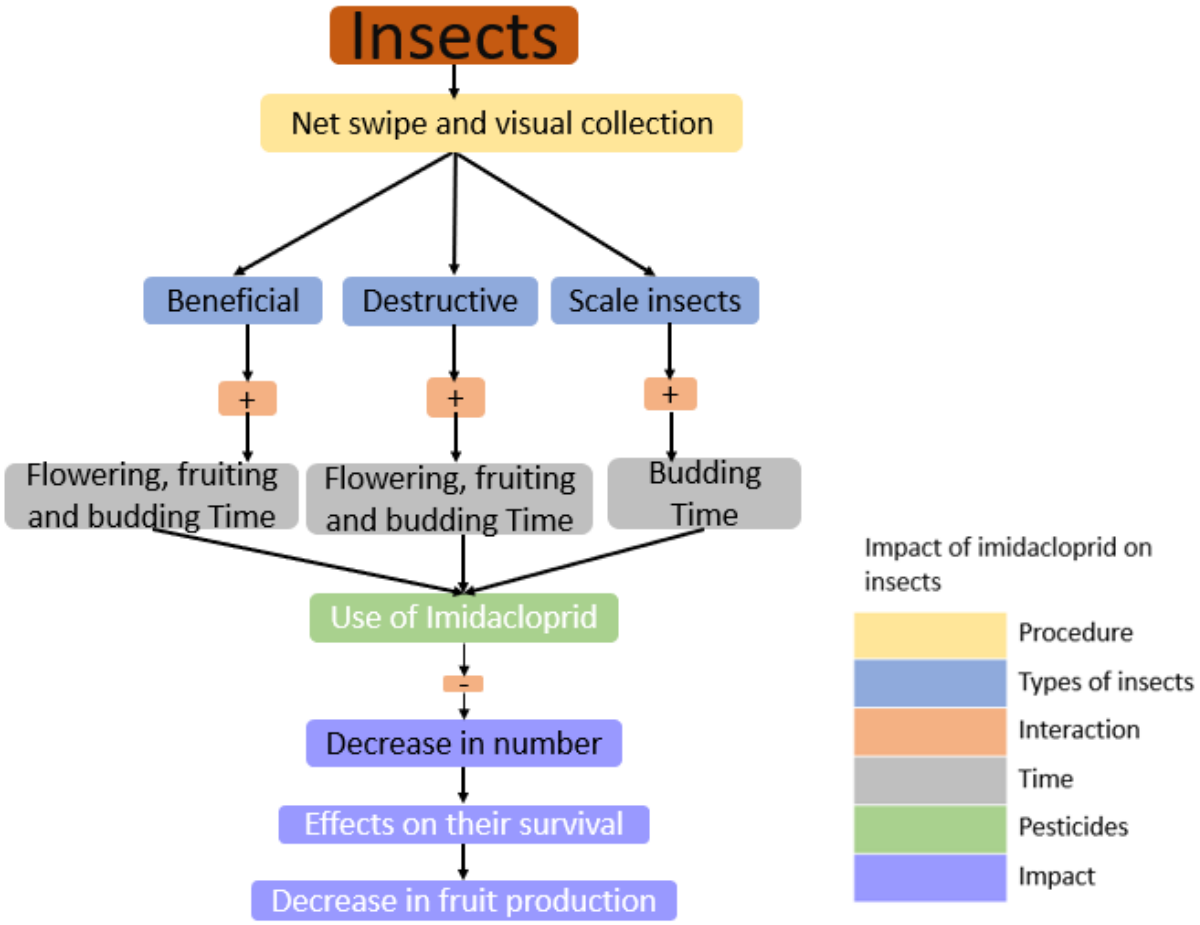


Figure 2: Conceptual model showing the inter-relationship between imidacloprid and insects

These models describe the method of collection of insects from the orchard, nature of insects based on how they act on the environment, the time of sample collection where the farmers applied imidacloprid in the National Centre for fruit development, Kirtipur, Nepal and the effects of imidacloprid on the insects. This model was designed after the collection of insects from the orchard of National Centre for fruit development taking five species of deciduous trees: apple, peach, pear,

Japanese guava and plum and six species of citrus trees: mandarin orange, trifoliate orange, pomelo, kumquat, sweet orange and kaffir lime and from the available literature.

Results

Insects are abundant organisms in all terrestrial ecosystem, playing both destructive and beneficial role.

Insects were collected before and after the uses of pesticides within February to May. Insects were observed within the deciduous fruits like apple (*Malus floribunda*), peach *(Prunus pessica*), Pharping pear (*Pyrus pyrifolia*), Japanese guava (*Psidium gaujava*) and Plum (*Prunus subh Prunus*) and Orange (*Citrus sinensis*), Kumquat (*Citrus japonica*), lemon (*Citrus hystrix*), trifoliate orange (*Citrus trifoliata*), Sweet orange (*Citrus limoliata*) and Pomelo (*Citrus hystrix*) of citrus fruits. This season is the month of budding, flowing and fruiting. During these periods of fruit trees (flowering and fruiting) different insects were observed. In the budding time, scale insects were abundant whereas, in fruiting time, pollinators were number were in large.

Insects captured before and after the uses of Imidacloprid

Total 36 insects were collected from the citrus tree before the uses of pesticides in which 14 were beneficial (pollinating) and other 16 were pest along with 6 scale insects. Similarly, in deciduous tree, total 31 insects were captured in which, 11species were destructive that feeds on saps from the branches and twigs along with 6 scale insects and remaining were beneficial that act as pollinator or predator to another pest like Robber fly.

Table 1: Collection of insects before the use of insecticides from various fruit tree

Name	Family	Order	Nature	Tree
Hover fly *(Sypherus species)*	Syrphidae	Diptera	Beneficial, helps in pollination	Orange *(Citrus sinensis),* Kumquats *(Citrus japonica)*
Lady Bird Beetle (*Propylea Species*)	Coccinellidae	Coleoptera	Beneficial,Predators feed on white fly and Aphid	Orange *(Citrus sinensis),* Kumquats *(Citrus japonica)*
Spider	Agelenidae	Araneae	Beneficial, Predators feed on insects	orange *(Citrus sinensis)*
$Spider_1$	Unidentified	Araneae	Beneficial	Kumquats *(Citrus japonica)*
Spider with Spike	Unidentified	Araneae	Beneficial	Sweet lemon (*Citrus limotta*)
Crane fly	Tipulidae	Diptera	Beneficial	Kaffir lime *(Citrus hystrix)*
Salt-Marsh Mosquito (*Ochelrotatus species*)	Culicidae	Diptera	Beneficial	Pomelo *(Citrus maxima)*
Seven spotted beetle (*Coccinella Species*)	Coccinellidae	Coleoptera	Beneficial, Prey on citrus aphids and scale insects	Kaffir lime *(Citrus hystrix)*
$Spider_2$	Agelenidae	Araneae	Beneficial	Kaffir lime *(Citrus hystrix)*
Hover fly (*Platycheirus species*)	Syrphidae	Diptera	Beneficial, helps in pollination	Kaffir lime *(Citrus hystrix)*
Lady Bird $Beetle_1$	Coccinellidae	Coleoptera	Beneficial, Predators feed on insects	Sweet lemon (Citrus limotta)
$Beetle_1$	Unidentified	Coleoptera	Beneficial	Sweet lemon *(Citrus limotta)*
Flower flies (Sphaerophoria sps)	Syrphidae	Diptera	Beneficial, helps in pollinator	Apple *(Malus floribunda)*
Lady bird beetle (Cheilomenes sps)	Coccinellidae	Coleoptera	Beneficial	Apple *(Malus floribunda),* Peach *(Prunus persica)*
Robber fly (Ommatius sps)	Asilinae	Diptera	Beneficial, predator to other insects	Apple *(Malus floribunda)*
Indian wave stripped lady bug (Cheilmenes species)	Coccinellinae	Coleoptera	Benefical	Apple *(Malus floribunda),* Peach *(Prunus persica)*
Hover fly (Episyrphus species)	Syrphidae	Diptera	Beneficial, helps in pollinator	Peach *(Prunus persica)*
Syrphid fly	Syrphidae	Diptera	Beneficial, helps in pollinator	Japanese Guava *(Psidium guajava)*

(Sphaerophovia sps)				
Click beetle	Elateridae	Coleoptera	Beneficial, feed on insects but larval stage is harmful feed on plants	Apple *(Malus floribunda)*
Casinaria sps	Ichneumonidae	Hymenoptera	Benficial, parasitic to insect (natural enemies), helpful to human and plants	Peach *(Prunus persica)*
Mosquito 1	Unidentified	Diptera	Beneficial	Peach *(Prunus persica)*
Spider 3	Unidentified	Aranea	Beneficial, predator feeds on insects	Pear *(Pyrus pyrifolia)*
Spider 2	Unidentified	Aranea	Beneficial, predator feeds on insects	Pear *(Pyrus pyrifolia)*
Hover fly (*Melanostoma species*)	Syrphidae	Diptera	Benificial, helps in pollinator	Japanese Guava *(Psidium guajava)*
Aphid (*Brachycadus species*)	Aphidinae	Hemiptera	Harmful, Feed on sap and may attack their leaves and fruits	Orange *(Citrus sinensis)*
Aphid (*Aphis species*)	Aphidinae	Hemiptera	Harmful, Feed on sap and may attack their leaves and fruits	Orange *(Citrus sinensis)*
Melon Aphid (*Aphis species*)	Aphidinae	Hemiptera	Harmful, Feed on sap and may attack their leaves and fruits	Kumquats *(Citrus japonica)*
Tortoise beetle (*Cassidini species*)	Chrysomelidae	Coleoptera	Harmful,Leaf eater	Kumquats *(Citrus japonica)*
Tortoise beetle (*Cassidini species*)	Chrysomelidae	Coleoptera	Harmful,Leaf eater	Kumquats *(Citrus japonica)*
Lady Bird Beetle (*Harmonica Species*)	Chrysomelidae	Coleoptera	Harmful,Leaf eater	Kumquats *(Citrus japonica),* Kaffir lime *(Citrus hystrix)*
Mottled Tortoise beetle (*Deloyala species*)	Chrysomelidae	Coleoptera	Harmful,Leaf eater	Kumquats *(Citrus japonica),* Pomelo *(Citrus maxima), Citrus limotta, Citrus trifoliata*
Eggplant Tortoise Beetle (*Gratiana species*)	Chrysomelidae	Coleoptera	Harmful,Leaf eater	Sweet lemon *(Citrus limotta)*
Mealybug Destroyer (*Cryptolaemus species)*	Coccinellidae	Coleoptera	Harmful,	Sweet lemon *(Citrus limotta)*
Aphid (*Aphis species)*	Aphidinae	Hemiptera	Harmful, Feed on sap and may attack their leaves and fruits	Sweet lemon *(Citrus limotta)*
Gnats	Unidentified	Diptera	Harmful in Maggot stage during fruit ripening and neutral in adult	Trifoliate orange *(Citrus trifoliata)*

Blue Bottle Fly (*Calliphora species*)	Calliphoridae	Diptera	Harmful, Spread diseases on maggots few on ripening fruit	Orange *(Citrus sinensis)*
Aphid (*Aphis spp*)	Aphididae	Hemiptera	Harmful, feeds on the sap and may attack their leaves and fruits	Apple (*Malus floribunda*)
False blister beetle (*Chrysanthia spp*)	Oedemeridae	Coleoptera	Harmful, leaf eater	Apple (*Malus floribunda*)
Soldier beetle (*Polemius species)*	Cantharidae	Coleoptera	Harmful, feed on the sap	Apple (*Malus floribunda*)
Wolly Aphid *(Eriosama species)*	Aphididae	Hemiptera	Harmful, feeds on the sap from the brancehs and twig	Apple (*Malus floribunda*)
Mottled tortoise beetle (*Deloyata spp*)	Chrysomelidae	Coleoptera	Harmful, leaf eater	Japanese Guava (*Psidium guajava*)
Red spider mite (*Tentanychus spp*)	Tetranychidae	Trombidiformes	Harmful	Apple (*Malus floribunda*)
Peach tree borer (*Synanthedon spp*)	Sesiidae	Lepidoptera	Harmfu at larval stage as it destructs the twigs	Peach (*Prunus persica*)
Rice hispa (*Hispa spp*)	Chrysomelidae	Coleoptera	Harmful, leaf eater	Japanese Guava (*Psidium guajava*)
Ant 1	Formicidae	Hymenoptera	Harmful	Apple (*Malus floribunda*)
Gnats		Diptera	Harmful at larval stage in ripening fruits and neutral in adult	Japanese Guava (*Psidium guajava*)
Green Peach Aphid	Aphididae	Hemiptera	Harmful, causing decreased growth, shriveling of the leaves and the death of various tissues	Peach (*Prunus persica*)
Ant	Formicidae	Hymenoptera	Harmful, chew bloosoms	Japanese Guava (*Psidium guajava*)

Table 2: Collection of insects after the use of insecticides from various fruit tree

Name	Family	Order	Nature	Tree
Butterfly (*Euphilotes species*)	Cycaenidae	Lepidoptera	Beneficial, helps in pollination	Orange *(Citrus sinensis)*
Butterfly (*Graphium species*)	Papilionae	Lepidoptera	Beneficial, helps in pollination	Orange *(Citrus sinensis)*
Seven spottedbeetle (*Coccinellia species*)	Coccinellidae	Coleoptera	Beneficial,Predators feed on white fly and Aphid	Kumquat *(Citrus japonica)*

Lady beetle (*Coccinella species)*	Coccinellidae	Coleoptera	Beneficial	*Citrus japonica*
Hoverfly (*Episyrphus* species)	Syrphidae	Diptera	Beneficial, helps in pollination	*Citrus japonica*
Ant_1	Formicidae	Hymenoptera	Beneficial	*Citrus maxima*
Ant_2	Formicidae	Hymenoptera	Beneficial	*Citrus limotta*
Spider	Unidentified	Araneae	Beneficial	*Citrus trifoliata*
Fly	Chloropidae	Diptera	Beneficial	*Citrus trifoliata*
Bee	Unidentified	Hymenoptera	Beneficial	*Citrus trifoliata*
Hoverfly (*Platycheirus species*)	Syrphidae	Diptera	Beneficial, helps in pollination	*Citrus hystrix*
Grey banded hoverfly (*Episyrphus species*)	Syrphidae	Diptera	Beneficial, helps in pollination	Peach (*Prunus persica*)
Lady bird bug	Coccinellidae	Coleoptera	Beneficial, predator feeds on aphids	Peach (*Prunus persica*)
Mosquitoes (*Chironominae species*)	Chironomidae	Diptera	Beneficial	Peach (*Prunus persica*)
Indian Cabbage white (*Pieris species*)	Pieridae	Lepidoptera	Beneficial, helps in pollination	Peach (*Prunus persica*)
Hoverfly (*Melanostoma species*)	Syrphidae	Diptera	Beneficial	Japanese Guava (*Psidium guajava*)
Clouded yellow butterfly (*Collas species*)	Pieridae	Lepidoptera	Beneficial, helps in pollination	Japanese Guava (Psidium guajava)
Cabbage butterfly (*Pieris brassica*)	Pieridae	Lepidoptera	Beneficial, helps in pollination	*Apple (Malus floribunda)*
Spider 1	Unidentified	Aranea	Beneficial	*Pear (Pyrus pyrifolia)*
Flower fly (*Sphaerophoria species*)	Syrphidae	Diptera	Beneficial	*Plum (Prunus subg Prunus)*
Seven spotted lady bug (*Coccinella species*)	Coccinellidae	Coleoptera	Beneficial	*Plum (Prunus subg Prunus)*
Gnat	Mycetophilidae	Diptera	Harmful	Pomelo *(Citrus maxima)*
Leaf Beetle (*Polyphaga species*)	Chyromelidae	Coleoptera	Harmful, Leaf eater	Pomelo *(Citrus maxima)*
Leaf Beetle	Chyromelidae	Coleoptera	Harmful, Leaf eater	*Kaffir lime (Citrus hystrix)*
Stink bug (*Halyomorpha species*)	Pentatomidae	Hemiptera	Harmful, leaf destruction, pitting and scaring of fruits	Pear (*Pyrus pyrifolia*), Japanese Guava (*Psidium guajava*)
Stripped flea beetle (*Phyllotreta species*)	Unidentified	Coleoptera	Harmful	Apple (Malus *floribunda*)
Mottled tortoise beetle	Chrysomelidae	Coleoptera	Harmful, leaf eater	Japanese Guava (*Psidium guajava*)

(*Deloyata species*)				
Eastern Boxelder bug (*Boisea species*)	Rhopalidae	Hemiptera	no significant damage but feaces may stain the leaves	Apple (*Malus floribunda*)
Fly_1	Pipanculidae	Diptera	Vector	Kumquat *(Citrus japonica)*
Fly_2	Unidentified	Diptera	Vector	Kumquat *(Citrus japonica)*
Common Green Bottle Fly (*Lucilia species*)	Calliphoridae	Diptera	Vector	Peach (*Prunus persica*), Plum (*Prunus subg Prunus*)
Common Housefly	Muscidae	Diptera	Vector	Plum (*Prunus subg Prunus*)
Fruit flies (*Thaumatomyia species*)	Chloropidae	Diptera		Pear (*Pyrus pyrifolia*)

Scale insects

Scaling insects were highly presence during the budding and flowering period of the fruits. Nest and the larvae of the Tussock moth and bag warm moth were seen in the peach tree. Tussock moth was observed in the apple tree too. Likewise, bagworm moth was observed in the pear tree. The presence of San Jose scale was high in peach tree, in every stem of the peach tree. Damages or tunneling of leaves were observed in the guava tree, which was the result of the moths and caterpillar. Mealybugs were also viewed on the guava tree highly. Seven different scale insects; Cotton camellia scale, mealy bugs, bagworm moth, mealy bugs thrips whitefly and armored scale were found in the Citrus tree before the uses of insecticides.

Scale insects				
Fruit name	Insect name	Family	Order	Nature
Peach (*Prunus persica*)	Latania scale			
Peach (*Prunus persica*)	White Peach Scale (*Pseudaulacaspic pentagona*)	Diaspididae	Hemiptera	Harmful, feeds on the sap
Apple (*Malus floribunda)*, Peach (*Prunus persica*)	San Jose Scale (*Quadraspidiotus perniciosus*)	Diaspididae	Hemiptera	Harmful, feeds on the sap, twigs
Pear (*Pyrus pyrifolia*)	Bag worm moth (*Thyridopteryx species*)	Psychidae	Lepidoptera	Harmful, causes defoliation
Apple (*Malus floribunda*), Pear (*Pyrus pyrifolia*)	Tussock Moth (*Hemerocampa sps*)	Lymantriidae	Lepidoptera	Harmful, leaf eater

Orange (*Citrus sinensis*)	Cottony camellia scale (*Pulvinaria species)*	Coccidae	Hemiptera	Harmful, feed on leaves, twigs
Orange *(Citrus sinensis)*	Mealy Bugs (*Pseudococcus citri*)	Pseudococcidae	Hemiptera	Harmful, fouls plant surfaces, giving rise to sooty moulds
Orange *(Citrus sinensis)*	Bag worm moth (*Thyridopteryx species*)	Psychidae	Lepidoptera	Harmful, causes defoliation
Kaffir lime (*Citrus hystrix*)	Mealy Bugs (*Planococcus citri*)	Pseudococcidae	Hemiptera	Harmful, premature leaf drop, stunted growth, and occasional death of infested plants
Kaffir lime (*Citrus hystrix*)	Mealybugs thrips	Pseudococcidae	Hemiptera	Harmful, infest fruit and formation of sooty mould
Sweet lemon (*Citrus limotta*)	White fly (*Bemisia spp*)	Aleyrodidae	Hemiptera	Harmful, affects plant growth, transmits geminiviruses and reduces fruit quality
Sweet lemon (*Citrus limotta*)	Armored scales	Diaspididae	Hemiptera	Harmful, infest folliage and fruits

Vector insects mean the insect that transmits diseases through infectious pathogen. Few vector insects such as Calliphoridae and Muscidae were also captured.

Impact of Imidacloprid on insects

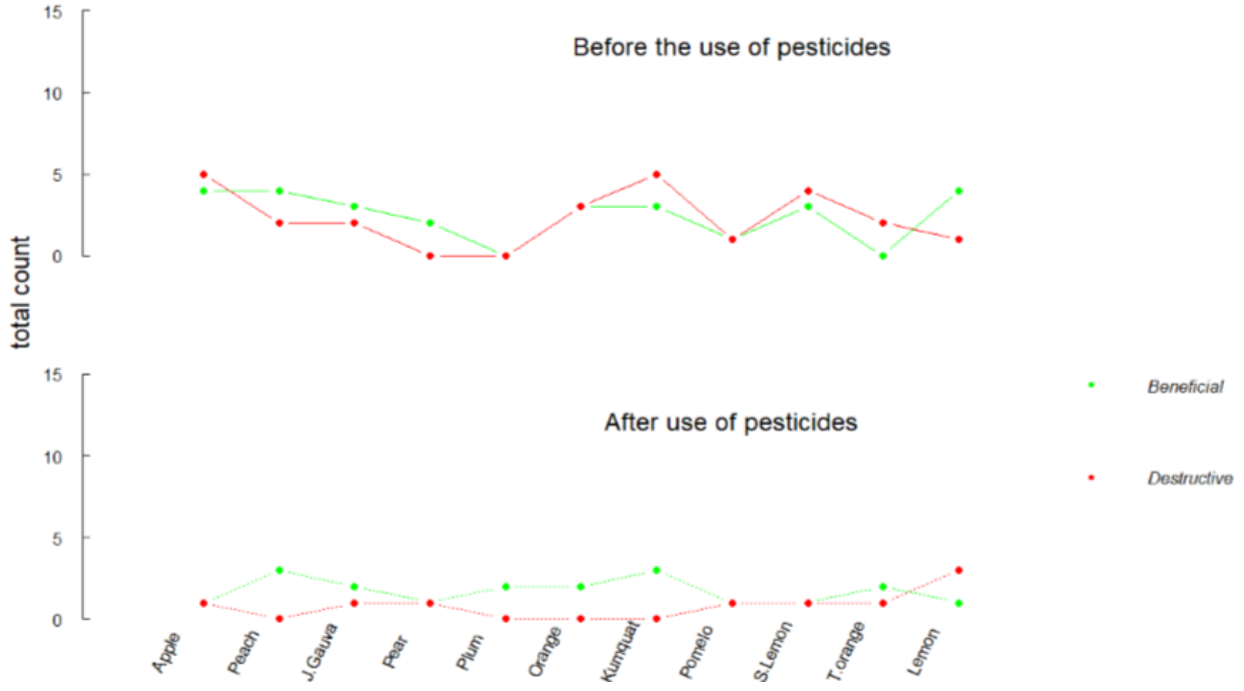


Figure 3: Line graphs showing the effects of imidacloprid on pests.

As shown in figure 3, most of the insects were captured before the uses of insecticides, where the pest was highly observed in Apple, Kumquat, Sweet Lemon and Trifoliate Orange. After the uses of insecticides, fewer insects were observed in the captured insects count few insects were captured. In citrus, only 17 insects were captured in which 11 were beneficial and 6 were a pest and in deciduous, 10 were beneficial and 4 harmful insects. In some trees like Pear, Pomelo and Sweet Lemon, absence of beneficial insects can be observed. Above plot shows that imidacloprid not only controls the pest but also somewhat effects on the survival of pollinating and other beneficial insects. Similarly, there is a significant association between Insects and Imidacloprid (p= 0.3039) in deciduous and (p=0.4752) in Citrus fruit).

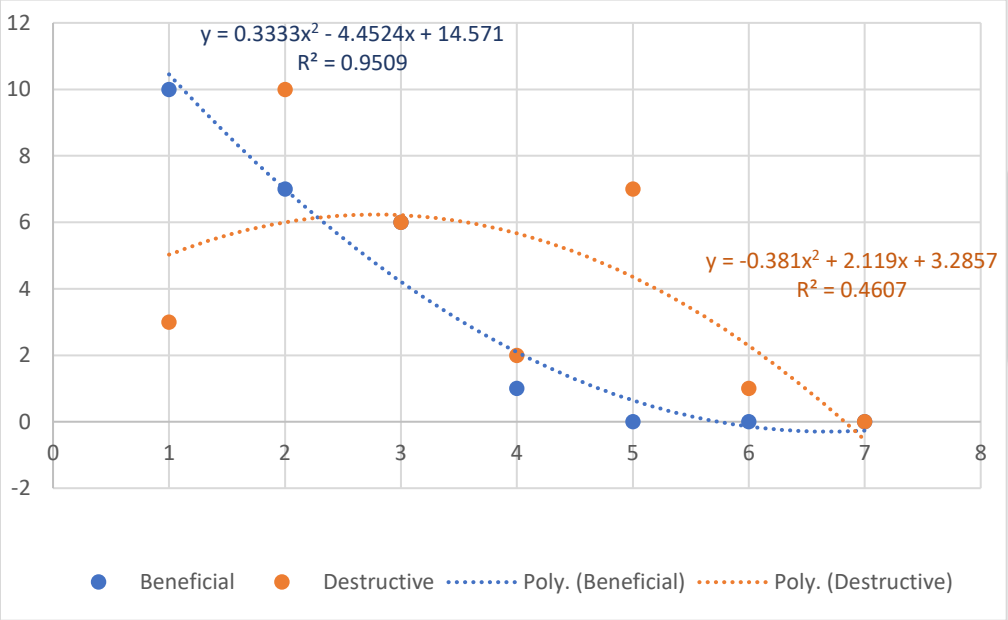


Figure 4: Line graph showing beneficial and destructive order of insects before the use of imidacloprid

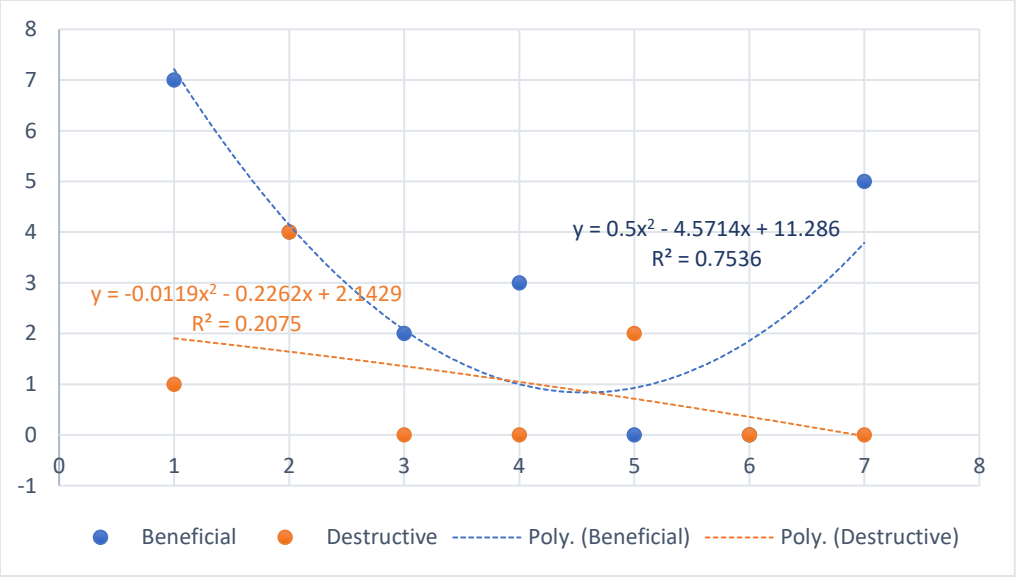


Figure 5: Line graph showing beneficial and destructive order insects after the use of imidacloprid

The above two-line graph X-axis represents the nature of insects where Y-axis represents the order of insects-Diptera, Coleoptera, Araneae, Hymenoptera, Hemiptera, Trombidiforms and Lepidoptera ranging from left to right. Figure 4 shows there is the dominant of destructive Coleoptera followed by Hemiptera, whereas beneficial Diptera is found in highest number followed by Coleoptera. There was the presence of Trombidiforms which was reduced after the presence of Imidacloprid. Figure 5 shows beneficial Diptera are found in higher number followed by Lepidoptera.

Most of the captured insects were Coleoptera, followed by Diptera and Hemiptera in citrus trees. In the deciduous tree, Diptera was highly captured, followed by Coleoptera and Hymenoptera. Pest like aphids was highly present especially in the peach and apple tree on their leaves and twigs. There were around more than 15 aphids on every leaf of the apple tree. In compare to an apple tree, a peach tree had less presence of aphid.

Mottled Tortoise Beetle (*Deloyala species*)-destructive Coleoptera was found frequently in *Citrus japonica, Citrus maxima, Citrus limotta, Citrus trifoliata* which is destructive in nature and feeds on the leaf. Whereas, Beneficial insects such as Hoverfly (*Sypherus species*)- beneficial Diptera are frequently found in *Citrus sinensis*, *Citrus japonica* and Lady Bird Beetle (*Propylea Species*)-beneficial Coleoptera in *Citrus sinensis, Citrus japonica* before the use of insecticides.Most of the captured insects were Coleoptera, followed by Diptera and Hemiptera in citrus trees. In deciduous

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Discussion

The study comprised of the insects present on Apple, Peach, Pear, Plum, Japanese Guava, Lemon, Kumquat, Sweet Lemon, Orange, Kaffir Lime and Trifolate lemon of the National Centre for the Fruit Development, Kirtipur. Most of the captured and observed insects during collection time were similar to the report of FDD annual report 2015/16. There were around more than 15 aphids on every leaf of the apple tree and Barbagallo et al 2007 concluded that mostly Aphid spp attacked deciduous fruits during the pre-flowering period that cause leaf deformation and shoot distortion, with sap draining.

Collins and Whitcomb (1975) studied the natural enemies of the white peach scale. And most of the white peach scale predator were Coccinellidae in Florida. Hondek and Honek (2009) exclaimed that ladybug beetle (family: Coccinellidae) prey on aphids and usually present in peach and mulberry. Even in our study, on the month of March, there was the absence of the white peach scale as the presence of Coccinellidae. Sarwar (2006) studied in Pakistan about the key insects present on the guava, some of the identified key insects were fruit fly, mealy bugs, mites, stink-bug, red-banded thrips, guava moth, guava whitefly and scale. But in this study few species like mealybugs and stink, bugs were only observed, since the study was only begun on the month of February to March.

Though imidacloprid manages insect's pest with less environmental impact, it causes difficulty in the survival of pollinators and other beneficial insects like black cutworm, Agrotis ipsilon

(Hufnagel) and Japanese beetle (Kunkel et al, 1999; Charvet et al., 2004; Fogel et al., 2013). It is known as the second leading factor in the cause of declination of honey bees, bumblebees and solitary bees, as it is situated in pollen and nectar of a flower, making them toxic to the pollinators that feed on them (Hopwood et al., 2016; Oder, 2019). In our captured insect count in the citrus tree, there was a decrease in the number of beneficial insects after the utilization of imidacloprid and complete absence of scale insects. Likewise, the presence of fewer aphid and leaf beetles in deciduous fruits.

In contrast to our study, IPM guidelines of the state of Queensland Government suggest imidacloprid has a moderate effect on beneficial insects such as predatory beetles, predatory bugs, parasitic bugs, spider and bees (IPM 2017).

After the use of imidacloprid in Citrus japonica, Citrus maxima, Citrus limotta, Citrus trifoliata the tortoise beetles were found to be reduced but Dyer, 2018 exclaimed it does not affect the leaf-eating beetle.

As Elbert et al. 1998 suggest in his study, after the application of imidacloprid in the deciduous plants it shows the positive results in controlling the aphids. Similarly, Thrips, Whiteflies, Coleoptera and Diptera were also found to be decreased in number which was found to be similar in our study. But in contrast to his study, the number of Lepidoptera which are beneficial was found to be increased in number declining the Lepidoptera that are destructive in nature.

Conclusion

Total 36 and 31 beneficial and destructive insects were captured from the Citrus tree and Deciduous tree where 12 scale insects were captured from citrus and the deciduous tree whereas the order such as Diptera, Coleoptera, Araneae, Hymenoptera, Hemiptera, Trombidiforms and Lepidoptera were found. It was found that Insects Lepidoptera was found in large number after the application of imidacloprid but the order such as Hemiptera, Araneae and Coleoptera was found to be decreased in number after the application of imidacloprid.

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