Journal of
Plant Pathology & Microbiology
ISSN: 2157-7471

Besufkad et al., J Plant Pathol Microbiol 2018, 9:4
DOI: 10.4172/2157-7471.1000437

Research Article Open Access

# A Survey on Temperate Fruit Pests and their Importance in the Highland Areas of North Shewa Zone, Amhara Region, Ethiopia

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## Abstract

Temperate fruits (Apple, Pear, Plum, Peach and Almond etc.) are deciduous fruit trees that grow well in temperate climate zones where most commercial varieties fulfill their required chilling temperature. Recently though, because of the low average temperatures, these crops are found to be grown well in the highlands of Ethiopia. Amongst the areas that have greater significance in this aspect is North Shewa zone, Amhara region of Ethiopia. Accordingly, aiming to get acquainted with the distribution, incidence, and severity of temperate fruit diseases and insect pests, a systematic survey was carried out in seven districts of North Shewa (Menz Gera, Menz mama, Basonaworana, Angolela Tara, Tarmaber, Ankober and Hagere Mariam) for two consecutive seasons. As revealed by the assessment, temperate fruit trees are subjected to numerous pests. Apple trees were found to be infested with apple scab, powdery mildew, canker, apple aphid, woolly aphid, beetles, spider mite and sting bug, whereas, leaf rust was the main disease of plum and peach. In most locations, apple scab, powdery mildew leaf rust, apple aphid and beetles were very much recurring and most destructive, therefore considered as economically important pests of temperate fruits in the area. Moreover, except for few conspicuous inconsistencies, the seasonal and altitudinal variation in distribution and severity of these diseases and insect pests were comparable.

**Keywords:** Survey; Temperate fruit; Disease; Insect pest

## Introduction

Temperate fruits (Apple, Pear, Plum, Peach and Almond etc.) are deciduous fruit trees that grow well in temperate climate zones where most commercial varieties fulfill their required chilling temperature (Figure 1). Although these crops are originated in temperate regions and their environmental requirement can be meet properly in this region, many tropical and subtropical countries are trying to produce their own deciduous fruits [1]. In Ethiopia, the first apple trees were introduced to the southern mountains (2700 m.a.s.l) 60 years before [2]. At such high altitudes in tropics average temperatures are lower; therefore, it allows reaching of their chilling requirement [3]. Temperate fruit crops are often cultivated together with similar management practices and could share similar diseases and insect pests. Currently, temperate fruits are becoming the most important product in the highlands of SNNPR (southern nation's nationalities peoples of Ethiopia). Thus far, the most commonly known temperate fruit diseases and insect pests in commercial and small-scale farms of these areas are apple scab, collar rot, powdery mildew, cankers, leaf spots, leaf curl, star crack, aphids, weevil, and scale insects [4].

In recent years, the government of Ethiopia has embarked on an economic growth strategy led by agricultural development. In this context, the government is restructuring sectors that can add value to agricultural production. At present, one of the issues that turn out to get massive emphasis in this regard is the introduction of temperate fruit crops to different regions of the country [4]. Some of the areas that can have critical importance to guarantee the success of this goal are in North Shewa zone of Amhara regional state. Earlier, uncoordinated efforts were made to introduce and disseminate temperate fruits (mainly apples) in this zone. In the last decade alone, millions of grafted apples, plum and peach seedlings were disseminated to small-scale farmers by different governmental and non-governmental organizations [5].

Even though temperate fruit seedlings are disseminated in bulk, fruit production is insignificant and consumed locally. The foremost reasons that diminish the success of temperate fruit production in the zone are chilling insufficiency, lack of knowledge on adaptable varieties, shortage of skill to manage fruit trees, the absence of expertise on propagation methods, poor agronomic management and disease and insect pest pressure. At present, all but the disease and insect pest extents of these production problems are being worked on by different stakeholders. Therefore, as the first of its kind in the zone, assessing the status of diseases and insect pests on these crops may have an immense prospect for the success of the sector. In the past, seedlings have been introduced to North Shewa from local nurseries at Chencha, Holleta, Awi and recently from South Wello areas of Ethiopia infested with different diseases and insect pests. For instance, more than 90% of previously distributed apple seedlings in Hagere Mariam and Asagirt districts

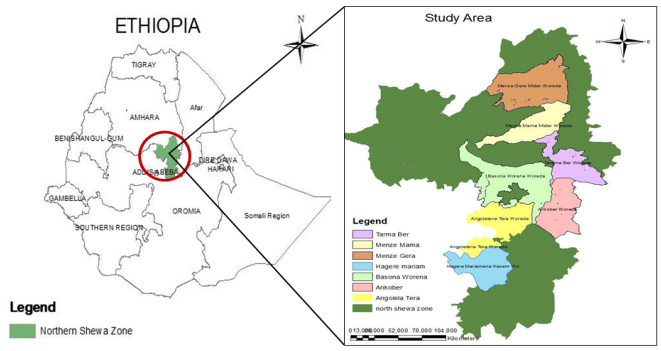


**Figure 1:** Map of study districts in North Shewa zone of Ethiopia.

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**Received** March 13, 2018; **Accepted** April 10, 2018; **Published** April 16, 2018

**Citation:** Besufkad A, Worku Y, Desalegn F, Aragaw D (2018) A Survey on Temperate Fruit Pests and their Importance in the Highland Areas of North Shewa Zone, Amhara Region, Ethiopia. J Plant Pathol Microbiol 9: 437. doi: 10.4172/2157-7471.1000437

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by *Menschen fur Menschen*, a well-known NGO in Ethiopia, were from Chencha area of southern Ethiopia (personal communication). Nonetheless, a recently published survey confirmed the existence of a myriad of diseases and insect pests and their dispersal with planting materials from in and around Chencha to different parts of Ethiopia [4]. Besides, our preliminary observation endorsed their report, as we had observed disease-like symptoms and insect pest damages on temperate fruit plantations in some districts of North Shewa. Therefore, this survey was initiated considering the economic importance of temperate fruits, the tremendous potential of the area and the lack of previous research on the status of diseases and insect pests in North Shewa. So, the aim of the survey was to generate valuable information on the status of diseases and insect pests, their distribution domain, and severity for future management and strategic interventions.

## Methodology

### Study area

A systematic survey of temperate fruit diseases and insect pests were conducted in 2013 and 2014 in the key temperate fruit production districts of North Shewa (Menz Gera, Menz mama, Basonaworana, Angolela Tara, Tarmaber, Ankober and Hagere Mariam) with in an elevation range of 2620-3190 meters above sea level (m.a.s.l). Because all the survey districts are highland areas, the overall climatic conditions between the districts are basically the same. For instance, in the case of Bassonaworana, 50% the total land is Dega (temperate), 48% Weyna-Dega (sub-tropical) and the remaining 2% is Wurch (afro-alpine). Moreover, 70% the total area is flat land, 23% is rugged land and 7% is mountainous [6]. Regarding average land-holding, because of the population density and the existing total land in these Woredas, it is estimated to be about 1 hectare per household [7]. Depending on the location of the farm, soil type, and availability of irrigation water, farmers in these areas grow cereal, pulse, oil, and horticultural crops. Additionally, livestock production alongside crops is a customary practice. Crop harvests are often for home consumption; however, livestock produces particularly sheep and goats are the typical cash sources.

### Survey and sampling method

Survey districts were selected purposively in consultation with the North Shewa zone agricultural office, generally by associating the relative expanse of temperate fruit production in all the districts of the zone. Likewise, kebeles within districts were selected in discussion with the respective district agricultural offices by considering proximity, accessibility, and the availability of a reasonable number of orchards in the kebeles. Likewise, orchards within kebeles were selected by observing the presence of more than ten trees per orchard. Furthermore, random sampling was used to select trees within temperate fruit orchards. The survey was conducted in the above mentioned seven districts during belg seasons of 2013 and 2014. The total number of kebeles and orchards surveyed were 20 and 57 respectively. Moreover, observation and sampling were made on 269 fruit trees that were on active vegetative growth or flowering/fruit-set stages. Management level of the orchard, soil type, source of planting material, growth stage of fruit trees, years since planting, the number of harvest since planting and canopy spread were noted. Successively, orchards surveyed in 2013 were assessed again in 2014 to detect seasonal variation.

Samples were collected on an individual tree bases and data on incidence (%) of disease and/or insect pest prevalent orchards, severity (score 1- 5, 1 as less severe and 5 as very severe) were taken. Disease and insect pest prevalence (occurrence) and incidence were assessed using the equation: Percent of occurrence (prevalence)=(Number of orchards with an infected temperate fruit)/ (Total number of assessed orchards) × 100. Disease/ insect pest incidence (I)=(Number of infected trees)/ (Total number of assessed trees) × 100. Furthermore, the 1-5 scale taken severity recordings were later changed into percent disease index (PDI) using the equation: Severity (%)=(sum of numerical ratings)/ (Number of plants scored × Maximum score on scales) × 100 [8]. Furthermore, diseases and insect pests were categorized as major, intermediate, and minor considering their relative occurrence, incidence, severity, and seasonal distribution [4].

### Pest identification and data analysis

To ascertain the predominant diseases and insect pests, samples were characterized both on the field and in the lab using pest identification guidebooks and preserved specimens respectively. Results are summarized descriptively using the sum, average and percentage procedures of Microsoft Excel 2010.

## Results and Discussion

### Temperate fruit cultivars and management practices

Almost all farmers in surveyed districts did not know the varieties they have been growing. However, efforts were made to identify the existing varieties by communicating with the planting material providers, development agents and by observing the tree structure, leaf morphology, fruit size, fruit color and onset and offset of dormancy. The main Apple varieties found in the surveyed districts of North Shewa were: Anna, Prencissa, Dorset Golden, Br, Gransmith, Pinova, Red India, Cp-92, and Crispin. Plum varieties: Cherry Plum, Methyl, Santarosa and Peach varieties: Florida king, Nova Dona, Uf Gold and Honey Blush were also seen. Based on the data of the North Shewa zone agricultural office [5], more than 75% tree seedlings were brought from Chencha, SNNPR of Ethiopia. Few materials were also originated from Orero, Spain, and Holetta, Oromia, and Awi, Amhara regions of Ethiopia. Because of the newness of the crop and the accompanying lack of awareness and skill to appropriately manage the trees, tree management practices (pruning and training) were found to be poor in most orchards. Besides, subsistence farmers tend to incline to annual crops and devote most of their time and energy before perennials.

### Farmers' view on the prevailing pests

Most farmers in the surveyed districts bluntly admitted that they were very much hesitant to include temperate fruits in their farming system when seedlings were provided by the respective agricultural bureaus and other organizations. The reluctance has been because of the newness of the trees, its perennial nature and the lack of knowledge and skill to appropriately manage it. Subsequently, in most cases, trees were poorly managed and sometimes entirely abandoned. Growers were clueless about the type of the diseases and insect pests on the trees, instead, they associate symptoms of temperate fruit pests with what has been recognized on annual crops. On few orchards, in consultation with agricultural experts, broad-spectrum fungicides were found to be used to control fungal diseases (apple scab and powdery mildew). In general, it might have been because of the lack of training and/or experience working with these crops, the expertise of both farmers' and agricultural experts on the existing pests of temperate fruits were found to be substandard.

### Temperate fruit diseases and insect pests in North Shewa

The type and status of temperate fruit diseases and insect pests in 2013 and 2014 cropping seasons are presented in Tables 1 and 2. As

| Common name | Scientific name | Status | Fruit tree type |
|---|---|---|---|
| Apple scab | *Venturia inaequalis* | Major | Apple |
| Powdery mildew | *Podosphaeria lecotrcha* | Major | ‘’ |
| Leaf rust | Sp.not identified | Major | Plum and Peach |
| Canker | Sp.not identified | Intermediate | Apple |

**Table 1:** Type and status of diseases observed in North Shewa on temperate fruits in 2013 and 2014.

| Common name | Scientific name | Status | Fruit tree type |
|---|---|---|---|
| Apple aphid | *Aphis pomi* | Intermediate | - |
| Beetles | *Altica foliaceae&Nemognatha scutellaris* | Intermediate | Apple and Plum |
| Spider mite | *Panonychus ulmi* | Minor | Apple |
| Woolly aphid | *Eriosoma lanigerum* | Minor | ‘’ |
| Sting bug | *Euschistus conspersus* | Minor | ‘’ |
| Apion | Sp.not identified | Minor | Plum |

**Table 2:** Type and status of insect pests observed in North Shewa on temperate fruits in 2013 and 2014.

demonstrated by the data of the two consecutive seasons, temperate fruit trees were subjected to different diseases and insect pests in the area. Three diseases and five insect pests were recorded on apple, whereas one disease and two of insect pests were observed on plum, and one disease was noted on peach. Apple scab and powdery mildew (PM) were the major diseases of apple in the area, while canker had an intermediate significance. Except for apple aphid and beetles, the importance of other observed insects was minor on apple. Two types of beetle species: apple flea beetle *(Altica foliaceae)* and orange blister beetle *(Nemognatha scutellaris)* were documented on apple and plum. Because it was difficult to independently quantify their prevalence and damage level, mainly due to their mutual existence, throughout this study they are presented as ‘beetles on apple or plum’. Though the number of samples were smaller than the sample size of the apple, on plum and peach leaf rust appeared to be the major disease.

Like the current finding, an assessment on temperate fruit diseases and insect pests in SNNPR revealed the presence of apple scab, powdery mildew, cankers, apple aphid and beetles on apple [4]. Furthermore, Apple scab and PM were also reported to be the major apple diseases in Kenyan highlands with relatively similar ecological conditions [9]. In their extensive survey, Fikre and Messele [4] reported the cultivation and large-scale propagation of temperate fruit seedlings and acknowledged the movement of pests with the planting materials. Therefore, as 75% temperate fruits cultivated in our study domain were obtained from there, pests might have been imported with the seedlings. Temperate fruit trees were also long being propagated and disseminated from Holleta area and Awi zone of Oromia and Amhara regions respectively. Accordingly, as there has not been a proper study on the distribution of temperate fruit pests in these areas, pests unreported in Fikre and Messele [4] assessment might have been originated from these areas. The case of woolly aphid strengthens this argument as the owners of the infested apple plants confirmed their source as Awi zone of Amhara region.

## Field symptomatology of important diseases and insect pests

**Apple Scab (*Venturia inaequalis*):** Apple scab is the most common and economically important disease of apple in almost all apple growing areas of the world. The causative agent of the disease is a fungus called *Venturia inaequalis*. In 2013 and 2014, it was observed on leaves, petioles, blossoms, fruits, and less frequently, on young shoots and buds. The initial lesions were often found on the lower surfaces of the leaf as a circular brown or light green asymmetrical spots with homocentric margin. In some cases, the underlying cells turned brown and died, therefore, brown lesions were also visible on the upper surfaces. On old leaves, tissues adjacent to the lesion thickened and the leaf surface becomes deformed with metallic black spots. Besides, when infections were numerous, young leaves appeared curled, dwarfed, distorted, and often fallen from the tree. Infections on blossoms often resulted in premature abscission. Lesions on fruits were like those on leaves, but on large fruits, lesions were brown and corky.

**Powdery mildew (*Podosphaeria lecotrcha*):** Powdery mildew of apple occurs in all apple-producing regions of the world. It can occur at any growth stage and causes economic damage by reducing tree vigor, flower bud production, and fruit quality. The causative agent is a fungus, *Podosphaeria lecotrcha.* Apple Powdery mildew produces symptoms on young shoots, leaves, blossoms, and fruit. In our case, symptoms were noticeable on younger shoots and leaves. Infected flag shoots had a silver-gray appearance and exhibited defoliation, stunted growth, and dieback. Fungal colonies composed of mycelium and spores appeared as white, felt-like patches on the leaves. Moreover, leaves affected along its margins appeared curled, creased, or pleated longitudinally.

**Apple canker (*Neonectria ditissima*):** Apple canker is a disease caused by a fungus named Neonectria ditissima, which attacks the bark of apples, causing a sunken area of dead bark, eventually, the death of limbs or trees. In both seasons, infected small and large branches with round and/or oval dead sunken bark were observed. Likewise, diseased larger branches have been losing its bark, exposing the dead wood in the center. In some cases, infected twigs in the first season found girdled and dead in the coming season.

**Leaf rust (*Tranzschelia discolor*):** Plum and peach leaf rust was the other temperate fruit disease documented in the assessed districts. Though leaf rust of plum and peach is primarily caused by a fungus, *Tranzschelia discolor, our analysis had not been decisive enough to precisely determine and suggest the exact fungal species. In any case, symptoms on the leaves appeared to be reddish to dark brown colored rust lesions underneath the surface. The disease load looked greater on older leaves than young ones. Additionally, in most cases, it was found to infect twigs with brown powdery masses of fungal spores on the barks.*

**Green apple aphids *(Aphis pomi)*:** There are many types of aphids that can attack apples, among them green apple aphid *(Aphis pomi)* was recorded in North Shewa. Both the nymphs and adults (winged and wingless) were observed. The nymph appeared very small in size with an oval shape and yellow-green to dark green in color, whereas, the adult was larger in size with bright green color. Both stages were found to attack succulent sprouts and water shoots and mainly seen on the underside of leaves. Generally, the visual presence of apple aphids in trees was much worse than the damage instigated by their feeding.

Their feeding of young leaves seemed to cause leaf curling and, in some cases, entire shoot curling. Furthermore, the feeding did not seem to harm large trees but found to stunt seedlings and young trees.

**Beetles:** Two beetle species: apple flea beetle (*Altica foliaceae*) and orange blister beetle (*Nemognatha scutellaris*) were observed. For no apparent known reason, repeatedly, their presence was mutual, and it was difficult to identify which damage was inflicted by which species. Apple flea beetle appeared small (3-5 mm) with a shiny green color. Whereas the other species seemed larger in size compared to apple flea beetle and it had an orange colored back with black strips at each end of its torso. Generally, affected plants showed small holes and notches on their leaves. Although apple flee beetle is known to cause serious defoliation, the damage level did not appear to be a major concern in North Shewa case. In addition to the leaves, orange blister beetles were found on the flowers of apple plants.

## Basic metrological data for 2013 and 2014

To reflect on the zonal scenario, the rainfall and temperature data obtained from Debre Berhan agricultural research center metrological station is indicated as follows: the total annual rainfall in 2013 was 1185 mm with an average of 4.2 for the surveyed months (January, February, and March). Whereas, the total annual rainfall in 2014 was 1046.7 mm with an average of 21.4 mm for the three surveyed months (January, February, and March). The mean maximum and minimum temperatures for 2013 and 2014 were 19.83 and 6.31 and 19.94°C and 6.42°C respectively. Moreover, the average mean maximum and minimum temperatures for the surveyed months in 2013 were 20.25°C and 4.02°C respectively. In contrast, the 2014 average mean maximum and minimum temperatures were 20.57°C and 7.81°C respectively.

According to the above described rainfall and temperature data, the total annual rainfall in 2013 was somewhat higher than 2014. Nevertheless, the average for the three surveyed months was much higher for 2014 than 2013. Moreover, 2014 appeared to be the hottest year compared to the previous year. These metrological conditions had distinctive implications on incidence, severity and seasonal distribution of diseases and insect pests.

## Distribution and severity of diseases and insect pests

In both seasons, irrespective of their relative prevalence, incidence and severity, the type of recorded diseases and insect pests were consistent. In 2013, apple scab, powdery mildew, and apple aphid presented higher prevalence, while beetles, woolly aphid, and spider mites were the least occurring pests. The incidence of canker, beetles and powdery mildew were relatively higher than the others. Furthermore, apple aphid followed by apple scab and beetles presented higher severity in 2013 (Table 3 and 4).

In 2014, like the previous season, apple scab and powdery mildew were the most widely distributed diseases of apple. Though, beetles were the highly distributed insects instead of apple aphid in 2013. The incidence of powdery mildew, apple scab and beetles were somewhat higher than the rest. In addition, the severity of the two most extensively distributed diseases of apple was greater than the other recorded pests in 2014 (Table 3 and 4).

Except for the presence of spider mite with small distribution domain, incidence, and severity in 2013, seasonal variation on the type of diseases and insect pests had not been noted. Nonetheless, the rate of distribution, incidence, and severity varies considerably. For instance, with advanced incidence and severity, the pervasiveness of both apple scab and powdery mildew (31.57% and 19.29% respectively) in 2013 had been doubled (70.17% and 38.59% respectively) in 2014. Additionally, the distribution of beetles in 2013 had been more than quadrupled in 2014. The most troublesome insect pest of apple, woolly aphid was recorded in two nursery sites in 2013. It was observed in Hagere M. (NGO owned nursery, Tilofa kebele) and Menz M.

| 2013 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **Altitude** (m.a.s.l) | **Type of Disease** | **Prevalence (%)** | **Incidence (%)** | **Severity (%)** | **Surveyed Fields** | **Sample Size** |
| North Shewa | 2620-3190 | Apple Scab | 31.57 | 36.71 | 48.33 | 57 | 269 |
| | | Powdery Mildew | 19.29 | 48.80 | 36.76 | 57 | 269 |
| | | Canker | 8.77 | 72.50 | 39.37 | 57 | 269 |
| | | Mean | 19.87 | 52,67 | 41.48 | - | - |
| **2014** | | | | | | | |
| - | - | Apple Scab | 70.17 | 45.98 | 50.17 | 57 | 269 |
| | | Powdery Mildew | 38.59 | 58.71 | 44.36 | 57 | 269 |
| | | Canker | 12.28 | 30.82 | 26.11 | 57 | 269 |
| | | Mean | 40.35 | 45.17 | 40.21 | - | - |

**Table 3:** Average prevalence, incidence, and severity of diseases on apple at the surveyed districts of North Shewa, 2013 and 2014.

| 2013 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **Altitude** (m.a.s.l) | **Type of Insect Pests** | **Prevalence (%)** | **Incidence (%)** | **Severity (%)** | **Surveyed Fields** | **Sample Size** |
| North Shewa | 2620-3190 | Apple Aphid | 22.80 | 20.40 | 51.66 | 57 | 269 |
| | | Beetles | 3.50 | 50.00 | 40.00 | 57 | 269 |
| | | Woolly Aphid | 3.50 | 30.00 | 30.00 | 57 | 269 |
| | | Spider mite | 1.75 | 20.00 | 20.00 | 57 | 269 |
| | | Mean | 7.89 | 30.10 | 35.42 | - | - |
| **2014** | | | | | | | |
| | | Apple Aphid | 15.79 | 21.00 | 27.66 | 57 | 269 |
| | | Beetles | 19.29 | 47.98 | 28.92 | 57 | 269 |
| | | Sting bug | 1.75 | 60.00 | 20.00 | 57 | 269 |
| | | Woolly Aphid | 1.75 | 20.00 | 75.00 | 57 | 269 |
| | | **Mean** | 9.65 | 37.24 | 37.89 | - | - |

**Table 4:** Average prevalence, incidence, and severity of insect pests on apple at the surveyed districts of North Shewa, 2013 and 2014.

| 2013 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| District | Altitude | Apple Scab | | | Powdery Mildew | | | Surveyed Fields | Sample Size |
| | | Prev. (%) | Inc. (%) | Sev. (%) | Prev. (%) | Inc. (%) | Sev. (%) | | |
| Basonaworana | 2830-3120 | 25.00 | 60.00 | 40.00 | 12.50 | 20.00 | 37.50 | 8 | 40 |
| Tarmaber | 2635-3160 | 22.20 | 40.00 | 45.00 | 33.30 | 57.00 | 40.00 | 9 | 43 |
| AngolelaTara | 2760-2860 | 50.00 | 40.00 | 53.33 | _ | _ | _ | 6 | 30 |
| Ankober | 2620-3040 | 57.10 | 40.00 | 40.00 | 42.80 | 47.00 | 48.00 | 7 | 35 |
| Hagere Mariam | 2640-2920 | 22.20 | 20.00 | 40.00 | _ | _ | _ | 9 | 43 |
| Menz Gera | 2920-3085 | 22.20 | 20.00 | 60.00 | 33.30 | 60.00 | 33.33 | 9 | 41 |
| Menz Mama | 2760-3190 | 33.30 | 37.00 | 60.00 | 11.10 | 60.00 | 25.00 | 9 | 44 |
| 2014 | | | | | | | | | |
| Basonaworana | 2830-3120 | 75.00 | 46.67 | 44.44 | 12.50 | 100.00 | 40.00 | 8 | 40 |
| Tarmaber | 2635-3160 | 77.77 | 38.57 | 64.28 | 55.55 | 76.00 | 70.00 | 9 | 43 |
| Angolela Tara | 2760-2860 | 100.00 | 80.00 | 60.00 | 50.00 | 33.33 | 44.44 | 6 | 30 |
| Ankober | 2620-3040 | 28.57 | 40.00 | 40.00 | 57.14 | 60.00 | 66.67 | 7 | 35 |
| Hagere Mariam | 2640-2920 | 88.88 | 40.00 | 37.50 | 44.44 | 35.00 | 20.00 | 9 | 43 |
| Menz Gera | 2920-3085 | 55.55 | 40.00 | 55.00 | 33.33 | 46.66 | 44.44 | 9 | 41 |
| Menz Mama | 2760-3190 | 66.67 | 36.67 | 50.00 | 22.22 | 60.00 | 25.00 | 9 | 44 |

**Table 5:** Incidence and severity of apple scab and powdery mildew on apple at the surveyed districts of North Shewa zone, 2013 and 2014.

| 2013 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| District | Altitude | Apple aphid | | | Beetles | | | Surveyed Fields | Sample Size |
| | | Prev. (%) | Inc. (%) | Sev. (%) | Prev. (%) | Inc. (%) | Sev. (%) | | |
| Basonaworana | 2830-3120 | _ | _ | _ | 12.50 | 80.00 | 20.00 | 8 | 40 |
| Tarmaber | 2635-3160 | 33.30 | 21.00 | 53.33 | _ | _ | _ | 9 | 43 |
| Angolela Tara | 2760-2860 | 33.30 | 30.00 | 50.00 | _ | _ | _ | 6 | 30 |
| Ankober | 2620-3040 | 14.28 | 20.00 | 40.00 | _ | _ | _ | 7 | 35 |
| Hagere Mariam | 2640-2920 | 55.50 | 26.00 | 55.00 | _ | _ | _ | 9 | 43 |
| Menz Gera | 2920-3085 | 22.20 | 25.00 | 60.00 | 11.10 | 20.00 | 60.00 | 9 | 41 |
| Menz Mama | 2760-3190 | _ | _ | _ | _ | _ | _ | 9 | 44 |
| 2014 | | | | | | | | | |
| Basonaworana | 2830-3120 | _ | _ | _ | 66.60 | 20.00 | 40.00 | 8 | 40 |
| Tarmaber | 2635-3160 | 11.10 | 20.00 | 20.00 | 40.00 | 20.00 | 70.00 | 9 | 43 |
| Angolela Tara | 2760-2860 | 33.33 | 20.00 | 20.00 | _ | _ | _ | 6 | 30 |
| Ankober | 2620-3040 | 14.28 | 20.00 | 20.00 | _ | _ | _ | 7 | 35 |
| Hagere Mariam | 2640-2920 | 44.44 | 25.00 | 58.33 | 33.33 | 31.25 | 20.00 | 9 | 43 |
| Menz Gera | 2920-3085 | _ | _ | _ | 40.00 | 33.33 | 44.44 | 9 | 41 |
| Menz Mama | 2760-3190 | 11.11 | 20.00 | 20.00 | 60.00 | 40.00 | 25.00 | 9 | 44 |

**Table 6:** Incidence and severity of apple aphid and beetles on apple at the surveyed districts of North Shewa zone, 2013 and 2014.

(Government owned nursery, kebele 07) districts. However, because of our suggestion to the nursery owners at Hagre M. to uproot and burn infected seedlings, it had not been detected in the coming season. Spider mite was observed in the first season, whereas sting bug was observed in the second season. Moreover, the recorded occurrence and severity of apple aphid in 2013 was down notably in 2014.

Apple scab and powdery mildew were the most damaging diseases to cause noticeable reduction in yield and quality of apple production in North Shewa zone. In 2013, the distributions of both diseases were higher at Ankober district, whereas in 2014, it was greater at Angolela Tera and Tarmaber areas (Table 5). In 2013, the damage level of apple scab was higher at Menz Gera and Menz Mama, while it was relatively lower at Basona worana, Ankober and Hagere Mariam districts. On the other hand, apple trees were more prone to Powdery mildew at Tarmaber and Ankober districts, but less susceptible in Menz Mama area. In 2014, Apple scab was more severe at Tarmaber and Menz Gera, and like 2013, it was less severe at Hagere Mariam and Ankober districts. Comparable to the previous season, apple trees were highly diseased by Powdery mildew at Ankober and Tarmaber districts. Mostly, except for the previously mentioned discrepancies, the distribution and infestation level of these major diseases of apple were roughly analogous seasonally between districts. Virtually, in all the surveyed fields, the agronomic and tree structure management practices were exceptionally poor; consequently, the effects of these diseases were often confounded with the effect of the poor management practice.

In 2013, apple aphid was recorded at five districts; however, beetles were only seen in two localities. Aphids were more widely spread in Hagere Mariam, but their distribution was smaller at Ankober. The extent of occurrence of beetles was almost identical between the two districts. Less variation was seen in the severity of apple aphid (40% - 60%) between districts, whereas for beetles, it was 60% at Menz Gera and 20% at Bassonaworana. In 2014, corresponding to the previous season, the prevalence of apple aphids was higher at Hegere Mariam (44.44%) and smaller at Menz Mama (11.11%). The presence of beetles was between 33.33%-66.60% and the level of damage was remarkably higher at Tarmaber (70%) and rather lower at Hagere Mariam (20%). Overall, except the surge in area coverage of beetles in 2014 compared to the previous season, and the lower severity of apple aphids in 2014, the seasonal trend was similar (Table 6)

As the result displays, apple scab and powdery mildew were the most extensively distributed diseases in North Shewa and wherever apple is

| Location | Altitude (m.a.s.l) | Type of Disease and Insect pests | Prevalence *(%)* | Incidence *(%)* | Severity *(%)* | Surveyed Fields | Sample Size |
|---|---|---|---|---|---|---|---|
| North Shewa | 2600-3000 | Apple scab | 74.19 | 53.63 | 44.92 | 31 | 151 |
| | | Powdery mildew | 48.39 | 45.67 | 51.11 | 31 | 151 |
| | | Canker | 6.45 | 33.10 | 20.00 | 31 | 151 |
| | | Apple aphid | 25.80 | 22.50 | 35.71 | 31 | 151 |
| | | Beetles | 32.25 | 45.71 | 35.41 | 31 | 151 |
| | | Sting bug | 3.22 | 60.00 | 20.00 | 31 | 151 |
| | | Mean | 31.72 | 43.43 | 34.52 | - | - |
| | >3000 | Apple scab | 65.38 | 37.95 | 55.42 | 26 | 118 |
| | | Powdery Mildew | 29.92 | 71.85 | 37.61 | 26 | 118 |
| | | Canker | 19.23 | 28.00 | 32.22 | 26 | 118 |
| | | Apple aphid | 3.85 | 20.00 | 19.61 | 26 | 118 |
| | | Beetles | 7.69 | 50.20 | 22.42 | 26 | 118 |
| | | Spider mite | 3.84 | 20.00 | 20.00 | 26 | 118 |
| | | Woolly Aphid | 3.84 | 20.00 | 75.00 | 26 | 118 |
| | | Mean | 19.11 | 35.43 | 37.47 | - | - |

**Table 7:** Average prevalence, incidence, and severity on altitudinal variations of diseases and insect pests on apple at the surveyed districts of North Shewa 2014.

| **2013** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **Altitude** (m.a.s.l) | **Type of Disease and Insect Pests** | **Prevalence (%)** | **Incidence (%)** | **Severity (%)** | **Surveyed Fields** | **Sample Size** |
| North Shewa | 2620-3190 | Leaf Rust | 36.40 | 80.00 | 70.00 | 11 | 52 |
| | | Beetles | 9.09 | 28.84 | 20.00 | 11 | 52 |
| | | Mean | 22.74 | 54.42 | 45.00 | - | - |
| **2014** | | | | | | | |
| - | | Leaf Rust | 60.00 | 66.67 | 48.88 | 15 | 69 |
| | | Beetles | 13.33 | 62.50 | 30.00 | 15 | 69 |
| | | Apion | 4.34 | 60.00 | 20.00 | 15 | 69 |
| | | Mean | 25.89 | 63.06 | 32.96 | - | - |

**Table 8:** Average prevalence, incidence and severity of diseases and insect pests at the surveyed districts of North Shewa, 2013 and 2014.

grown, these diseases are reported as persistent problems [10,11]. The occurrence and severity of these bothersome diseases were somewhat greater in 2014 than the previous season and this might have been because of the mid-season rainfall in 2014 [12,13]. These diseases become severe during years with recurrent spring rain, mainly because spores can easily get carried away by the splashing rain to other leaves and fruits where new infections occur. Furthermore, higher relative humidity, 60%-70% and >70% for apple scab and powdery mildew respectively are required for conidia germination and spore production [14].

Amongst insect pests, apple aphid (*aphis pomi*) and beetles (*Altica foliaceae* and *Nemognatha scutellaris*) were the most common insect pests of apple. Parallel to the finding by Milenković et al. [15], throughout the assessed fields, apple aphid was severe on nursery seedlings and young plantations as succulent plant parts are more appealing to sucking insects. Moreover, aphid pressure was lessened in 2014 compared to the previous season. As Flint [16] conveyed, attributable to the spring rain in 2014, aphid populations and their honeydew on sturdy plants might have been washed off. Although their number was not as optimal as used in biological aphid control tactics, ladybird beetles (*Hippodamia convergens*) were also spotted in most aphid-infested fields. In both seasons and all locations, the two-beetle species observed in apple and plum appeared to coexist. Research stating the co-occurrences of the specified beetle types on apple and plum cannot be found. Nevertheless, in other plant species, the coexistence of two or more beetle species on a single host plant species is evident. For example, Harmonious coexistence of hispine beetles on Heliconia [17], *G. calmariensis* and *G. pusilla* on purple loosestrife (*Lythrumsalicaria*) [18] and seven closely related leaf beetle species (Chrysomelidae:Cassidinae) on a common host plant system (fam. Convovulaceae) [19]. Because we did not anticipate such type of complex interspecific coexistence beforehand, our research failed to unequivocally show their co-occurrence mode. Though, as many models suggested, the two species might have shared the same host by means of either resource partitioning in time or space [20] or spatial segregation [21].

The variation in distribution, incidence, and severity across altitudinal ranges between the two consecutive surveying seasons was identical. Therefore, to show the disparity in distribution, incidence, and severity of diseases and insect pests of apple in North Shewa regarding the altitudinal difference, the second season data is displayed (Table 7).

Apple scab, PM, canker, apple aphid, and beetles appeared in both elevation ranges. Whereas, sting bug was observed with elevation range 2500-3000 m.a.s.l, and spider mites and woolly aphids were observed on elevations >3000 m.a.s.l. The pest builds up was relatively higher at lower altitudes with a mean occurrence of 31.72% and an incidence of 43.43%, compared to 19.11% and 35.43% in higher altitudes respectively. Nevertheless, the damage inflicted was advanced in higher altitudes than lower altitudes. For instance, the distributions of both apple scab and powdery mildew were higher at lower altitudes with comparable incidence and severity. Likewise, the two most important insect pests of apple: apple aphid and beetles were more prevalent in lower altitudes with more destructive ability (Table 7).

The possible scenarios for relatively higher pest build up in the lower elevations might have been because of the favorable conditions for pest infestation i.e. temperature and relative humidity. For example, like most of foliar fungal pathogens, apple scab and powdery mildew need high humidity (>60%) and temperature (10°C-25°C) for spores to cause infection [14,22]. In North Shewa condition, for the most part of the year, these requirements can be achieved within the specified lower altitudinal ranges as higher elevations tend to get cooler and drier.

Nevertheless, the overall severity on higher elevations appeared to be slightly advanced as this might have been because of the confounding of frost injury with pest damage symptoms.

Next to apple, plums and peaches are important temperate fruits in North Shewa. Although the sampling was not as extensive as apples, we have tried to assess their associated pests. On plum, in 2013, leaf rust and beetles were observed (Table 8), while in 2014, besides leaf rust and beetles, apion was documented. The distribution of leaf rust in the second season (60%) was higher than the first season (36.4%). However, the reverse was true for incidence and severity. In both seasons, leaf rust was the major concern on peach.

As evidently revealed by our result, leaf rust was the major disease of the existing stone fruits (plum and peach) in North Shewa. Leaf rust has a considerable economic importance in many parts of the world whenever stone fruits are grown [23,24]. Most importantly, with similar varieties as our survey areas, it is reported to be the major disease in low-chill subtropical peaches in Florida [25] and plums grown in Turkey [26]. Furthermore, corresponding to our observation, it was found to infect leaves but also twigs and fruits [27,28]. In 2014, though the incidence and severity decreased, the occurrence of leaf rust increased on plums. The surge in distribution might have been because of the spring rainfall in 2014, as humid air favors the pathogen [29]. Besides, because of the absence of pruning in almost all the assessed fields, as the age of trees increases, the canopy might have been congested to create a suitable humid microclimate for new infections. As discussed earlier, the case of beetles on plum was like apple, and although it was reported to infest mung bean in North Shewa (unpublished report), Apion as a pest of plum could not be supplemented by previous research.

## Conclusion and Recommendations

The highland climate of North Shewa can mimic the temperate environment for the successful production of temperate fruits; therefore, temperate fruits have a major significance to improve the livelihoods highland communities. Still, apart from pest management, a lot must be done to get there. Low chill apple varieties are the predominantly grown temperate fruits in North Shewa. Regarding pests of temperate fruits in the zone, apple scab and powdery mildew are the major diseases of apple with higher occurrence rate and damage level. Leaf rust is the main disease of plum and peach. Although not serious as scab and PM, insect pests: green apple aphids, beetles, woolly aphid, spider mites and sting bugs are also observed to damage plantations.

Generally, to realize the preeminent outcome out of temperate fruit production, a lot of things must be right, not merely in pest management but also on agronomic and tree management practices. At first, because of the newness of the crop, extensive training should be given to agricultural experts, development agents and growers. Moreover, the climatic requirement (i.e. chill unit) of temperate fruit varieties must be known before dissemination, archiving distributed varieties is also enormously important considering future marketing, and these orchards are learning fields for researchers, agricultural experts, and growers. Regarding pests of temperate fruits in the zone, planting materials should be acquired from genuine source with proper quarantine. For instance, woolly aphid had not been carried into the zone if importing agents were well-read about the existence of the pest in and around Awi zone and rigorous quarantine had been thru. Growers and experts should also be trained about the prevailing pests, their dispersal means, and possible management options. Moreover, agricultural bureaus should comprise temperate fruit pest management in their production package, and research centers must strengthen their research work on the different aspects of these pests.

### Acknowledgment

We thank Amhara agricultural research institute (ARARI) for providing the fund and the respective agricultural offices, their attentive experts and diligent development agents for their special assistance in identifying approachable temperate fruit growing areas and fields. This work wouldn't also be successful without the hospitality and insightfulness of small-scale temperate fruit tree owners.

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