academicJournals

Vol. 12(13), pp. 312-320, 7 April, 2018
DOI: 10.5897/AJMR2017.8780
Article Number: 5A4B9B756697
ISSN 1996-0808

http://www.academicjournals.org/AJMR

African Journal of Microbiology Research

Full Length Research Paper

Identification of insect and disease associated to citrus in Northern Ethiopia

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Received 8 December, 2017; Accepted 28 February, 2018

The survey was carried out in 2016 in the production of citrus fruits at Adiha and Sheka Tekli irrigation schemes of Kolla Tembien and Tanqua Abergelle districts, to assess the type of diseases, the causes and the characteristic symptoms of the diseases and to identify the types of insect pests that inflict serious damage. The laboratory analysis result depicted that bacteria and fungi caused most of the diseases of citrus at Adiha and Sheka Tekli irrigation schemes. Exceptionally cyst nematode and climbing weed were problems in production of citrus at the irrigation schemes. Diseases like citrus melanose, brown rot, root rot, blue mold, sooty mold, leaf spot and fruit spot were among the fungal diseases identified at the irrigation schemes. Moreover, citrus greening, and citrus canker were also some of the bacterial diseases of citrus at Adiha and Sheka Tekli irrigation schemes. Conversely, the type of insect pest that predominantly constrained the production of citrus in both areas were woolly whitefly, citrus mealybugs, orange dogs, cottony cushion scale insects, brown scale insect, citrus leafminer, citrus psyllid, fruit fly, adult flatid planthoppers, citrus aphid, red scale and root weevil respectively. Most of these insect pests belong to the Hemipteran order followed by lepidopteron insect group. Milk vine had also been observed as one of the weeds that pose serious problems to some of the citrus trees at Adiha and Sheka Tekli irrigation schemes. Therefore, further research intervention should focus on management of these insect and disease pests at Adiha and Sheka Tekli irrigation schemes.

Key words: Citrus disease, insect pest, symptoms and identification.

INTRODUCTION

Crop intensification is one of the strategies to increase productivity per unit area of land. Small-scale irrigation has been chosen as a strategic intervention to address food security in Ethiopia. This is because irrigation increases the potential for producing more food consistently in the drought-prone areas. Horticultural crops play a significant role in a developing country like Ethiopia, both in improving income and social spheres for the fulfilment of human nutrition. In addition, they help in maintaining ecological balance since they are so diverse. Furthermore, the sector provides employment opportunities for their management being too intensive to

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labour and the sector is encouraging where countries having abundant labour and scarce capital like Ethiopia.

Citrus (*Citrus* spp.) constitutes the major group of fruits including oranges, grapefruits, trifoliate orange, mandarins, pummelo, citranges and lemon. It serves as the main source of vitamins, minerals elements and sugar; hence, it controls the building process of human bodies (Oviasogie et al., 2015). The crop has been produced widely in the tropical and subtropical regions of the world, in over 137 countries and generates around 105 billion US dollar per year (FAO, 2016). Based on FAO report, China, United States, Brazil, Italy and Mexico are the main producers of citrus that represent two–thirds of the global production. In Africa, Egypt, South Africa, Morocco, Algeria and Tunisia are the leading producers of Citrus. Ethiopia has a huge potential in the production of many types of fruits including citrus. Despite the exact time of citrus introduction to Ethiopia is not known, the start of its cultivation dates back to the early of 14 centuries by the monasteries of Gund Gundo (Northern Ethiopia). Later it has been cultivated in upper Awash valley and Melkassa in central Ethiopia. Currently, it is widely cultivated around Dire Dawa, lower and middle Awash and Melkassa areas in the southeast region of Ethiopia (Mekonen et al., 2015). According to the report of Kedebe (2015), about 61,472.74 ha of land were cultivated with a different type of fruits annually. Among the fruits, citrus is the leading fruit crops grown by many small-scale and commercial farmers (CSA, 2012). Hence, the annual production and productivity of citrus have estimated 5,947 ha and 77,087 tons, respectively (Dagnew et al., 2014). Based on the report of Mekonen et al. (2015), citrus occupied about 7290 ha of land in 1985, but later the coverage has reduced to 5380 ha with a production of 33500 metric tons.

Most parts of Tigray region have suitable agroecology for production of citrus. Recently the regional government has given prior attention for the expansion of small-scale irrigation to increase the production of vegetables and fruit crop. Thus, the regional Bureau of Agriculture and rural development and other Non-Governmental Organizations have introduced planting materials from across the corners of the country to different parts of the region including Kola Tembien and Tanqua Abergelle districts for the last few years. According to the Ethiopian Central Statistics Agency (CSA, 2012) report, the regional (Tigray) productivity and area coverage of citrus in 2001/2002 cropping season was not more than 1930 quintals and 48.2 ha respectively. However, the latest report indicated that the total area coverage and annual production of citrus in the region have been increased to 5,947 ha and 77,087 tons, respectively (CSA, 2013). The area under citrus cultivation in the region has increased by 99% within the last eight years. Among the fruits, citrus is widely cultivated crop both at Adiha and Sheka Tekli irrigation schemes. Over 163.75 ha of land has been planted with citrus at Adiha and Sheka Tekli irrigation schemes. Despite its increase in acreage and production of citrus, the productivity still remains low (15 to 30 ton ha^{-1}) compared to the productivity of citrus in Brazil and USA (50 to 100 tone ha^{-1}) (FAO, 2014).

The decline in productivity of citrus has been attributed to several biotic and abiotic factors. Among the factors, many types of fungal, bacterial, viral, nematode, insect pests and less likely binding weeds seriously threaten the production and productivity of citrus. In Ethiopia, many bacterial and fungal diseases; mainly citrus canker, citrus greening, gummosis, anthracnose, Phaeoramularia leaf and fruit spot, melanose, blue and green mold of citrus fruits were recorded in many citrus farms of Awara Melka, Melka Werer, Merti Jeju, Aleta Wendo, Dale and Bebeka (Derso and Sijam, 2007; Yesuf, 2013). The specific cause of citrus greening named *Candidatus* Liberibacter Africanus subsp. clausenae and the vector (citrus psyllid) of the disease were identified in Ethiopia in 2016. Hence, the presence of the disease and the natural vector can lead to rapid spread of the diseases to many parts of Ethiopia (Agricultural Research Council-Plant Health Protection (ARC-PHP), 2017). Based on the reports of Mekbib et al. (2006), fruit pests inflict up to 80% of yield reduction in citrus fruits around Arbaminch. The yield loss of citrus varies among pests, as yield reduction due to *Pseudocercospora angolensis,* for instance*,* ranges from 50-100% (Yesuf, 2013). Another disease like gummosis also causes a yield loss of 10 to 30% throughout the world. The damage of gummosis increased with the use of susceptible rootstocks and application of excessive irrigation water (Al-Sadi et al., 2014). Among the citrus, sweet orange is susceptible to postharvest diseases, in which, the extent of damage range from 25.5 to 43.8% (Oviasogie et al., 2015). Similarly, citrus nematode cause damage to over 50 species of citrus that belongs to the Rutaceae family. Based on the reports of Irshad et al. (2012), nematode can cause up to 43.3% of yield loss in citrus.

The type of insect pests like Red scale, leaf miner, Orange dog, Mediterranean fruit fly, woolly whitefly, false codling moth, thrips, aphids and Bud mites have been identified so far as the main pests of citrus in many fruit growing parts of Ethiopia (Yosef et al., 2014). Among the insects, woolly whiteflies are the newly introduced alien invasive pests of citrus across many parts of Ethiopia. The pest sucks the saps of phloem, causing the leaf to wilt and drop when the population of the insect starts increasing. The droplets of the insects collect dust and provide a favourable environment for the growth of sooty mold (Getu, 2007).

Disease and insect pests are the main constraints to production of citrus trees at Adiha and Sheka Tekli irrigation schemes. Knowledge of the type of disease and insect pests is essential for appropriate monitoring leading to a devising of effective management strategies. However, the available information on the type of diseases, insect pests and weeds pose serious threats to

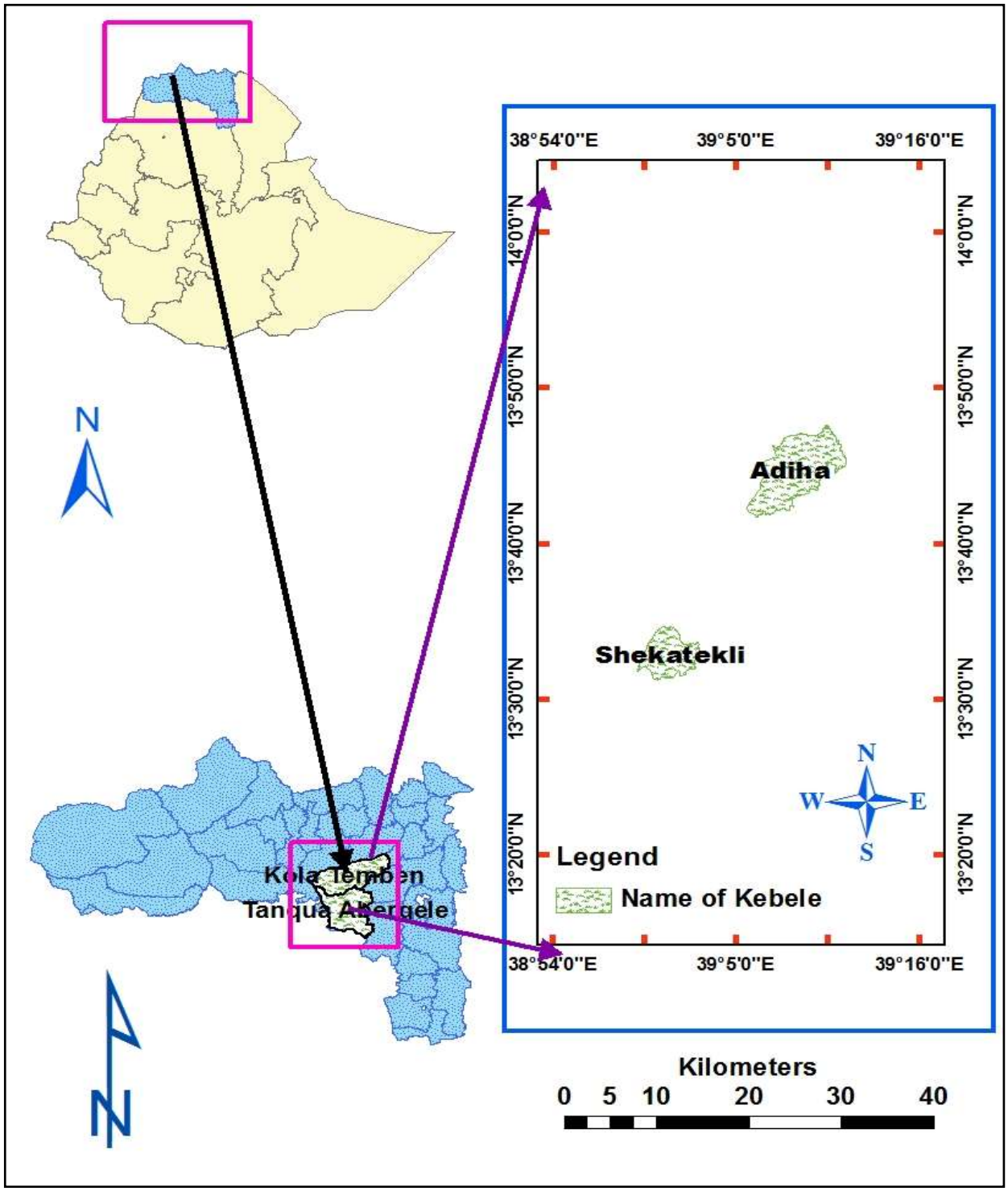

Figure 1. Map showing location of study sites.

production of citrus in the irrigation schemes as very limited. Therefore, field assessment was carried out to identify the main type of diseases, the causes and the characteristic symptoms of the diseases and to identify the types of insect pests that inflict serious damage in the irrigation schemes.

MATERIALS AND METHODS

Description of the study sites

The survey was carried out in Kola-Tembien and Tanqua Abergelle districts at Adiha and Sheka Tekli irrigation schemes (Figure 1). The study sites are located 35 km and 36 km away from Abyi-Addi and

Yechila administrative unit of Kolla Tembien and Tanqua Abergelle districts respectively. Adiha irrigation scheme is situated at an altitude of 1600-1750 m.a.s.l., whereas, Sheka Tekli irrigation scheme it is located at an elevation below 1500 m.a.s.l and the soil texture that dominantly comprises 58% sand soil and 42% silt loam soil types in both irrigation schemes. The mean annual rainfall and temperature range from 500-800 mm and 25 - 30°C respectively (Data of the Woreda's OoARD, 1998). Citrus is the main fruit that is widely grown in both locations since they have favourable environmental conditions and the presence of a year-round source of irrigation water.

Survey and sampling techniques

The survey was conducted in May 2016 at Adiha and Sheka Tekli irrigation schemes where citrus is widely planted in irrigation fields. Systematic sampling technique was employed to determine sampling fields. Hence, 10 orange-planted fields were assessed from each location. Thereafter, the diseased and insect-infested specimen was collected from the leaf, fruit and shoot part of the standing plant. Most insect pests were determined visually during the execution of the survey. Whereas those diseased plant specimens (including fruits, leaves and roots) that could not easily be distinguished on the field were collected, tagged and sent to plant protection laboratory in Ambo.

Sampling and handling technique

Plant parts with clear disease symptoms were selected from each sampled citrus tree. The specimens were collected using sterilized scatter and finally packed in transparent plastic bags. Eventually, each plastic bag was enveloped in brown paper bags and necessary information about the specimen written on it. Finally, specimens were placed in the icebox to prevent desiccation from sun and air currents and were thus sent to Ambo Plant Protection Center for further isolation and identification of the type and causal agents of the diseases.

Isolation and Identification of fungal pathogen

Diseased leaf and fruit samples were cut into larger pieces followed by washing with distilled water. Finally, they were surface sterilized using 70% ethanol followed by 5% Clorox for a minute and rinsed in distilled water three times. Sterilized leaves or fruit peels were cut into four discs or pieces and placed in Petri dishes containing potato dextrose agar (PDA) in five replicates and incubated at 25±1°C. Cultures were purified using hyphal tipping onto fresh PDA medium and were incubated for four to seven days at 25±1°C. The fungal isolates were identified by analyzing cultural and morphological features through examination of the growth pattern of colonies, morphological structure of conidia, development of fungal growth structures, pigmentation of the colonies, shape of the hyphal growth and mycelia (Thiyam and Sharma, 2013). The identification was carried out by placing a small portion of the aerial Mycelia from each culture on a clean slide with the help of mounting needle. The mycelium was properly spread on the slide using a needle. A coverslip was carefully placed and pressed gently over the spread to prevent the formation of air bubbles. Finally, the slide was then mounted and examined with help of a microscope. The morphological characteristics and features of the fungal organisms were examined and identified in accordance with Onuorah (2015).

Isolation, purification and identification of bacterial pathogens

Bacterial isolation, purification and identification were the first steps for plant bacteriological studies. The isolation of bacterial pathogens was done to obtain pure bacterial cultures, in which it was essential in the identification of the pathogens through analyzing the morphology, physiology and biochemical characteristics of a particular bacterial strain. The isolation of pure bacterial culture was carried out by taking pieces of leaf and fruit from sampled specimens. The pieces were washed and surface sterilized with distilled water, 70% alcohol and sodium hypochlorite respectively. Thereafter, the pieces were chopped into pieces using mortar and pistol until bacterial agents adequately released into the suspension. Finally, pure cultures were found by taking a loop of suspension and streak into general and differential media. The differential media was used for specific suspected bacterial pathogens. Eventually, the cultures were incubated for four to five days within the incubator under the specific requirement. The cultures were examined starting from 20 h of incubation for any signs of bacterial growth, color and shape of the colonies. Finally, a piece of culture was taken and examined using a binocular microscope. Therefore, the identification was accomplished by performing the morphological, physiological and biochemical tests and the results were compared to established identification schemes.

Nematode extraction and identification

A soil sample was taken from 30 cm of rooting depth of citrus and finally, one kilogram of soil sample together with some roots citrus was sampled and immediately sent to Ambo Plant Protection Research Center before soil loss its moisture. Eventually, 200 ml of soil was taken from the sample to extract nematode using Baermann technique. Nematodes were extracted after 24 h on aperture stainless steel sieve. Species identification was conducted after the transfer of female nematodes into anhydrous glycerol on permanent slide mounts following the method described by Hooper et al. (2005). Finally, the specimens were examined using compound microscope equipped with differential interference contrast at 630-1000x magnification. Finally, the presence and identification of the type of nematode was made following the image of scanned picture using DC 180 camera.

RESULTS AND DISCUSSION

Main diseases of citrus fruits at Adiha and Sheka Tekli irrigation scheme

Citrus greening

Citrus greening is an obligate bacterial disease that was serious in many citrus plantings at Adiha and Sheka Tekli irrigation schemes. Based on the biochemical characterization of the disease, the cause of the disease has been recognized as *Candidatus africanum.* The African citrus psyllid (*Trioza ertreae*) is common minor insect pest and transmits huanglongbing, also called citrus greening while feeding on the saps of the phloem. The psyllid was also another pest of citrus at Adiha and Sheka Tekli irrigation schemes. Hence, the disease could be transmitted from infected trees to a healthy one with the help of the vector so-called citrus Psyllid. According to the report of Agricultural Research Council-Plant Health Protection (ARC-PHP, 2017), the specific cause of the disease and its vector (citrus psyllid) were identified in

Figure 2. The image of citrus attacked by fungal, bacterial and vine weed at Adiha and Sheka Tekli irrigation scheme.

Ethiopia in 2016. Hence, the presence of the disease and the natural vector may lead to rapid spread of the diseases to many parts of Ethiopia including Adiha and Sheka Tekli citrus orchards. Citrus leaves infected with citrus greening showed a characteristic symptom of blotchy mottled and yellowing discolorations (Figure 2). In addition, the leaves were found to be narrowly structured and they did have a bunchy appearance. Severely infested citrus trees at Adiha and Sheka Tekli irrigation schemes ultimately remained as leafless twigs and dieback.

Citrus canker

The laboratory analysis result indicated that citrus canker was caused by *Xanthomonas citri* pv. citri. The disease resulted in premature leaf and fruit drop, twig dieback, eventual decline, and blemished citrus at both Adiha and Sheka Tekli irrigations schemes. The symptom of the disease was actually starting as tiny blister-like lesions and finally, it appeared as distinct necrotic lesions with a raised corky appearance that often had a yellow halo. The diseased portion appeared scabby or corky. Citrus infested with canker had got dark brown to black raised lesions. Based on the survey conducted in 2008, the disease was recorded in many parts of the rift valley located at an altitude below 1300 m and it was confirmed to affect many citrus species across the rift valley of Ethiopia (Derso, 2009). He also mentions that several strains of canker have been proven to have wide host range of citrus. He confirmed that the Ethiopian strain of canker has had wide geographical distribution across many citrus growing African Regions. The planting materials of citrus had been introduced to Adiha and Sheka Tekli kebeles from major citrus growing parts of Ethiopia mostly from Gunda Gundo, lower and upper awash citrus farms. Therefore, the diseases may be introduced to these irrigation schemes associated with the planting materials.

Citrus melanose

Melanose disease affected young leaves and fruits of certain citrus at Adiha and Sheka Tekli irrigation schemes.

When rain and humid weather extend to certain period, the tissues expand and show variegated symptoms like small spots or scab-like lesions to patterns of damage referred to as teardrop, mud cake, and star melanose (Figure 2). That was one of the common diseases of citrus fruits at Adiha and Sheka Tekli farms. Examination of the spores of the fungus indicated that *Diaporthe citri* is the cause of the disease. It can create severe fruit rind blemishes, but the fungus does not normally affect the pulp. On leaves, the small, black, raised lesions are often surrounded by yellow halos and can cause leaf distortion. Based on the reports of Scot (2008), the disease spreads to nearby healthy citrus fruits through rain or overhead irrigation splash water. He also mentioned the ascospores of the fungus mainly dispersed to distant citrus fruits by wind currents. However, in all cases, the infection is caused by the conidia of the fungus. Similarly, the disease was recorded in many citrus farms of Ethiopia including Awara Melka, Melka Werer, Merti Jeju, Aleta Wendo, Dale, and Bebeka (Derso and Sijam, 2007).

Gummosis

The disease is caused by *Phytophthora citrophthora* and that was a well-known gumming disease of citrus at Adiha and Sheka Tekli irrigations schemes. It was characterized based on the formation of Gum on the trunk or branches. Tree with gummosis formed longitudinal cracking of bark, accompanied by brown gumming from the lesions. While the affected barks were removed from the base of the trunk, water soaked, reddish-brown, or in late stages black slimy appearance was revealed. Diseased bark would remove easily in recently affected citrus woods. Later, the trees collapse and die due to the girdling of the bark by the pathogen. Based on the report of Al-Sadi et al. (2014), severe infestation and the damage of gummosis to citrus occurred while farmers use susceptible rootstocks and during application of excessive irrigation water. Besides additional factors like freeze damage, high water table and salt accumulation also contribute to the development of the disease. Gummosis develops rapidly when moist, cool conditions prevail at both Adiha and Sheka Tekli irrigation schemes. However, there was seen slow spread and development of the diseases when hot summer weather appeared. Such conditions play an essential role in healing and drying of mechanical wounds.

Nematode

The root and soil sample examined in plant protection laboratory indicated that some numbers of citrus grown at Adiha and Sheka Tekli irrigation schemes were infested with nematode. The type of nematode identified in both schemes was known as *Tylenchulus semipenetrans* and it was widely observed as parasitic nematode of citrus at both Adiha and Sheka Tekli irrigation schemes. The report of Irshad et al. (2012) indicated that citrus nematode inflicts damage to over 50 species of citrus across the world. He also added that the yield loss of citrus due to nematode was estimated to be 43.3% on average. According to the reports of Inserra et al. (2003), most citrus species are preferred host of nematode.

Sooty mold

Sooty mold damage was often observed in most plantations of Adiha and Sheka Tekli citrus fruits. It appeared as black discolouration on portions of the fruit and leaves following the massive infestation of woolly whiteflies. The sooty mold was a black thin mat of fungal growth usually observed on the upper leaf surfaces and fruit. It was grown following the excretion of sugary dew (honeydew) of sap sacking whiteflies, scale insects, aphids, psyllids, and mealy bugs. The current result is in line with the finding of Getu (2007), who stated that the droplets of some sap-sucking insects inflict the collection of specks of dust, which in turn provides an optimum condition for the growth of sooty mold. When the fungus becomes abundant, the mold could reduce photosynthesis and delay fruit colouring. Sooty mold represents a dramatic sign that insect population has reached damaging levels.

Blue mold

Blue mold was caused by *Penicillium italicum* Wehmer (most important on citrus). It was widely observed as postharvest diseases of citrus fruits at Adiha and Sheka Tekli irrigation schemes (Table 1). Initially, it appeared as a soft, water socked and slightly discolored spot and later enlarges in diameter within a few days when the daytime temperature increases. White mycelium then appeared on the surface of the fruit, and when the fungi grow blue colored spores were produced. Within a few days after the appearance of the diseases, the entire fruit surface was covered with blue colored spores. The spores do spread easily while fruits expose to wind. The laboratory analysis result was in accord with the findings of Oviasogie et al. (2015), who stated that blue molds were common airborne diseases that occur during post-harvest handling or storage of citrus fruits. The infestation of the diseases started at field and proceeds during packaging.

Main insect pests of citrus at Adiha and Sheka Tekli irrigation schemes

The result of the survey indicated that a considerable number of insect pest's constraint the production and productivity of citrus at Adiha and Sheka Tekli irrigation schemes. Most of these insects belong to the order

Table 1. Diseases that attack orange at Adiha and Sheka Tekli Irrigation scheme.

Common name	Order	Family	Causative agent
Citrus Greening	Rhizobiales	Rhizobiaceae	*Candidatus africanum*
Citrus Canker	Xanthomonadales	Xanthomonadaceae	*Xanthomonas citri* pv. citri
Orange Scab	Myriangiales	Elsinoaceae	*Elsinoe fawcettii*
Blue mold	Eurotiales	Trichocomaceae	*Penicillium italicum*
Gummosis	Pythiales	Pythiaceae	*Phytophthora citrophthora*
Sooty mold	Capnodiales	Davidiellaceae	*Cladosporium herbarium*
Black mold	Eurotiales	Trichocomaceae	*Aspergillus niger*
Nematode	Tylenchida	Tylenchulidae	*Tylenchulus semipenetrans*

Table 2. List of insect pests that attack orange at Adiha and Sheka Tekli irrigation scheme.

Common name	Order	Family	Causative agent
Wooly whitefly	Hemiptera	Aleyrodidae	*Aleurothrixus floccosus*
Citrus Mealybugs	Hemiptera	Pseudococcidae	*Planococcus citri*
Orange dogs	lepidoptera	Papilionidae	*Papilio demodocus*
Cottony cushion scale	Hemiptera	Margarodidae	*Icerya purchasi*
Brown scale	Hemiptera	Coccidae	*Coccus hesperidum*(L.)
Citrus Leaf minor	Lepidoptera	Gracillariidae	*Phyllocnistis citrella*
Citrus psyllid	Homoptera	Psyllidae	*Trioza erytreae*
Fruit fly	Diptera	Tephritidae	*Bacterocera spp*
Adult flatid planthoppers	Hemiptera	Flatidae	*Metcalfa pruinosa*
Citrus Aphid	Hemiptera	Aphididae	Toxoptera citricida
Root weevil	Coleoptera	Curculionidae	*Diaprepes abbreviatus*

Hemiptera followed by the lepidopteran insect pests. As depicted in the Table 2, woolly whitefly, citrus Mealybugs, Orange dogs, Cottony cushion scale, Brown scale insect, Citrus psyllid, Fruit fly, Adult flatid planthoppers, Citrus Aphid and Root weevil had been identified as the main pests of citrus at Adiha and Sheka Tekli irrigation schemes. Based on the reports of Yosef et al. (2014), many insect pests mainly Red scale insect, leaf miner, Orange dog, Mediterranean fruit fly, woolly whitefly, false codling moth, thrips, aphids and Bud mites were serious constraints of citrus across many parts of the nation. Insect pests like woolly whiteflies are the newly introduced alien invasive pests of citrus across many parts of Ethiopia. The pest sucks the saps of phloem, causing the leaf to wilt and drop when the population of the insect increases (Getu, 2007). Some insects like Adult flatid planthoppers and Root weevil were first recognized as pests of citrus at Adiha and Sheka Tekli irrigation schemes (Figure 3).

Relative occurrence of insect pests on citrus fruits

The relative occurrence of insect pests in citrus was classified according to the order of each insect that it belongs to. The result of the survey indicated that the Hemipteran insect pests were observed most frequently in many citrus plants of Adiha and Sheka Tekli irrigation schemes (Figure 4). The lepidopteran insect pests were also another threat to the production of citrus at Adiha and Sheka Tekli irrigation schemes following Hemipteran. However, the Homopteran, Dipteran and Coleopteran insect pests were less prevalent compared to the Hemipteran and lepidopteran insects.

Weed infestation

Apart from the insect and disease pests, there had been milkweed vine that had seriously threatened citrus trees at Adiha and Sheka Tekli irrigation schemes. Milkweed vine was the only weed that competes with citrus for water, nutrient, space and light in the irrigation schemes. In citrus orchards, the vine climbs the citrus trees, strangling tightly the stems and branches of the plant. The stem of the vine is woody, hard, inflexible and over tightening the collar and braches of citrus at Adiha and Sheka Tekli irrigation schemes (Table 3). The weed first originated in South America (Futch, 2006), but currently it has been observed in many citrus framings of Ethiopia

Figure 3. The image of citrus attacked by major insect pests at Adiha and Sheka Tekli irrigation scheme.

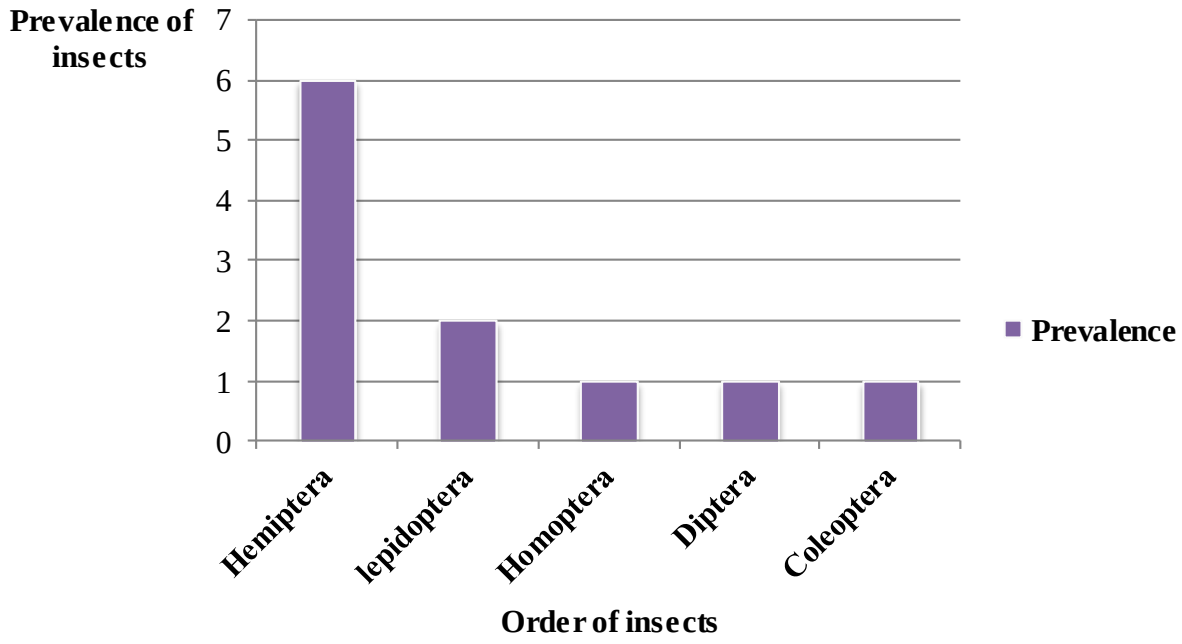

Figure 4. Graphical illustration of insect pests on citrus.

Table 3. Type of non-parasitic weeds of orange at Adiha and Sheka Tekli.

Common name	Order	Family	Scientific name
Milkweed vine (weed)	Rhamnales	Vitaceae	*Cissus trifoliata*

including the citrus farms at Adiha and Sheka Tekli irrigation schemes. According to Futch (2006), milkweed vines are broadleaf weeds with sail or parachute like structures on their seeds which help them to relocate to new locations.

Conclusion and recommendation

The production of citrus fruit is declining in the district. The occurrence of insect and disease pests of citrus leads to yield and quality reduction of orange. Ten most widely observed microbial pathogens of citrus have been identified at Adiha and Sheka Tekli irrigation schemes. Based on the result of the experiment, the main type of fungi and bacterial diseases that constraint the production and productivity of Citrus at Adiha and Sheka Tekli citrus farms were Citrus Greening, Citrus Canker, Orange Scab, Leaf and fruit Spot, Blue mold, Phytophthora foot rot, Nematode, Sooty mold, Brown rot and Black respectively. Besides, it has been found that 11 insect pests keep threatening the production of citrus at Adiha and Sheka Tekli citrus farms. Insects that belong to Hemiptera order followed by lepidopterans were predominant pests across the irrigation schemes. Therefore, further research intervention should focus on determination of the severity and abundance of each type of disease and insect pests of citrus at the irrigation schemes. Furthermore, any intervention should also gear towards management of those pests to improve the productivity of citrus at the irrigation schemes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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