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## Influence of Pathogens on Disease Development with Various Crops Grown in Zoba-Anseba, Eritrea during 2007-2017: A Report

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### ABSTRACT

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This compilation includes various diseases observed in Zoba-Anseba, Eritrea during a decade of time from 2007-2017. The total productive area of horticultural farms in this Zoba is over 26,885 ha and it is one of the most drought-prone regions of Eritrea. Farmers grow crops such cereals, oil seeds, vegetables and fruits etc. Enormous pathogens such as fungi, bacteria and other microbes; nematodes, and intervention of migratory insect pests cause a lot of damage to these crops and finally it leads in yield loss. In spite of application of chemicals, various botanical extracts also in practice to control some of these diseases. The methodologies used in this research were surveys, field experiments, diseases assessments and isolation of pathogens. Most of the fungal pathogens were identified and recorded their occurrence from various parts of the plants, at different phenological stages and also from the soils of these crops cultivated.

### Introduction

This compendium includes the descriptions and illustrations of identified diseases and pests on various crops cultivated in Zoba-Anseba, Eritrea. It is estimated that 463,926 hectares of arable area is under cereal cultivation in Eritrea (Gran do, *et al.*, 2010). About 80% of the Eritrean farmers depend on mixed farming systems and rain-fed agriculture. However, a wide range of crops are grown in this country under rainfed production system (AAT F 2011). The soil profile of the sub-zoba is predominantly sandy loam with low water retention capacity and

pH 6 -7 (MoA, 2014). Another report of MoA, 2012 mentions that the major soil types in Eritrea are the Cambisols, Lithosols, Fluvisols, Regosols and Cambisols.

Eritrea is situated in the horn of East Africa and has a total area of 124,320 square kilometers. It is bordered in the north and west by Sudan, in the south by Ethiopia and Djibuti and in the east by the Red Sea, The country (capital town-Asmara), has six administrative provinces (called obas) viz. Anseba, Debub, Gash barka, Maekel, Northern Redsea and Southern Redsea and is having into 529 villages. Figure 1 shows the 15% of land is

under cultivation of the total arable land, Zoba-Anseba, with a capital town Keren, is situated in the north western part of Eritrea and it covers an area of 22,834 square kilometers. The total productive area of horticultural farms in this Zoba is over 26,885 ha, Anseba is one of the most drought-prone regions of Eritrea as annual rain fall is low, very erratic and it is divided into 11 sub-zobas.

Important cereal crops in this country are: sorghum (locally called *Machala*), pearl millet (*Bultuk*), barley (*Segem*), finger millet (*Dagusha*), taff (*Taff*), maize (*Offun*), wheat (*Sernay*), chickpea and groundnut (Grando, *et al.*, 2010). On the other hand, the vegetable crops are tomato (*Komedero*), potato (*Dineesh*), chilli (*Beryberi*), okra (*Baamia*), eggplant (*Aswa*), cabbage (*Caulov*), cauliflower (*Fiori-caulov*), zucchini, lettuce, molukya and onion (*sukruthi*); and the horticultural crops are rose, citrus, grapes and mangoes. The total vegetables grown in this sub-Zoba are tomato and chillis accounting for 47% of the total crop produced.

Sorghum (*Sorghum bicolor* L.) (Poaceae family) is a native of Africa in the south of the Sahara desert. According to ASARECA, (2004) and Rohrbach, (2004), sorghum is grown on approximately 10 million ha and millets on over 3 million ha, in Eastern and Central Africa, all accounting for about 56% of cereal acreage and 41% of cereal production.

In Eritrea, Sorghum is the most important and widely grown cereal crop, especially in the lowlands. Sorghum ranks first in the contribution towards national economy, diet and on an average 45% of the bulk total food production for the nation. In the Anseba region, according to Anon, 2002, till 2001 the area cultivated under sorghum and groundnut was about 20,178 hectares with a production

of about 8442.1 tonnes. Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the second most important cereal grown after sorghum in Eritrea, and is grown on 17,000 hectare (AATF 2011) and indigenous to North Africa (D'Andrea, *et al.*, 2001). In 2000, one of the investigations done by Bhasker *et al.*, (2000), more than 50% of pearl millet plants surveyed in Anseba and Gash Barka were found to be infected with downy mildew caused by *Sclerospora graminicola* (Sacc.) J. Schröt. and caused major yield losses, estimated at 30% in Anseba in 2000.

Some of the economically important vegetables of Eritrea produced in sub-zobas Adi-Tekeliezan, Hamelmalo and Hagaz of Zoba Anseba are: Tomato (*Lycopersicon esculentum* L.); Potato (*Solanum tuberosum* L.); Chilli (*Capsicum annum* L.) and Eggplant (*Solanum melongena* L.); Okra (*Abelmoschus esculentus* Moench) and Jute mallow (*Corchorus olitorious*) and Lettuce (*Lactuca sativa*).

Tomato (*Lycopersicon esculentum* Mill) belongs to the Solanaceae family. In Eritrea, the main tomato production areas are Hamelmao, Keren, Elabred, Hagaz and Zoba Maekel and it is considered a major component in the diets of majority of Eritreans. According to Mario, 1997, the most commonly grown varieties of tomatoes are *Sanmarzano*, *Chico3*, *Roma VF*, *Riogrande* and *Marglobe*. According to Ministry of Agriculture (MoA, 2012), the area of cultivation tomato (3740 ha) and its production is 96228mt in Eritrea, whereas, in Zoba-Anseba the production of tomato is 6663 mt in an area of 617 ha. Chillies (*Capsicum annum* L.) are used either in green or as dried fruits of pungent forms which are widely cultivated throughout the world, and also as the most popular vegetable crop in zoba-Anseba. The cultivation of chilli, is an area of 3550ha in the country but in Zoba-Anseba it is

only 300ha with the 874mt of production. Besides fungal and bacterial diseases, *Chilli veinal mottle virus* (ChiVMV) has also been found recently in East Africa (Nono-Womdim *et al.*, 2001). The natural hosts of ChiVMV are sweet and hot pepper (*Capsicum* spp.), tomato (*Lycopersicon esculentum*), and African eggplant (*Solanum aethiopicum*) and this virus is transmitted in a non-persistent manner by several aphid species (Ong *et al.*, 1979). However, it is also mechanically transmitted.

In Africa citrus is cultivated in 551.95 thousand ha with a total production of 8.400 thousand tones with production share of 8.3 percent (FAO, 2007). In Eritrea, according to the statistics of MoA, 2003, the average yield of orange, lemon and mandarin 10.7t ha<sup>-1</sup>, 14.0t ha<sup>-1</sup> and 4.3t ha<sup>-1</sup> respectively in the cultivated area.

Average yield per hectare for all citrus is around 10.0 t ha<sup>-1</sup> international averages. A wide range of tropical fruit crops i.e., mango are cultivated along the banks of the river 'Anseba' production (MoA, 1995 and Leipzig, 1996). More than 70 diseases have been reported from groundnut due to fungi, bacteria, viruses, nematodes, etc (Lukose *et al.*, 2008). Like field crops, vegetable crops are also affected by a plethora of pathogens which results in unmarketability. Among the pests, fungi are one of the significant factors in damaging grains, fruits, vegetables and storage food commodity and also reduce seed viability. Besides, there are many other diseases occurring in these sub-zobas on various vegetable crops (Syed *et al.*, 2014 and Sethumadhava Rao *et al.*, 2016) about which more information is necessary for boosting production. As it is known, the infectious pathogens such as fungi, bacteria and other microbes; nematodes, and intervention of migratory insect pests cause a lot of damage to the crops. Due to the infections caused by

these pathogens, the plants get sick, which lead to weakness as shown in physiological activities, metabolism and finally it results in yield loss. When unfavorable environmental conditions are considered this will be doubled or more. It is difficult to know exactly when a plant is infected because it is unknown until the symptoms are visible on the plant surface. Viral infections are 'latent' and 'masked' which are transmitted by vectors. In the case of nematode infections, the symptoms appear after the penetration by them into roots which are called 'hidden enemies'. The water transportation in xylem and movements of photosynthates in phloem are blocked due to the accumulation of inoculums in the vascular bundles. Whatever pathogens are causing the diseases, the symptomatology gives us the intensity rate of the crops to analyze the epidemics. As pest control, aqueous extracts of flowers, cloves, leaves, bark, root and seed of different plants have been used to control the diseases. Onion, garlic and ginger are some of the most important botanical pesticides which are more effective and easily available as compared to synthetic pesticides. Garlic due to the presence of diallyl sulfide and triallyl sulfide shows fungicidal property against seed borne fungus. Mancozeb belongs to thiocarbamates fungicides containing Manganese and Zinc and it is very effective against seed borne diseases especially in blight, seed rot, damping off and wilt etc.

Nowadays, many of the farmers use fungicides, nematicides and insecticides to minimize the diseases. The continuous use of chemicals has posed a serious threat to the environment and resulted in repercussions on the ecosystem. To avoid excess application of chemicals and post applications residue which will remain on the produce, it is better to switch to use plant extracts for controlling the disease. Research is still going on regarding the efficacy of various botanicals and biopesticides to control the diseases. For

example, *Trichoderma viride* (Singh *et al.*, 2003 and Sonawane and Pawar, 2001) or the combination of *Trichoderma harzianum* and *Trichoderma viride* (Syed, 2012) resulting in significant reduction in the growth of *Fusarium oxysporum* f.sp. *ciceri* which is one of the causal agents of fusarial wilts of chickpea (*Cicer arietinum* L.). The highest inhibitory effect of *Trichoderma* spp. (radial growth 42.67 mm) was reported against *Fusarium oxysporum* f.sp. *ciceri* at different intervals. In this report, the overall results were based on the investigations, observations in the field, examinations in the lab, intensive surveys and direct interviews done in various regions where these crops are grown. Newly described diseases and insects are also described briefly, so this serves to alert the experts to take the necessary action (Fig. 3).

## Materials and Methods

### Experimental location

All experiments were conducted in the Laboratory and field of Plant Protection, Hamelmalo Agricultural College, Eritrea. Hamelmalo is located at 12km north east of Keren town on the bank of the river Anseba at 15° 53' N latitude and 38° 66' E longitude and an elevation of 1292m above sea level. Zoba-Anseba falls under semi-arid midland region of the country (Fig. 2). Annual rainfall, in the past six years, of this region ranged from 370

mm to 663.1mm with a mean value of 488 mm (Anonymous, 1997). The temperature of the area varies from 16°C to 38°C during the winter and summer seasons and has an average of 27°C. The soil of Zoba-Anseba is sandy and sandy loam with low water retention capacity and pH of 6-7 (Anonymous, 2000).

### Survey

For survey, methodologies of James (1971 and 1974), and Weeks *et al.*, (2000) were followed.

### Disease assessments

Both disease incidence and disease severities (intensity) were assessed according to Jagtap *et al.*, 2012.

### Disease incidence

$$\text{Percent Disease Incidence} = \frac{\text{Number of plants infected}}{\text{Total number of plant examined}} \times 100$$

Disease Intensity was recorded and calculated using the following formula: (Davis *et al.*, (1993).

$$\text{Disease intensity (\%)} = \left\{ \frac{B}{(A \times 9)} \right\} \times 100$$

where, B = total disease rating, A = total number of samples and 9 = maximum grade as shown below for different diseases:

**Table.1**

Percentage of infected leaf/unit area of Leaf Spots*	Percentage of infected head/unit area of Smuts#	Rating grade (P) <sup>\$</sup>	Number of leaves/units in the grade (Q)	Rating of Disease (PXQ)
0.5 – 1%	0	1		
1 – 5%	1 -10%	3		
6 - 20%	11 - 35%	5		
21 -50%	36 -50%	7		
>50%	> 0%	9		
Total			A	B

## Inoculation and incubation techniques

The Seed germination was done by standard blotter method which was developed by Doyer in 1938, later included in the International Seed Testing Association Rules of 1966. The experiments were done in the Plant Protection Agricultural College, Eritrea.

## Isolation of fungi

Potato Dextrose Agar (PDA) as a Nutrient Medium was used for fungal isolation (Aina *et al.*, 2011). The pH of the medium acidified with 25% lactic acid was maintained at 5.5, it being optimal for the growth and sporulation of fungi. The Soil Plate Method (Warcup, 1950) and Serial Dilution Method (Waksman, 1922) on PDA media were used as isolation techniques.

## Identification of pathogens

Fungal identifications were carried out on the basis of characterization of colonies and also examining under microscope and consulting relevant literature (Aneja, 2004, Barnett and Hunter, 1972, Ellis, 1971, Gilman, 1957; Raper and Fennell 1965 and Nagamani *et al.*, 2006).

## Percent occurrence

The percent contribution of each isolate was calculated by using the following formula: (Singh, 1998).

$$\% \text{ occurrence} = \frac{\text{Total number of individual fungal spp.}}{\text{Total number of all fungal spp.}} \times 100$$

## Statistical analysis of data

Data recorded about various parameters were statistically analyzed using GENSTAT 10.3 (2011) with ANOVA at 5% level of significance.

## Results and Discussion

In one of the studies an attempt was made to identify the occurrence of soil-borne mycoflora during different crop growth stages of sorghum and pearl millet crops in different villages of Hamelmalo region. Field mycoflora (*Alternaria alternata*, *Aspergillus niger*, *Aspergillus terreus*, *Fusarium oxysporium*, *Phytophthora infestans*, *Rhizoctonia solani* and *Pythium debaryanum*) were isolated in the fields sorghum crop. *Alternaria alternata*, *Aspergillus niger*, *Fusarium oxysporium*, *Penicillium chrysogenum*, *Phytophthora infestans*, *Rhizoctonia solani*, *Rhizopus stolonifer* and *Pythium debaryanum* from the Basher villa e from the soils of pearl millet at various phenological stages. Fungal species *Alternaria alternata*, *Aspergillus niger*, *A. flavus*, *Fusarium oxysporium*, *Penicillium chrysogenum*, *Phytophthora infestans*, *Cladosporium cladosporoides* *Pythium debaryanum* and *Rhizopus stolonifer* isolated from both of pearl millet and sorghum fields of Wazentit village of Hamelmalo sub-zoba. Among eleven fungal flora isolated from the field samples, the maximum incidence of fungal numbers (cfu/g x10<sup>3</sup>) of *Pythium debaryanum* was counted from the fields of pearl millet of Wazentit village (36) followed by Basher villa e (31) (Syed *et al.*, 2016).

Maximum seed-borne infection by *A. alternata* and *F. oxysporium* showed between 21 and 64% among seed samples of sorghum and groundnut crops tested from different farmers of zoba-Anseba. Studies of Syed *et al.*, 2012, stated that there was reduction in germination in the grains due to the increase of infection by these fungi.

The evaluation of fungicides and garlic extracts against seed borne fungal pathogen of sorghum and groundnut revealed that the treatments of 4 gm garlic extract/kg seed was

most effective which showed maximum seed germination (96.70%) in sorghum and groundnut then, followed by germination of (93.33%) in the treatments of (2 g garlic extract+2 g mancozeb per kg seed) and (only 2 g mancozeb per kg seed), whereas in control (no treatment) the seed germination percentages were 76.7% in sorghum and 83.33% in ground nut. This result in support of Olkowski *et al.*, (1995), that garlic extract spray has a broad spectrum effect and the seed treatment is effective and a cheap means of managing seed borne diseases in crops (Shenge, 2007). Similar findings of loss in seed germination percentage by *Alternaria*, *Fusarium*, *Rhizopus*, *Aspergillus* and *Colletotrichum* were reported by Agarwal and Sinclair (1997), Abdurahman (2005), Javid *et al.*, (2006), Masum *et al.*, (2008), Mesta *et al.*, (2009), Rathod *et al.*, (2010).

In another study done by Syed *et al.*, 2013 on seed-borne fungi, collected from three zobas (Anseba, Debub and Gashbarka) of Eritrea covering 14 villages, viz., Adinamn, Areza, Bashery, BeguDbarwa, Elabered, Endagergish, Golug, Hagaz, Hamelmalo, Hastina, Ksadeka, Oana, and Sabnait during August to November 2011, seven mycoflora were encountered in high percent frequencies of seed-borne fungal in the samples of sorghum, pearl millet and groundnut. Standard blotter method as described by the International Seed Testing Association (ISTA 1976), was used for the isolation of the seed-borne fungi associated with stored seeds.

The results showed that for all the samples germination of sorghum was higher in Araya-Hastina (93.3%) followed by Brhane-Dbarba and Mhretab-Adinamm (92.0%), Belay-Areza (90.7%), Ahmedin-Sabnait (89.3%), Siele-Hastina (84.0%), Fshaye-Areza (76.0%), Mensur-Hamelmallo (57.3%), Abdu-Hamelmallo (46.6%) and Zeineb-Hamelmallo (45.3%).

The identified fungal species were *Alternaria*, *Aspergillus*, *Fusarium*, *Helminthosporium*, *Mucor*, *Penicillium* and *Rhizopus* isolated from sorghum var. *bushuka*, *shambuko*, whereas in pearl millet var. *hagaz*, *kona* above fungal pathogens were identified except *Mucor* while in the seed samples of groundnut var. *spanish valentia* - *Alternaria*, *Aspergillus*, *Fusarium*, *Helminthosporium* and *Rhizopus* were detected. Similar results were collaborated with the research of Mathur and Manandhar (2003), Shazia *et al.*, (2004), and Zida *et al.*, (2008) that the grains of these crops are highly susceptible to diseases as they act as a source of stored nutrients for fungi. Percent pathogen frequency of seed-borne fungi was higher in groundnut 73.0% in Fshaye-Areza and minimum in sorghum 15.3% in Abdu-Hamelmallo.

The major fungal diseases appeared at different phenological stages of on various crops (local varieties) in sub-zone Hamelmalo under natural field conditions in 2011 (Syed, 2013) were leaf spot of peanut (*Passalora personata* - early leaf spot and *Passalora arachidichola* - late leaf spot), rust of pearl millet (*Puccinia penniseti*), downy mildew of pearl millet (*Sclerospora graminicola*), anthracnose of sorghum (*Colletotrichum graminicola*) and covered smut of sorghum (*Sphacelotheca sorghi*). The results are in agreement with earlier works of Chaudhary (1985), Gwary *et al.*, (2007), Kausar and Nayeemullah (1957), Mirza (1982) and Thakur *et al.*, (1998). On average, the maximum leaf spot disease incidence was recorded in all phases in 'Musa Local variety' (50.32%) compared to other local varieties *Ibrahim* (49.52%), *Adem* (38.27%), *Ahmed* (49.16%) and *Idris* (38.96%) local varieties. Incidence percentage of leaf spots may be dependent on growth stages and prevailing climatic conditions. These observations were well in conformity with the earlier studies by Pande *et al.*, (2004).

The average of three weeks interval survey revealed that the maximum percentage of disease incidence of pearl millet downy mildew was 9.72% in *Ibrahim* Local variety followed by 9.59%, 7.76% and 4.53% in *Idris Local variety*, *Ahmed Local variety* and *Adil Local variety* respectively. The results of this study corroborate the findings of Nene and Singh (1976), Williams (1984) and Hash *et al.*, (1999). The disease incidences of rusts (18.65%) and sorghum covered smuts (27.88%) were very high in *Idris Local variety* at seven days interval. Ngugi *et al.*, (2002) assessed the disease intensity due to covered smut as more than 30% in 42 to 43% of the fields surveyed. The results are also in accordance with the report of earlier works by Nutsugah *et al.*, (2007).

Six fungal species *i.e.*, (*Alternaria alternata*, *Aspergillus niger*, *Fusarium moniliforme*, *Penicillium oxalicum*, *Helminthosporium* and *Rhizopus*) were isolated from the sorghum seeds collected from five villages *viz.*, Basherri, Hamelmalo, Hitsat, Kurba-bered and Wazentit of Hamelmalo sub-zoba of Zoba Anseba after treating with cow urine, whereas eight species of fungi *viz.*, (*Alternaria alternata*, *Aspergillus niger*, *Fusarium moniliforme*, *Penicillium oxalicum*, *Helminthosporium*, *Mucor*, *Rhizopus* and *Colletotrichum graminicola*) were identified in unwashed seeds. It is stated that the fungal pathogen frequency was higher (35.7%) in unwashed seeds and lower (14.7%) in the cattle urine treated seeds. Therefore, it is clearly indicated that treatment with cow urine was found more effective for minimizing seed borne fungal pathogens than water treatment (Bisrat *et al.*, 2014).

One of the reports of Syed *et al.*, (2015) stated that, fungi such as *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus niger*, *Colletotrichum graminicola*, *Fusarium moniliforme*, *Helminthosporium sorghicola*,

*Mucor* spp., *Penicillium oxalicum* and *Rhizopus* spp. were isolated from the sorghum variety HACNL (Hamelmallo Agricultural College New Line). In case of application of botanical and fungicides, the aqueous leaf extracts of *Calotropis* sp showed more efficacy followed by the extracts of *Allium cepa* and *Lantana camara*. Figure 1 clearly shows that the effect of fungicide (ridomil) and botanicals on fungal colony units (*cfu*) formation. *Calotropis* sp. had shown more suppressive effect on all fungal flora growth, while the least mycoflora formation recorded for ridomil treatment. Both extracts of *Lantana camera* leaves and *Allium cepa* had shown less *cfu* in-vitro, whereas, untreated seeds showed highest *cfu* especially it was recorded abundantly in the growth of *Aternaria alternata*, *Helminthosporium sorghicola*, *Aspergillus niger* and *Mucor* spp.

The major diseases recorded in Hamelmalo region were damping-off, early blight, late blight and powdery mildews on tomato. Disease incidence as high as 95.13% and disease severity was noticed 87.91%. In some of the fields of Hamelmalo the incidence rate is reached up to 95.31% in 39 days of time. In one of the surveys (Syed, 2014) done in tomato growing areas of Hamelmalo during November 2013 to March 2014, the most commonly observed diseases were early blight (*Alternaria solani*), late blight (*Phytophthora infestans*), wilt (*Fusarium* spp.) and powdery mildew (*Oidium neolycopersici*). The most common insect pests were African boll worm (*Helicoverpa armigera*) and white fly and fruit borer *Tuta absoluta*. The results revealed that after three observations with a weekly interval, the overall maximum percentage of disease complex of powdery mildew and early blight of tomato was recorded in the Tsebab village fields 71.60% and minimum in the fields of Abderes 62.60%. The incidence percentage may be depending on growth stage and prevailing climatic conditions for the

incidence and development of disease (Douglas, 2003). The maximum and minimum disease incidence of powdery mildew was found in the village of Genfelom (38.96%) and in Awrari village (13.42%) respectively whereas; early blight alone was very severe in fields of Tsebab village (41.27%).

In a pathological survey (Sethumadhava Rao, 2016), conducted in two seasons, *i.e.* autumn (*Qewi*) Season (August to November) and Winter (*Hagay*) Season (January to March) on the vegetable crops of tomato and chillies which were grown in selected five villages, *i.e.* *Wazntet*, *Basheri*, *Awrari*, *Genfelom* and *Hamelmallo* of sub Zoba-Hamelmallo were early blight and late blight, bacterial wilt, fusarial wilt and blossom end rot; and infestations caused by insect pests such as tomato borer and *Septoria* leaf spot rarely found. Powdery mildews were observed only in *Wazntet* and *Genfelom* villages. Damping off, yellowing leaf and leaf curl were observed in *Awrari*, *Genfelom*, *Basheri* and *Hamelmallo* villages.

This survey clearly stated that in *Basheri* village, the lowest percentage of disease incidence (disease complex) with 59.7% was found at seedling stage, whereas, the highest percentage of disease incidence with 97.8 % occurred at fruiting stage of tomato; and the high disease severity with 82.9% was recorded, in *Autumn (Qewi) season*. This shows that, the mean average disease intensity was 77.23% and almost 3/4<sup>th</sup> of tomatoes cultivated in those villages were infected at a particular growth period of the crop.

It is recorded that the mean average disease severity of chillies was 46.67% at any growth stages in sub Zoba Hamelmallo, except in the village *Basheri* that was recorded as extremely severe (75.3%). The maximum range of disease incidence and severity reported in both *Basheri* (94.90%) and *Gonfelom* (95.50%)

during autumn (*Qewi*) season. In both vegetable crops, tomatoes and chillies, the percentage of disease incidence showed more than 77% in all villages during *Hagay* season but the severity was observed as between 20 and 60%. The reasons for those results are low/no educational level among farmers, no proper irrigation/cultivation practices, unavailability of fertilizers and chemicals for controlling the diseases.

In an intensive survey that was conducted in five villages in sub-zoba-Hamelmallo (*Hamelmallo*, *Genfelom*, *Zeron*, *Genfelom*, *Wazantet* and *Basheri*), 5 villages in sub-zoba-Adi-Tekeliezan (*Adi-Tekeliezan*, *Dekemhare*, *Golagul*, *Melati* and *Dekighebru*) and 3 villages in sub-zoba-Hagaz (*Hagaz*, *Derotay* and *Hagaz Agro Technical School*) on different vegetable crops in 2016, early blight (*Alternaria solani*), powdery mildew (*Leveillula taurica*), late blight (*Phytophthora parasitica*), leaf curl virus (tomato leaf curl virus disease-TLCV), blossom end rot (*Botrytis* spp.) on tomato; downy mildews (*Peronospora* spp.) and purple blotch on onion; wilt (bacterial and *Fusarium* spp.), anthracnose (*Colletotrichum* spp.), late blight, collar rot and scab on potato were noticed. And leaf minor, fruit borer (*Helicoverpa armigera* (L.)), whitefly (*Bemisia tabaci*), African boll worm (*ABW-Helicoverpa armigera*), aphids (Aphididae; Order Homoptera), cutworm, potato tuber moth, spider mites (*Tetranychus urticae* (Koch)), jassids, less wing bug and thrips were also observed as the major insect pests (Syed *et al.*, 2016a). Transmission of the virus by these insect pests, leads to the incidence of leaf curl disease and also serious in some of the crops. On one hand, leaf curl virus and powdery mildews appeared in tomato and chilli; collar rot in potato; powdery mildews in zucchini and carrot almost in all villages where the crops are grown. On the other hand, percentage of severity prevailed due to



whiteflies and infestation by fruit borer and aphids and registered in all grown crops of sub-zoba Hamelmalo. Tomato and okra showed low to medium percentage of disease severity. Powdery mildew was recorded medium to high in Hagaz and low to high in Derotay. Diamond back moth (*Plutella xylostella*) on cabbage; cabbage butterfly on cabbage and zucchini; cutworms (*Agrotis* spp.) on potato; and ABW on tomato appeared as very common pests. Among all vegetable crops, tomato, okra and chilli crops were more affected by fungal diseases and insect pests compared to other vegetable crops. This intensive survey revealed that there was a heavy toll of pathogens causing powdery mildews and the disease incidence was high in tomato (65%), chilli (65%), zucchini (60%) and carrot (70%). *Hamelmallo* and *Genfelom* villages experienced almost all types of diseases and insect infestations in all crops.

In the similar survey, the farmers were interviewed based on a developed questionnaire for knowing cultivating crops in the area, varieties, husbandry practices, diseases and pests of the crops, management practices and farmers' educational level. About 34.88 to 62.50% of farmers were using the locally available seeds, but 65.51% of growers by the seeds from the market. The vegetable growers use the potato varieties *Ageba*, *Sudan White*, *Red* and *Yemani*; tomato variety *Sumberson* and *Margelob* and okra variety *Bloctihona*. About 51.72% of farmers use irrigation and the rest of 49.27 per cent depend on rainfed cultivation. Most of the farmers do hand weeding, 5-6 times during the crop season. In sub-zobas Hamelmalo (58.06%), Adi-Tekeliezan (89.65%) and Hagaz (81.25%) of farmers use cow dung ash as seed treatment (Syed *et al.*, 2016b).

In a group discussion conducted in three sub-zobas (Subzoba-Hamelmallo; subzoba Hagaz and Subzoba- Adi-Tekeliezan) with 33

farmers to collect quantitative information on various practices and managements, *Zolpho* and ash were used in Hamelmalo. Drusban/chloro-pyrifos 45% EC, malathion 57% EC, dimethoate 40% EC, Focus, cypermethrin 25% EC, redomil and mancozeb were used in Hagaz. And only dimethoate and sulphur dust were applied in Adi-Teklezeian for controlling the diseases and insect pests as well. Farmers of this zoba are not aware of the methods of application of the chemical as per the directions given on the pack, but some of the farmers measured the chemical with one lid/cap (20cc) of the bottle per 20 l water (Naqvi *et al.*, 2017). Majority of the vegetable growers used oxen for ploughing the field for cultivation. Due to the paucity of seed sources farmers buy the seed from the neighbourhoods and irrigation was done through wells where they get adequate water. The discussion showed that due to the lack of proper crop husbandry practices and lack of awareness of usage of chemicals various infections as well as infestations are caused.

Medhanie *et al.*, (2017) reported that the fungal occurrence and identification of mycoflora in vegetable cultivating rhizosphere soils from seven vegetable crops (tomato, potato, chili, okra, eggplant, lettuce and Jute mallow) from six villages of three sub-zobas (from sub-zoba Hamelmalo - Hamelmalo village and Kurbaberead village; from sub-zoba-Hagaz the villages are Hagaz and Derato; and from sub-zoba Adi-Tekeliezan villages are Adi-Tekeliezan and Golagul) for isolation and identification of soil mycoflora. A total of 15 fungi, *Alternaria*, *Arthrobotrys*, *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus terreus*, *Cladosporium*, *Curvularia*, *Drechslera*, *Fusarium*, *Mucor*, *Penicillium*, *Phoma*, *Phytophthora*, *Pythium* and *Rhizopus* were identified. The results show that, the maximum occurrence of *Cladosporium* (44.4%) and *Rhizopus* (37.5%) and the minimum occurrence of *Drechslera* in

tomato Adi-Tekeliezan were calculated. Around 20% of fungal occurrence was recorded in two villages of sub zoba Hagaz. *Arthrobotrys*, a nematophagous fungus, was identified for the first time in the rhizosphere of chilli of Derato village.

The study of disease and its intensity on grape vines (*Vitis vinifera*) as conducted at Hagaz Technical School where this crop was commercially grown of Zoba Anseba in 2012 to 2013 (Syed *et al.*, 2013). The most commonly grown varieties of grapes in these areas are *viz.*, *Barberia* (red), *Nero* (red), *Srah* (red), *Cabernet* (red), *Melot*(red), *Sandioverge* (red), *Malvasia* (white), *Scavia* (red), *Maltopwllichano* (red) and *Muscata* (white). In this investigation it was clearly identified that the *Uncinula necator*, *Plasmopara viticola* and *Colletotrichum gloeosporioides* were causing agents of the common diseases of powdery mildew, downy mildew and anthracnose, respectively. The 39.05% (high) disease severity was observed due to powdery mildew where as 1.43% (low) was from anthracnose at 21 to 50% level of disease severity index. And maximum disease incidence (100%) was due to powdery mildew followed by downy mildew (67.43%) and anthracnose (31.92%).

In one of the important surveys done on citrus in three sub-zones *i.e.* Hamelmalo, Hagaz and Elabered of Zoba-Anseba from 2014 to 2015, foot rot disease caused by fungi (*Phytophthora* spp.) was recorded (Syed *et al.*, 2016c). The characteristics of this disease are gum exudates from gum pockets (pink-orange coloured blisters) located on trunks. Gradually, root system, the trunk below and above the soil line, branches, leaves and fruits are affected and it was very severe in the rainy season.

Citrus crops *i.e.*, orange, lemon and mandarin showed highest incidence of foot rot in Hagaz,

*i.e.* 81, 91.5 and 80.6% and the lowest incidence was found in Hamelmalo *i.e.* 52.7, 30.1 and 59.8 per cent respectively. It was observed that the highest disease severity was noted in Hagaz region and the lowest was recorded in sub-region Elabered. The disease incidence 95.83% was recorded in Technical School area and 90.90% was noted in Hagaz (Gebina) area on oranges. The Mandarin fruit crop growing in the Technical School area showed the percentages of disease incidence 91.90%; 30.15% in lemon of Hamelmalo (Wazentet); and 38.33% in orange of Elabered (Girat Peteros). In lemon highest disease was recorded at Hagaz Technical School and Hagaz (Daerotiy) *i.e.* 95.74 and 90.90 per cent respectively. The appearance of this phenomenon may be due to relatively warm weather and close spacing among plants; farmers of Hagaz were not careful in the field operation with proper pruning. The farmers also do not follow the proper management practices due to a lack of knowledge.

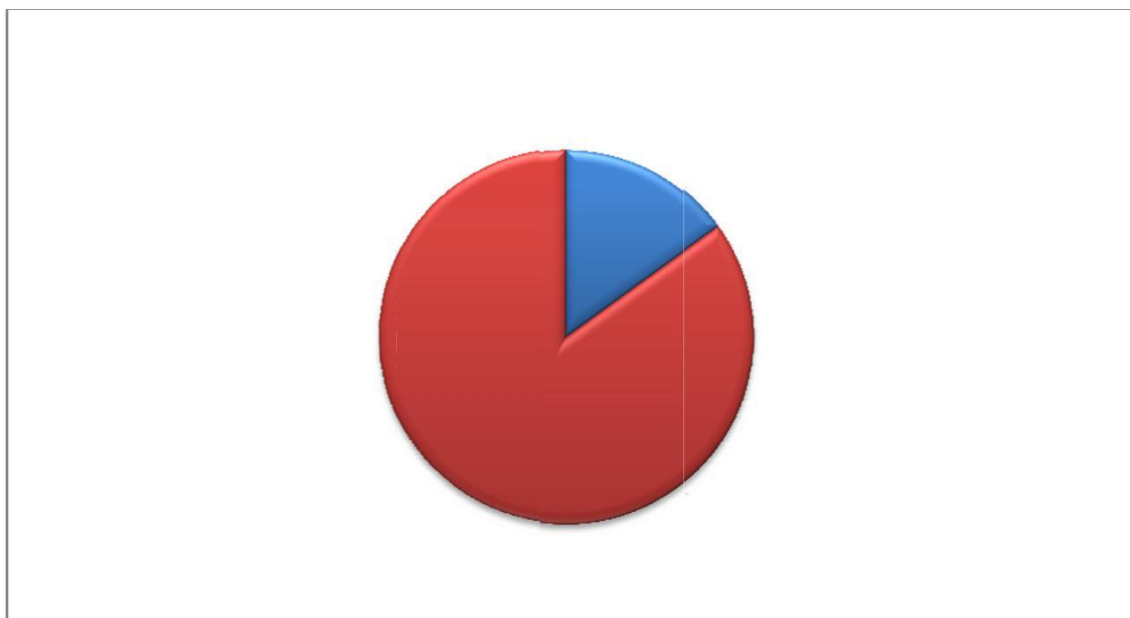
Growing of cut roses was started by the Eritrean farmers around 40-45 years ago. Now this country is capable for producing cut roses on a large scale and (70%) were distributed for local market to Asmara flower shops and 30% is sent for export to Saudi Arabia (Fitwi *et al.*, 2003). The government of Eritrea established green houses in MaiSirwa in 2009, at an area of 8.2ha. They are located 13 km North West from Asmara, at 15° 23' north latitude and 38° 54' east longitudes and an elevation of 2300 meter above sea level. The annual rainfall of the area ranges from 4000mm to 600mm and annual mean of maximum and minimum temperature are 4.3 to 25.5°C (Ministry of Agriculture, 2015).

A pathological survey was done at Asmara flowers Company (MaiSirwa) during the years of 2015 and 2016 (Awet *et al.*, 2016). In MaiSirwa there are two types of greenhouses *i.e.*, greenhouse-1 which includes eight

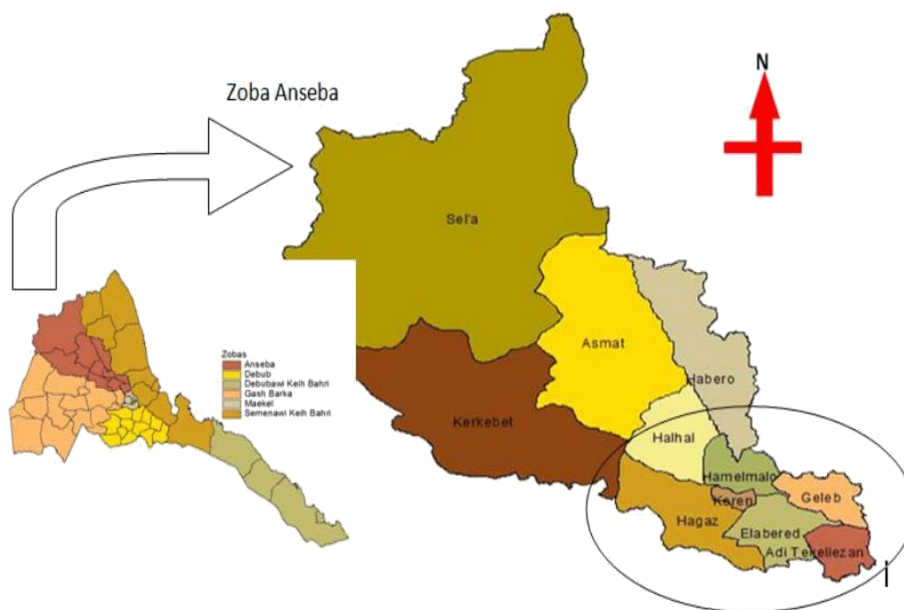
cultivars (*High and Magic, Marie Claire, Tropical Amazone, Aqua, Bordeaux, Upper Class, Avalanche* and *Poisson*) of three years and eight months old and greenhouse-2 that includes seven cultivars (namely: *Avalanche,*

*Gold strike, Contrast, Wham, Top Secret, Upper Class* and *Poisson*) of ten months old, which were introduced from India (Zoba Maekel Admin, 2014).

**Fig.1** Total potential and cultivating land in Eritrea



**Fig.2** Eritrea and the sub-zobas in Zoba-Anseba



**Diseases causing by pathogens on Various Crops in Zoba- Anseba**



Powdery mildews on okra



Blight on okra leaves



Blight on potato



Collar rot in tomato



Early blight on tomato



leaf curl on tomato plant



Powdery mildew on the Rose



Leaf spot in groundnut

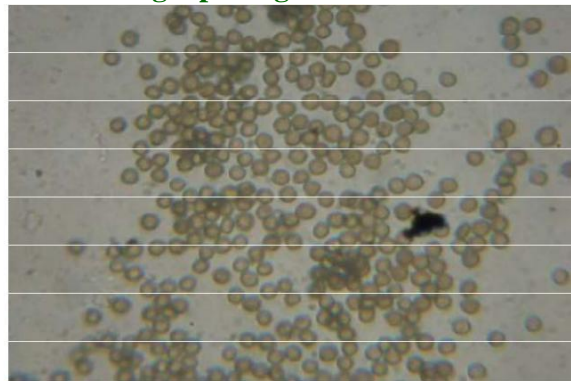


Powdery mildews and Downy mildews on grape leaf

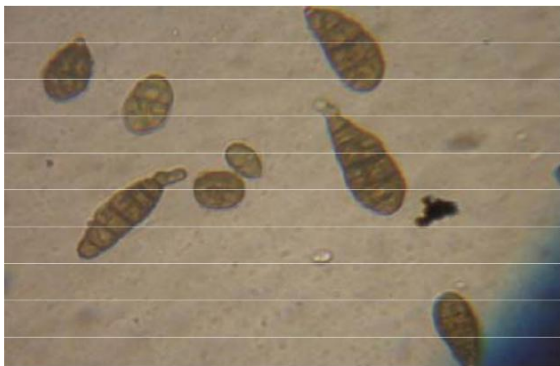
**Microscopic images of various fungal pathogens**



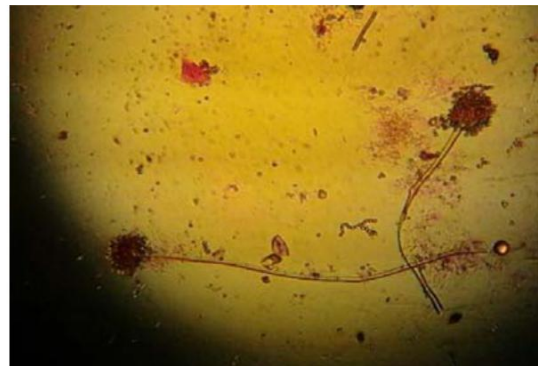
*Colletotrichum graminicola*



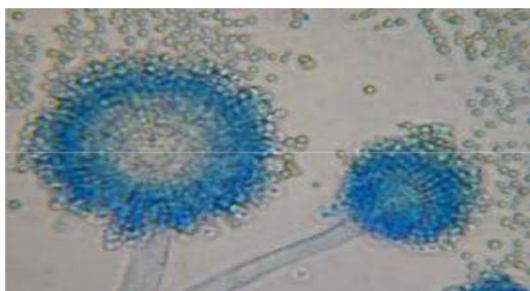
*Sphacelotheca sorghi* spores



*Alternaria alternata*



*Aspergillus niger*



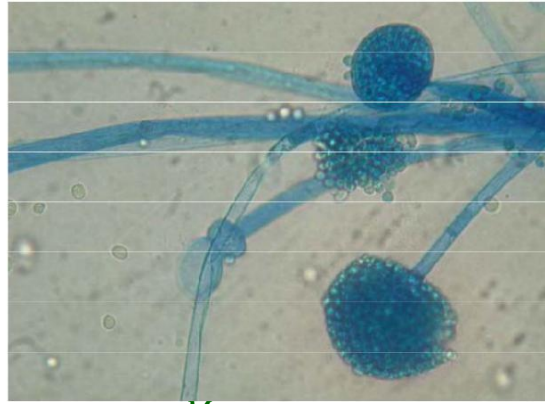
*Aspergillus flavus*



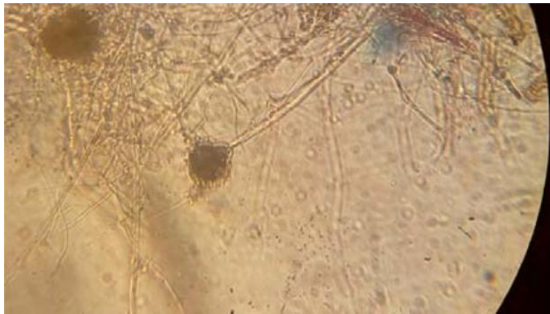
*Fusarium moniliforme*



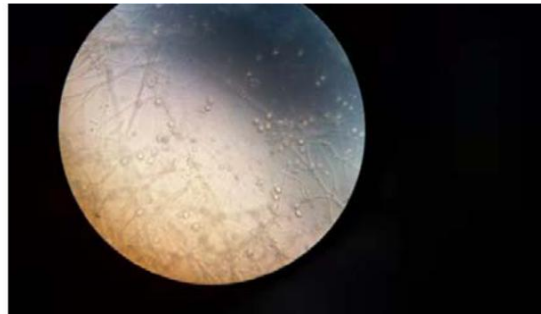
*Penicillium oxalicum*



*Mucor* spp.



*Aspergillus terreus*



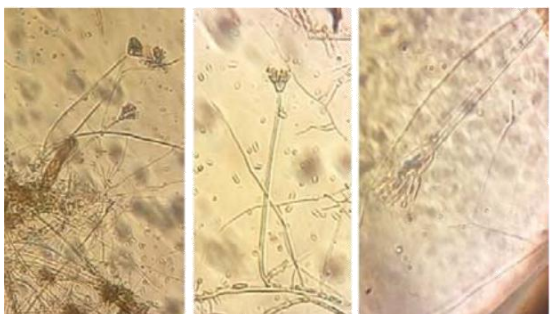
*Cladosporium*



*Curvularia*



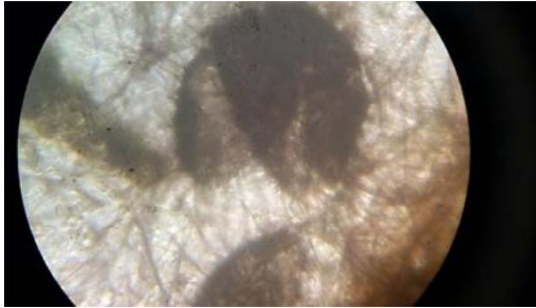
*Drechslera*



*Penicillium*



*Arthrotrrys*



*Phoma*



*Phytophthora*



*Pythium*



*Rhizopus*

**Infestations causing by insect pests on Various Crops in Zoba- Anseba**



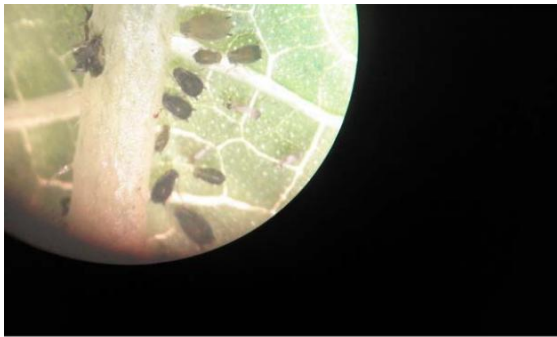
Leaf minor and



Aphids on leaf



Whiteflies on leaf and under microscope



African boll worm (ABW) *Helicoverpa armigera*

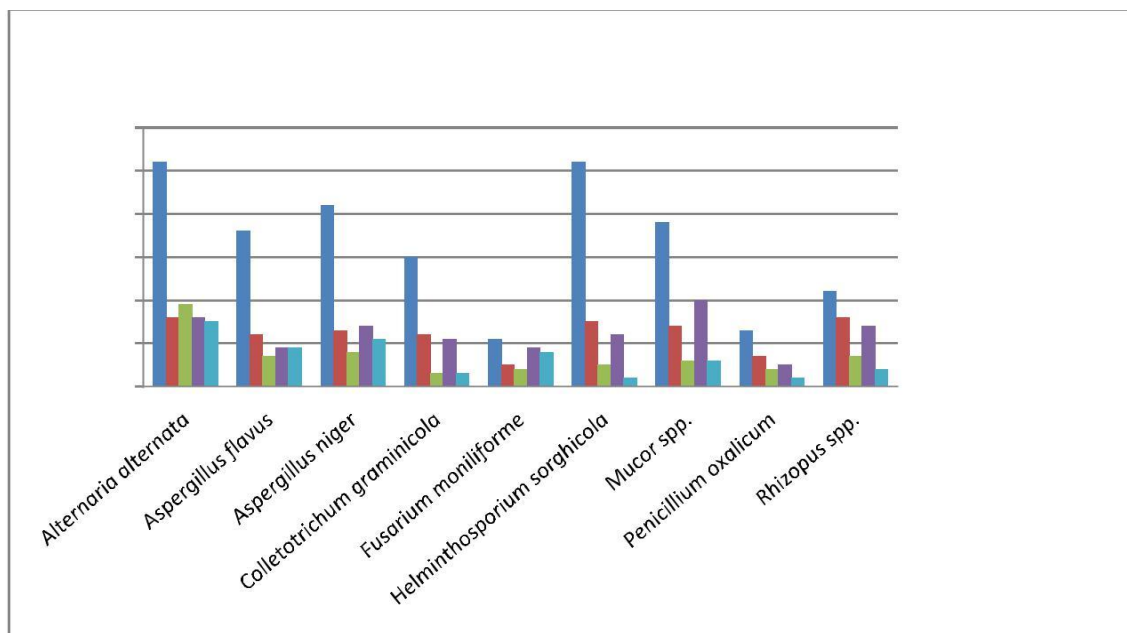


*Bemisia tabaci* on tomato

Diamondback moth, *Plutella xylostella*



**Fig.3** The effect of Ridomil and Plant aqueous extracts on the growth of Colony Forming Units in sorghum variety HACNL



In Eritrea powdery mildew is one of the most harmful fungal diseases on roses, both in the garden as well as in the greenhouses. It is caused by a special form of *Sphaerotheca pannosa* (Wallr.) de Bary f. sp. *rosae*. Awet *et al.*, 2016 survey report revealed that during the autumn season the disease incidence and severity were calculated was 81.94 to 100% and 25.83 to 86.81% in greenhouse-I respectively, while, in greenhouse-II disease incidence was 23.33 to 78.70% and disease severity was 25.11 to 4.66% recorded. During winter season disease incidence was between 29.44 to 7.77% and severity was 5.88 to 1.55% in greenhouse-I, in green house-II it was observed that 34.72 to 10% and 8.11 to 2% respectively.

Conclusion and future perspective of the study are as follows:

The main objective of this study was to identify, isolate, and determine various phylloplane, rhizosphere fungal and other microbial organisms causing diseases on field

and horticultural crops from the zoba-Anseba, Eritrea during the decade of 2007-2017. The surveys and assessments of diseases were done within the zoba-Anseba in different seasons. All the experimental works were done in the Plant Protection Field and Laboratory of Hamelmalo Agricultural College. Based on morphological descriptions, many diseases were reported in selected villages of this region. Field mycoflora (*Alternaria alternata*, *Aspergillus niger*, *Aspergillus terreus*, *Fusarium oxysporium*, *Phytophthora infestans*, *Rhizoctonia solani* and *Pythium debaryanum*) were isolated in the fields of sorghum crop. *Alternaria alternata*, *Aspergillus niger*, *Fusarium oxysporium*, *Penicillium chrysogenum*, *Phytophthora infestans*, *Rhizoctonia solani*, *Rhizopus stolonifer* and *Pythium debaryanum* from the Basherri village from the soils of pearl millet at various phenological stages. Nine fungal species i.e., *Alternaria alternata*, *Aspergillus niger*, *A. flavus*, *Fusarium oxysporium*, *Penicillium chrysogenum*, *Phytophthora infestans*,

*Cladosporium cladosporoides*, *Pythium debaryanum* and *Rhizopus stolonifer* isolated from both pearl millet and sorghum fields. The treatments of 4 gm garlic extract/kg seed were found to be most effective showing maximum seed germination (96.70%) in sorghum and groundnut.

In an intensive survey that was conducted in sub-zoba-Hamelmallo, sub-zoba-Adi-Tekeliezan and sub-zoba-Hagaz on different vegetable crops in 2016, early blight (*Alternaria solani*), powdery mildew (*Leveillula taurica*), late blight (*Phytophthora parasitica*), leaf curl virus (tomato leaf curl virus disease-TLCV), blossom end rot (*Botrytis* spp.) on tomato; downy mildews (*Peronospora* spp.) and purple blotch (bacterial) on onion; wilt (bacterial and *Fusarium* spp.), anthracnose (*Colletotrichum* spp.), late blight, collar rot and scab on potato were noticed. Along with leaf minor, fruit borer (*Helicoverpa armigera* L.), whitefly (*Bemisia tabaci*), African boll worm (ABW-*Helicoverpa armigera*), aphids (Aphididae; Order Homoptera), cutworm, potato tuber moth, spider mites (*Tetranychus urticae* Koch), jassids, less wing bug and thrips as the major insect pests.

The fungal flora of *Alternaria*, *Arthrobotrys*, *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus terreus*, *Cladosporium*, *Curvularia*, *Drechslera*, *Fusarium*, *Mucor*, *Penicillium*, *Phoma*, *Phytophthora*, *Pythium* and *Rhizopus* were identified from the vegetable cultivating rhizosphere soils from seven vegetable crops (tomato, potato, chili, okra, egg plant, lettuce and Jute mallow).

*Uncinula necator*, *Plasmopara viticola* and *Colletotrichum gloeosporioides* were the causal agents of the common diseases of powdery mildew, downy mildew and anthracnose, respectively on grape vines (*Vitis vinifera*). The high disease incidence

(95.83%) was recorded in Technical School area and 90.90% was noted in Hagaz (Gebina) area on oranges. The Mandarin fruit crop growing in Technical School area showed the percentages of disease incidence 91.90%; 30.15% in lemon of Hamelmalo (Wazentet); and 38.33% in orange of Elabered (Girat Peteros). In lemon highest disease incidence was recorded at Hagaz Technical School and Hagaz (Daerotiy) i.e. 95.74 and 90.90 per cent respectively.

The disease incidence and severity were calculated 81.94 to 100% and 25.83 to 86.81%, in a pathological survey which was done at Asmara Flowers Company in various varieties of roses, during the autumn season.

In conclusion, the report showed that due to the lack of proper crop husbandry practices and lack of awareness of usage of chemicals, various infections as well as infestations are caused. It is recommended that the growers should be made aware or be trained about the diseases and pest infestations by their morphological characteristics. It would be better if a prepared manual or chart is provided showing the symptoms of the diseases and insect pests which cause infestations, so that based on the colour images, the diseases would be identified now and then.

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