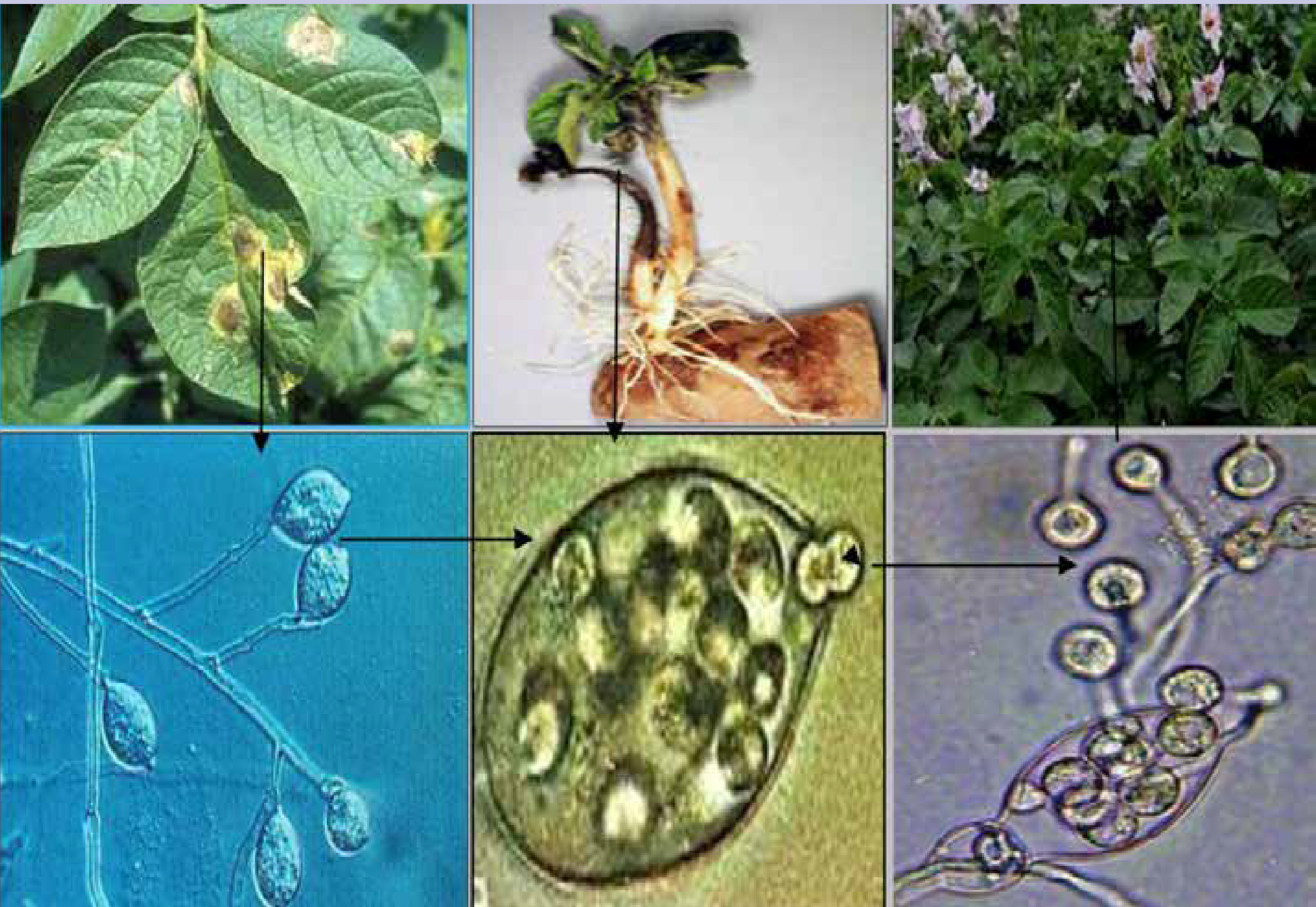
Major Diseases of Vegetable Crops and this Management in Adjara, Georgia



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Abstract

Our dependence on healthy vegetable crops as a reliable source of food transcends all barriers of nation and culture. Consumers now demand excellent quality from the industry that produces large volumes of high quality vegetables to be sold locally, regionally and shipped internationally. The diseases that affect vegetables compromise such quality and therefore are of great importance to grower, shipper, marketer, and consumer.

This book focuses primarily on diseases that are caused by pathogens. With chapters and subchapters written by working on specific vegetables disease, the volume covers many vegetable including Solanum tuberosum, Beta vulgaris, Lycopersicum esculentum, Brasica oleraceae, Cucurbita pepo, Solanum melongena, Cucumis sativus, Daucus sativus, and many more. Chapters dealing with the general principles of the causes, diagnosis favorable conditions for disease development, and the latest management strategies for disease prevention and mitigation in vegetable crops. Each disease entry includes a brief introduction to the disease, detailed description of disease symptoms, information on the pathogen and disease development, and suggestions on how to manage the problem. Top quality color photos illustrate the book throughout.

This book is useful to a range of professionals including research and extension plant pathologists; diagnosticians and plant lab personnel; teachers of agriculture and related subjects; university students in agriculture and related fields; commercial farmers, vegetable producers, and farm managers; agriculturalists in the fields of seed production, vegetable breeding, agrichemicals, pest control, marketing, and other subjects; government and regulatory persons dealing with agriculture; serious gardeners and hobbyists and anyone working with vegetable crops.

Table of Contents

Introduction

Adjara with its characteristic climate, climatic conditions and soils is known to be an important region for growing agricultural crops, including vegetables. People know vegetable crops (including: Potato, Tomato, Solanum melongena, Beta vulgaris, Brasica oleraceae, Phaseolus vulgaris, Cucurbita pepo, Cucumis sativus, Allium cepa, Allium porum, Allium sativum, Capsicum annuum, Daucus sativus, Rapistrum rugosum, Glicinia hispida, Pisum sativus, Coriandrum sativum, Petroselinum crispum, Anethum graveoleus, Ocimum basilicum Latuca sativa et al.) from ancient times. Their importance in the human ration is especially great. Vegetables contain substances essential for the body, such as: vitamins, salts, acids and more. Vegetables are also a source of energy for the human body and play a major role in the functioning and regulation of the nervous system, digestive organs, and enhance the body's resistance to various infectious diseases.

Sustainable, successful and effective development of horticulture is impossible without the knowledge of modern agrarian technologies and its practical implementation. The most important in this respect is the production of environmentally friendly, healthy foodstuffs, which are closely linked to the complex study and solution of plant protection problems.

It has been established that as a result of co-occurence of unenviable abiotic (humidity, temperature, soil erosion, etc.) and biotic (viruses, bacteria, fungi, insects, mites, nematodes, shielded, weeds) factors on plants, crop damage according to plant species fluctuates between 20 to 90%, and is sometimes almost completely destroyed. In this regard, in the conditions of iAdjara, the harmful diseases of vegetable crops, which greatly reduce the productivity and deteriorate the quality of production - are significantly harmful.

The main content of the work

In Adjara, mycological and phytopathological work was carried out by different specialists at different times (Kanchaveli, 1978; Kuprashvili, 2006, Davitadze, 2006; Shainidze, 1999, 2013 2015, 2016, 2017a, b, c, 1919a, b, 2020, 2021, 2022).

Unfortunately, in recent times in the of Adjara, many pathogenic fungi, bacteria and virus have been widely spread on vegetable crops, the composition of which and dominant representatives among them have not been completely studied.

However, there is an invasion of new species causing plant diseases whose systematics, ecology and effective means of plant protection have not been studied at all.

Introduction of planting materials also impose threat in the introduction of new diseases not known to be present earlier. However, the diseases, if not managed on a war foot, it will result in drrastic yield reduction and quality of the produces. Hence adoption of suitable management measures with low residue levels in the final produces becomes as a need of the hour. Modern, effective measures to combat the pathogens spread on certain vegetable crops have not been developed.

That is why it was timely and necessary to study and generalize this problem. Therefore, the topic is relevant and has both theoretical and practical significance.

In this regard with the abovementioned, we set out the following:

- To study and analyse the literature on microbiota and diseases of vegetable crops;
- To obtain factual material through route and stationary surveys;
- To examine the collected mycological material by microscope and specify the composition;
- To Analyse the recorded microbiota according to major systematic groups (taxonomic units);
- To study the diseases of the vegetable crops and identify the dominant pathogens;
- To determine the time of emergence, bioecology, seasonal and zonal development stages of dominant diseases, to identify their relation to seasonal variability and climatic-hydrological conditions;

- To use environmentally friendly biological measures to combat dominant diseases and determine their effectiveness in developing recommendations for researchers, educators, educators, students, industry and anyone working with vegetable crops.

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Chapter I: Materials and Methods

1.1. Description of the Experimental site

Adjara is an autonomous republic of Georgia. Adjara, located in the southwestern corner of Georgia, is on the eastern end of the Black Sea and is bordered by Turkey to the south (Fig.1). Geography and climate Adjara is located on the south-eastern coast of the Black Sea and extends into the wooded foothills and mountains of the Lesser Caucasus. It has borders with the region of Guria to the north, Samtskhe-Javakheti to the east and Turkey to the south. Most of Adjara's territory either consists of hills or mountains. The highest mountains rise more than 3,000 meters (9,800 feet) above sea level. Around 60% of Adjara is covered by forests. Many parts of the Meskheti Range (the west-facing slopes) are covered by temperate rain forests. Climate Adjara is well known for its humid climate (especially along the coastal regions) and prolonged rainy weather, although there is plentiful sunshine during the Spring and Summer months. Adjara receives the highest amounts of precipitation both in Georgia and in the Caucasus. It is also one of the wettest temperate regions in the northern hemisphere. No region along Adjara's coast receives less than 2,200 mm (86.6 in) of precipitation per year. The west-facing (windward) slopes of the Meskheti Range receive upwards of 4,500 mm (177.2 in) of precipitation per year. The coastal lowlands receive most of the precipitation in the form of rain (due to the area's subtropical climate). September and October are usually the wettest months. Batumi's average monthly rainfall for the month of September is 410 mm (16.14 in). The interior parts of Adjara are considerably drier than the coastal mountains and lowlands. Winter usually brings significant snowfall to the higher regions of Adjara, where snowfall often reaches several meters. Average summer temperatures are between 22–24°C in the lowland areas and 17–21°C in the highlands. The highest areas of Adjara have lower temperatures. Average winter temperatures are between 4–6°C along the coast while the interior areas and mountains average around -3–2 degrees Celsius. Some of the highest mountains of Adjara have average winter temperatures of -8–(-7)°C.

In Ajara, soil forming rocks are andesite or basaltic andesite alluviums with strong magmatic intrusive cracks and mostly the combination of exhaustion mechanisms is characteristic to their transformation and translocation which takes place in different directions and determines soil taxon formation. The main objects of research are: Yellow, red, gray, sandy, forest and others soils.

Fig 1. Autonomous Republic of Adjara

1.1.2. Research materials

Potato - *Solanum tuberosum,* Tomato - *Lycopersicon esculentum,* Eggplant - *Solanum melongena*, Cucumber - *Cucumis sativus,* Pumpkins - *Cucurbita pepo*, Cabbage - *Brasica oleraceae,* Beet - Beta vulgaris, Bans - *Phaseolus vulgaris*, Peas - *Pisum sativus,* Pepper - *Capsicum annuum,* Radish-*Raphanus sativus,* Carrot - *Daucus carota,* Celerys - *Coriandrum sativum*, Coriander - *Petroselinum crispum* and Dill - *Anethum graveoleus,* Onion - *Allium cepa,* Leek - *A. porum* and Garlic *A. sativum,* lettuce - *Lactuca sativa*.

1.1.3. Sample collection

The object of the study was 5 ecosystem of the Adjara.The samples were collected from the 38 points: Kobuleti (Cixisdziri, Chakvi, Cecxlauri, Alambari, Mtirala); Khelvachauri (Acharisckali, Akhalsheni, Chutuneti, Gonio, Kvariati, Mirveti, Sameba, Sarfi); Keda (Dandalo, Tshmorisi, Pirvelimaisi, Kvashta, Kokotauri); Xulo (Agara, Didachara, Khikhadziri, Sxalta, Oktomberi, Dioknisi, Danisparauli, Beshumi, Goderdzi, Khikhadziri, Skvana, Sarichairi Mountainous Adjaraet); Shuakhevi (Akhaldaba, Baratauli, Buturauli, Chvana, Gogadzeebi, Kidzinidzeebi, Intskirveti, Shubaniet).

1.1.4. Laboratory material

We used various tools (reagents, materials, tools, equipment, vessels); biosafety cabinets, microscopes, thermostats, analytical scales, centrifuges, digital and professional cameras, spectrophotometers and computers connected to the internet, fungicides, biological preparations, spray apparatus and others.

1.1.5. Research methodology

The work was carried out in 2000 - 2021 at the Plant Protection Laboratory of Batumi Shota Rustaveli State University. Mycological and phytopathological studies were carried in all municipalities of Adjara (Kobuleti, Khelvachauri, Keda, Shuakhevi, Khulo), starting from early spring including winter.Studies of some cultures were carried out throughout Georgia. We conducted selective surveys throughout all the vegetation period as needed. Material was collected and analyzed using familiar methods (Bilai and et al., 1982; Velikanov and et al., 1980; Dudka and et al., 1982; Mishistin and et al., 1987; Foster and et al., 2004). We excluded the symptoms of a diseased plant (decomposition, mummification, wilting, spotting, necrosis, mould, galls, tumor, deformation, chlorosis, mosaic, etc.); we collected the above and underground organs of the diseased plant, labeling, cameral and laboratory processing of material, herbarization, fixation, storage, evaluating the condition of diseased and unaffected plants; we excluded the intensity of disease development and spreading, economic loss, etc.

1.1.6. Sterilization technique

Petri plates, media bottles, distilled water, syringes were sterilized inthe autoclave. For sterilization purpose, all apparatus was autoclaved for 30 minutes at 121°C. After autoclaving, all sterilized material was dried in an oven at 9^{0}C.

1.1.7. Isolation of fungi

For isolation of fungi from plants, the agar method was applied. Fungal pathogens were responsible for disease isolated from the vegetative and generative organs of the plant. From the samples obtained, serial dilutions (1:10) were prepared in test tubes with 9 ml sterile water, adding 1 g of fruit samples until dilutions 10-5, 10-6 and 10-7, of which 50 ìL and shaked at 200 rpm for 3 hours. Samples collected were seeded by duplicate through diffusion technique on Petri dishes of 90 mm diameter containing one of the following artificial Potato Dextrose Aga (PDA) and Czapecks agar medium. After incubation (23oC for 6 days) the number for each fungus was calculated. All fungi were cultured using a single spore technique on PDA and Czapecks medium. After incubation, fungi were identified by their macroscopic and microscopic characteristics.

1.1.8. Identification of fungi

Fungal cultures identification was based on macroscopic characteristics like colony morphology, color, texture, shape and appearance were observed on potatodextrose agar (PDA) and microscopic characteristics like conidia shape, hyphe color, concentric zone, and pigmentation. Species identification was based on the morphological characteristics of single – sporedisolates (Foster, et al., 2004). Collections of the fungi have been examined by standard light microscopy (Pereval, Carl Zeiss, Jena and Olympus, BX50, Hamburg, Germany). The SEM micrographs have been prepared by means of a JSM-35 (Japan) SEM microscope. The specimens examined were deposited at HAL, KW and TGM (Holmgren, et al., 1990).

Different sources were used during the identificacia of microbiota (Saccardo, 1896, 1886, 1888, 1902, 1913; Lindau, 1907, 1910; Ellis, 1971, 76; Khokhriakov, 1984; Watanabe, 2001).

The systematic list of fungi, according to individual taxonomic units, is mainly compiled by Müller and Leffler (Mueller, Leffler, 1995; Watanbe, 2000). Because different researchers - systematists give different variants of mycobiont classification, we favored the classification of world-renowned scientist Agrios (Agrios, 2004), as well as we have been guided by the closest phylogenetic classification adopted at the 67th International Congress of Mycologists (Hibbett, David S.; etc; 2007).

1.1.9. Treatments, Experimental Design and Management Procedures

The experiments consisted of 12 treatment combinations. A plot size of 2.5 m x 1.8 m area, and 0.3 m inter-rows and 0.1 m intra-plants spacing were used during the experiment. Plots and blocks were separated by 1.0 m and 1.5 m, respectively.

There were five rows of plant per plot and the plants were spaced at 0.25 m in each row. The central three rows were used as effective rows for data collection.

Applications of fungicides were done at starting from the onset of the first typical symptom of the disease. Four times spray frequencies of fungicides were employed at seven-day interval as used by Worku (2017). Plants were treated with Apron star prior to planting to prevent untargeted seedborne disease(s) as this fungicide is good for seed treatment and also effective for white rot disease management as suggested by Dilbo et al. (2015). Agronomic practices and regular monitoring were done uniformly to each experimental plot as recommended for the crop in the areas.

1.1.10. Medical material

24 different plant species *(Alium cepa*, *Althaea officinalis, Betonica officinalis, Buxus colchica*,*Corylopsis sinensis*, *Eucalyptus cinerea, Galium aparine, Inula racemosa, Foeniculum vulgare, Hamamelis mollis, Hippophae rhamnoides, Jasminum officinale, Mentha sylvestris, Mentha longifolia, Panax ginseng,Panax ginseng, Pimpinella anisum, Pyrethrum vulgare, Ricinus communis, Rubia coradifolia, Rubia iberica,Salvia officinalis, Sambucus ebulus* and *Stevia rebaudiana*) known for their medicinal value in traditional medicine, were cut into small pieces and dried at room temperature for one week.

1.1.11. Assessment Disease Severity

Disease severityIt was ratted using a 0 to 5 and 0 to 9 disease scoring scale; where, 1 = no infections; 2 = 1-10% leaf area infected; 3 = 11- 20% leaf area infected; 4 = 21-30% leaf area infected; 5 = 31-40% leaf area infected; 6 = 41-50% leaf area infected; 7 = 51-60% leaf area infected; 8 = 61-70% leaf area infected; and 9 = 71-100% leaf area infected as described by Horneburg and Becker (2011). The severity of the disease was also assessed on a scale from 0 to 5.

Disease severity scores were converted into percentage severity as follows

$$Disease\ Severity\ (\%) = \frac{Area\ of\ Diseased\ Tissue}{Total\ Tissue\ Area}\ X\ 100$$

The severity grades were converted into percentage severity index (PSI) for analyses as indicated by Wheeler (1969):

$$\text{PSI} = \frac{\text{Sum of numerical ratings}}{\text{No. of plants scored x maximum disease score on scale}} \text{ X } 100$$

The relative disease severity reduction on untreated and treated plots of the treatment combination was calculated as follows.

$$\text{Relative disease severity reduction (\%)} = \frac{\text{untreated treated}}{\text{untreated}} \text{ X } 100$$

Area under disease progress curve (AUDPC): It was also computed from PSI values for each plot as described by Campbell and Madden (1990).

$$\text{AUDPC} = \sum_{i=1}^{n-1} 05\ (\text{Xi} + \text{Xi} + 1\ (\text{ti} + 1 - \text{ti})$$

Where, n is the total number of disease assessments, ti is the time of the ith assessment in days from the first assessment date and xi is the PSI of disease at the ith assessment. AUDPC was expressed in %-days because severity (x) is expressed in percent and time (t) in days. Disease progress rate: Logistic, ln [(Y/1-Y)] (Van der Plank, 1963), and Gompertz, -ln[-ln(Y)] (Berger, 1981) models were compared for estimation of disease progression rate from each treatment, and the Logistic model was found fit to the data. The goodness of fit of the models was tested based on the magnitude of the coefficient of determination (R2). The transformed data of disease severity were regressed over time (DAT) to determine the model. The model was then used to determine the apparent rate of disease increase (r) and the intercept of the curve.

$$\text{Yt} = \frac{1}{1+exp^{-1n[Yo/(1-Yo)]+rLt}}$$

Percentage fruit infection (PFI): It was recorded as percentage of tomato fruits infected per plant in the middle four rows as the average of 12 plants. Then the score was expressed as a percentage as follows:

$$\text{PFI} = \frac{No.of\ fruits\ infected}{Total\ no.of\ fruits\ assessed}\ X\ 100$$

Assessment of Growth, Yield and Yield Related Traits: Important parameters like days to 50% flowering, days to 50% fruit setting, days to first and last picking, number of branches per plant, number of fruit clusters per plant, plant stand count, yield (t/ha) (marketable, unmarketable and total fruit yields) and single fruit weight (g) were collected.

1.1.12 Data Analysis

Data were analyzed following a procedure appropriate to the design of the experiment as described by Gomez and Gomez (1984) and logistic model and, general linear model (GLM) of SAS version 9.2 (SAS, 2009). The treatment means were separated using the least significant difference (LSD) test at 5% probability level. Correlation and regression analysis was used to determine the relationships between growth, yield and yield related traits, and disease severity and AUDPC across the treatments. It was performed to determine the association of disease parameters with yield obtained from the different fungicide schedules.

Relative yield loss and Yield increase in fruit yield: In addition to the above, relative yield loss from each plot was calculated using the formula suggested by Robert and James (1991):

$$\text{Relative\% yield loss} = \frac{Ybt - Ylt}{Ybt} X\ 100$$

Where, Ybt is the yield of best treatment and Ylt is the yield of lower treatments. At the same time, yield increase, and change in yield increase, over the untreated plots were obtained with the formula:

$$\text{Yield increase over the untreated check} = \frac{\text{Treated} - \text{Untreaded}}{\text{Treated}} X\ 100$$

Cost and Benefit Analysis: Cost and benefit of each treatment was analyzed using partially and marginal rate of return (MRR) as computed by considering the variable cost (fungicides and knapsack sprayer costs and cost of labor for fungicide applications) available for the respective treatment. Price of fruits, in $, of each tomato variety per kilogram was obtained from the contemporary local market at harvest and total sale from one hectare were computed. Costbenefit analysis of each fungicide schedule was made to evaluate the economic benefits expected using the farm gate price of tomato at the time of harvest. Before applying the partial budget analysis (economic analysis) statistical analysis was done on the collected data to compare the average yields between each treatment to determine the economics of the disease management. With this, there were significance differences among the treatments. MRR was calculated using (CIMMYT, 1988):

$$\text{MRR}\ \% = \frac{\text{DNI}}{\text{DIC}} X\ 100$$

Where, DNI = difference in net income compared with control, and DIC = difference in input cost compared with control. During cost benefit analysis using partial budget important points were considered; costs for all agronomic practices were uniform for all treatments; cost of labor and spraying equipment were taken based on the prevailing rates of payment in the locality; costs, return and benefit were calculated on hectare basis; and it is assumed that farmers produce this variety under integrated management of tomato late blight when the variety provided 100% marginal rate of returns.

Chapter II. Major Diseases of Potato - *Solanum tuberosum*

Introduction

Potatoes (Solanaceae) are a staple food and occupy a prominent place in many national cuisines. They almost complete food product, providing all the necessary nutrients. Potatoes has a worldwide increasing value (Birch et al., 2012) and considered to be the fourth most important food crop (wheat, maize and rice), is cultivated in temperate and subtropical regions across the world.

In Georgia, there have been significant advances in food production over the past six decades, in connection with the adoption of improved techniques, including high-yielding varieties of potatoes. Unfortunately, potato production is constrained primarily due to biotic and abiotic stresses. The yield of potato is sharply reduced by fungal, bacterial and viral pathogens.

Results and Discussion

The research conducted in 30 years (1990-2020) showed us that the potato microbiota is rich and diverse. A total the following species of 29 fungi and fungus-like organisms are registered on potato culture by us (*Spongospora subterranea, Pythium deliense, Phytophthora cryptogea, Phytopthora infestans, Synchytrium endobioticum, Mucor sp., Gibberella pulicaris, Botryotinia fuckeliana, Mycovellosiella concors, Cercospora solani, Polyscytalum pustulans, Sclerotinia sclerotiorum, Aspergillus niger, Penicillium citrinum, Botrytis cinerea, Alternaria alternate, Alternaria solani, Fusarium equiseta, Fusarium crookwellense, Verticillium albo-atrum, Verticillium dahlia, Helminthosporium solan, Colletotrichum atramentarium, Colletotrichum coccodes, Septoria lycopersici var. malagutii, Macrophomina phaseolina, Phoma solani-cola f. foveata, Rhizoctonia solani* and *Athelia rolfsii*), 3 spesies virus (*Potato virus A, Potato virus X, Potato Virus Y*) and 1 species bacteria (*Ralstonia solanacearum*), as a result of phytopathological and mycological studies carried out in different places in industrial regions.

It was established that, mong the total microbiota, Late Blight - *Phytophthora infestans*, Early blight - *Alternaria solani*, Potato cancer - *Synchytrium endobioticum*, Dry rot - *Fusarium solani*, Bacterial Wilt - *Ralstonia solanacearum*, *Potato virus A* and *Potato Virus Y*, they are of the most devastating potato maior diseases.

2.1. Fungal diseases

2.1.1. Late Blight of Potato - *Phytophthora infestans*

Introduction

Potato late blight caused by the fungus *Phytophthora infestans* (Mont.) de Bary (Oomycetes) is one of the most important diseases of potato (*Solanum tuherosum*). Leaves and tubers of susceptible cultivars become readily infected by this pathogen. The fungus spreads rapidly through the plant tissue, causing a destructive necrosis.

Late blight was a major culprit in the 1840s European, the 1845 Irish and 1846 Highland potato famines. The organism can also infect tomatoes and some other members of the Solanaceae. In the world, this disease causes about $ 6 billion damage to crops each year (Chand, Sudeep, 2009; Nowicki, Marcin; et al., 2011, 2013). Direct cash costs of efforts to control and production losses are estimated only Potata> $ 3 billion / year worldwide CIP, 1996). In this regard, at least, have a bad situation in Georgia. In the Georgian Republic under favorable cold and wet conditions and without any corresponding levels of regulation against the pathogen, *P. infestans* can lead to almost 100% reduction in crop yields; therefore, potatoes can not be controlled without frequent fungicide applications for the effective control of the disease. Even now, more than 170 years after it was first associated with the potato late blight disease in Europe and in North America, P. *infestans* remains a major problem in agriculture and recalcitrant to low-input, stable disease suppression. Despite the fact that considerable progress has been made in the understanding of its basic biology, ecology and pathogenicity (Coffey, Wilson, 1983; Bourke,1991; Andrivon, 1996; Fay and Fry, 1997; Forbes et al.,1997; Turkensteen et al., 2000; Smart et al, 2000; Vleeshouwers et al., 2000; Aylor et al., 2001; Garrett et al., 2001; Lee et al., 2002; Grunwald et al., 2002b; Judelson and Roberts, 2002; Cvitanich and Judelson, 2003a, 2003b; Madden and Wheelis, 2003; Stewart et al, 2003; Fernandez-Pavia et al, 2004; Latijnhouwers et al., 2004; Grunwald and Flier, 2005; Whisson et al., 2005; Tani and Judelson, 2006; Mizubuti and Fry, 2006; Flier et al, 2007; Whisson et al., 2007; Widmark et al., 2007), and there are a lot of books (Dowley et al., 1995), thousands of scientific articles and thousands of popular reports, as well as many historical processes (Turner, 2005); etc., P. infestans is still a serious problem in agriculture. In Georgia, a considerable amount of research has been devoted to date on various aspects of relations P. infestans potato (Kanchaveli, 1978; Shainidze, 1999, 2013; and et al.). Here we look at the current state of the patogena.

Results and Discussion

Symptoms

Among the total microbiota, late blight is one of the most devastating potato diseases In Georgia.

Common symptom of the disease is the "Leaf Blight", which is found everywhere. Lesions on leaf blades can be extended to the shell sheet. Defeat increases in length and width, and may also have wavy edges.

Long-term monitoring showed that in Georgia potato rot is identified by black or brown lesions on the leaves and stems (Figure 1), which at first glance it may seem that small and watery or have chlorotic borders, but soon quickly expand and become necrotic.

Infected tubers occur when sporangia are washed from the leaves into the soil. Infections generally begin in tuber cracks, eyes or lenticels.

Fig. 1. Symptoms of late blight on the leaves, stems and tuberes of potato

Sometimes, during storage, infected tubers may be covered with different colored mycelia (Figure 2), which includes 11 species of fungi (*Alternaria solani, Aspergillus niger, Botritis cinerea, Fusarium solani, F. moniliforme, Mucor sp., Penicillium citrinum, Phytophtora infestans, Sclerotium rolfsi, Rhizoctonia solani* and *Rhizopus psapzzh*).

Some are plant pathogens causing root and stem rot, vascular wilt or fruit rot. Other species cause storage rot and are important mycotoxin producers. Several species, notably Fusarium moniliforme, F. oxysporum, and F. solani, are recognized as being pathogenic to man and animals (Kriek Kellerman and Marasas, 1981; Kriek Marasas and Thiel, 1981).

It should be noted that a wide range of microbiota tubers (Consortium, Association) marks the first time in Georgia (maybe all over the world).

Observations have shown that the formation of consortium of begins when the temperature reaches - 20°C, and the optimum temperature is about 22 °C. High air humidity (90-95%) accelerates the formation of the consortium. Currently, research is ongoing to discover the initiator of the fungus, taking part in the creation of the consortium and to determine the relationship between the fungi involved in it.

Fig. 2. Symptoms of consortium the Infected tubers

Life cycle

In humid conditions, late blight produces sporangia and sporangiophores on the surface of infected tissue. This leads to a significant increase in white sporulation at the forefront of defeats on the abaxial (lower) surfaces of the leaves and stems (Figure 3).

Sporangiophores grow out of diseased tissue. Sporangia are released into the atmosphere for aerial dispersal during a drop in relative humidity, or they can be dispersed in water splashes. Indirect germination releases zoospores, which, after encystment and germination on host tissue, produce lesions visible after 2– 4 days.

It has been found that in humid areas (Ajara) Georgia sporangia are formed, when the relative humidity is 89%, and in mountainous areas - 90-91%. Sporulation can occur from 3,5 -26,5°C, but the optimum range is 18-22°C. Sporangia germinate directly via a germ tube at 21-26°C. Below 18° C, sporangia produce 6 to 8 zoospores which require water for swimming.

Each zoospore is able to initiate an infection, which explains why the disease is more severe in cool, moist conditions.

After colonization leaf tissue Sporangiophores exit stomata thousands forming sporangia which can be moved by wind or rain, and eventually infect plants close or distant range. Almost similar findings were made by foreign researchers (Pristou and Gallegly, 1954; Coffey and Wilson, 1983).

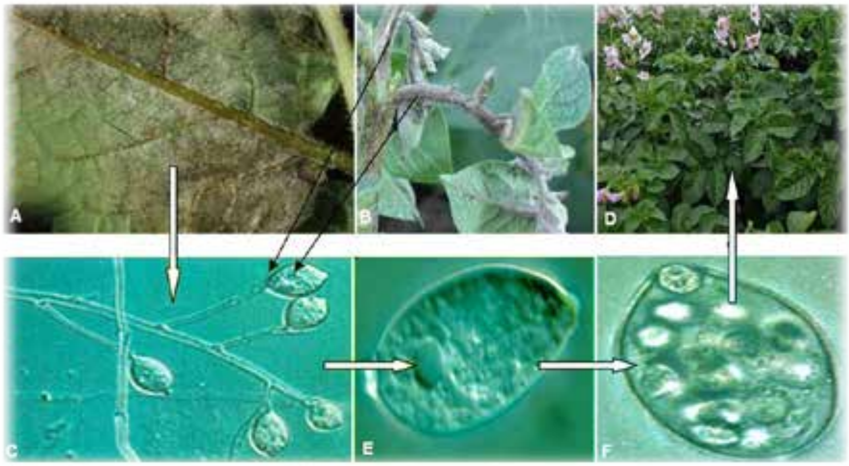

Fig. 3. Asexual life cycle of *P. infestans*: A, B, C - Sporangiophores grow out of diseased tissue

D - Sporangia are released into the atmosphere; E - Indirect germination zoospores, which produce lesions;

F - visible after 2– 4 days.

Solanum tuberosum as a host, the asexual life cycle of P. infestans can be completed rapidly with production of massive numbers of sporangia that are readily dispersed—explaining why whole fields can be transformed from slightly diseased to nearly completely destroyed within just a few days.

Development and Spreading

Late blight struck the growing plants as a frost in summer. It spread faster than other dangerous diseases.

The leaves, stems and tubers are all susceptible (Figure 4), so that the potato late blight pathogen, certainly deserves the name Phytophthora, "plant destroyer."

As a result of monitoring (2013-2015) it was established that late blight potato is characterized with different spread and intensity in different geographical zone.

Adjarian lowland is distinguished with high spreading of potato late blight (Figure 5), where the spread of the disease is 92%. Area under potato crops of Kvemo Kartli Plain is characterized with the lowest spread, where it reaches 44 %.

Fig. 4. The speed with which late blight can destroy a field of potatoes is impressive:

A - healthy plant before flowering; B - siptomy affected leaves next week; C, D - and within another week can be totally destroyed.

Investigations of areas under potato crops showed that inspite of sorts (Jelly, Europlant, Picasso, Marfona, Agria et al) diversity spreading late blight of potato fluctuates within 70-75 in The Samtskhe-Javakheti Region.

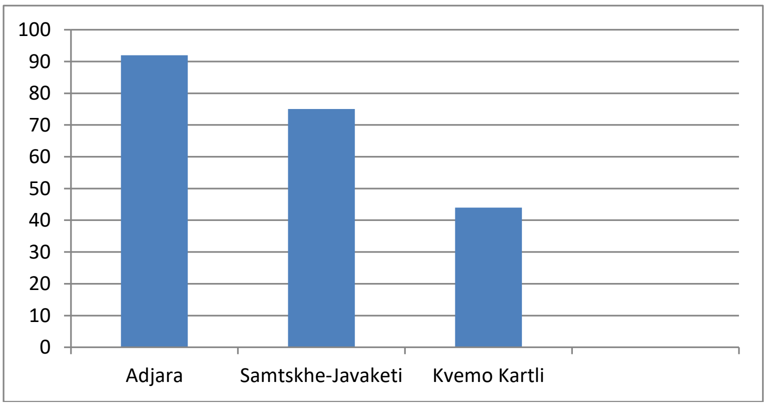

Fig. 5 Spread of potato late blight according to zones in Georgia

As spreading late blight of potato so intensity of disease development are comparatively high in Adjarian Lowland. Disease development intensity index in Adjara reaches 53% (Figure 6). Intensity of development potato late blight is comparatively low 32-35% in areas under potato crops of Samtskhe-Javakheti and Kvemo Kartli.

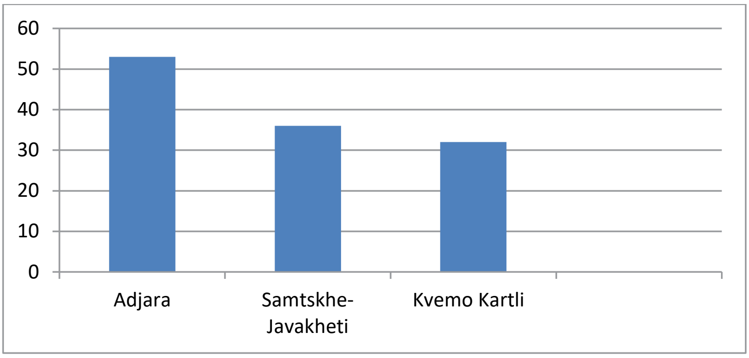

Fig. 6. Spreading of potato late blight according to regions in Georgia

Intensity of spreading and development potato late blight according to regions was established by us. Results of monitoring showed that the high indicator spreading of late blight potato was fixed under potato plantations of Khulo, Shuakhevi, Keda, Khelvachauri and Kobuleti regions where spreading late blight potato reaches 87-92%. Comparatively low spread of late blight potato (from 32-73 %) was fixed under potato plantations of Tsalka, Adigeni, Aspindza, Borjomi, Ninotsminda, Akhaltsikhe and Akalkalaki. Late blight Potato is spread the least (30-39%) in Bolnisi, Gardabani, Dmanisi, Marneuli and Tetritsqaro (Figure 7*)*.

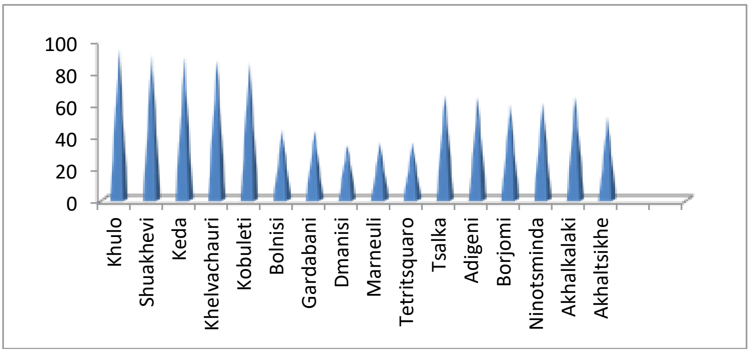

Fig. 7. Intensity of development of late blight potato according to zones in Georgia

Studies have shown that the intensity of the potato late blight development in general has been fixed at the average level for the regions (Figure 8) Areas under of potato crops of Khulo and Shuakhevi are distinguished with comparatively high intensity of spreading potato late blight and disease development where the intensity reaches up to 53%. Comparatively low indicator (31-34%) Tsalka, Adigeni, Aspindza, Borjomi, Ninotsminda, Akhaltsikhe and Akalkalaki.

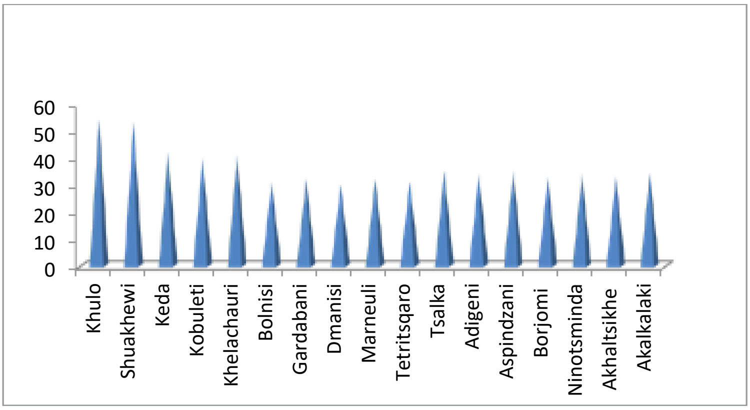

Fig 8.Intensity of spreading potato late blight according to regions in Georgia

Intensity of spreading potato late blight is the lowest in areas under potato crop of Bolnisi, Gardabani, Dmanisi, Marneuli and Tetritsquaro. Its indicator is only from 26-30%. These five regions are distinguished as with low indicator of spreading potato late blight so with the low frequency of development intensity.

Disease control

Eco-friendly and economically sound tactics to suppress late blight is the immediate goal of many researchers and this objective is also an incentive for a wide range of fundamental research by many scientists. At present, the most reliable approach for integrated management, using an array of tactics, including planting healthy seed tubers, eliminating the source of the pathogen farm, using "resistant" varieties and fungicide application in response to a real need as determined by scouts or forecast.

The test of varieties of potatoes

The test of 12 varieties (Table 1) of potatoes shows significant differences in the resistance of varieties. In 2013-2015 years, the highest disease severity was on the Nevsky and Picaso variety, the highest resistance to diseases manifested German variety – Kardena, Russian – Sante, Finland– Katu and Holland variety - Desire.

Increasing the severity of the disease it was noted research years on all grades. In particular, in 2013 the development of late blight was 23.8%, it was 37.7% in 2014, while it reached 41.4% in 2015. Very high incidence of potato (100%) was observed in 2015 on Russian variety Nevsi and Picaso. This year warm days, and extended wet conditions with rain and fog led to a late blight epidemic, which in less than two weeks, destroyed all the potato.

It was found that every year the loss of potato late blight reached from 5 to 92 percent, depending on location, time of year, weather conditions and cultivars.

Tab. 1. Defeat varieties of potato late blight on years,%

№№	Potato varieties	2013		2014		2015		Average	
		Development	Spreading	Development	Spreading	Development	Spreading	Development	Spreading
1	Arinda	35,9	43, 3	53,5	96,7	59,7	97,0	49.7	65.9
2	Average	19,8	30,0	56,7	97,7	58,2	98,4	44.9	75.4
3	Desire	6,4	13,3	10,4	26,7	9,9	14,0	8.9	18.0
4	Kardena	7,7	15,8	9,2	16,8	8,5	21,2	8.46	17.9
5	Katu	7,9	14,8	12,3	23,3	10,1	24,1	10.1	20.7
6	Marfona	21,8	63,3	29,6	96,7	56,7	70,0	69.4	76.7
7	Nevski	46,0	64,8	63,3	95,3	76,2	100	61.8	86.7
8	Picasso	45,4	64,3	63,7	94,3	76,7	100	61.9	86.2
9	Sante	-	–	–	-	7. 8	12.6	7. 8	12.6
10	Jelly	41,8	73,3	69,0	56,5	50,7	70,0	53.8	66.5
11	Wital	21,2	66,6	66,7	97,7	70,7	88,0	52.7	84.1
12	Redpantazi	32,4	49,1	18,5	83,8	15,0	61,0	23.0	64.6
	Average	23.8	41.5	37.7	65.6	41.4	63.0	32.5	56.3

Biological Control

The biological method used against Phytophtora infestans proved to be the most effective among the agro-technical, sanitary – hygienic, chemical and other types of controls. In particular, the antagonist fungus Trichoderma viride (Trichoderma lignorum) was used against pathogens. Soil was tilled with 4% of the suspension (400 gm of T. viride per 10 Lin 5 m^2 area) prior to planting the potatoes. In this case, the percentage of infection of plant was 7.2% in a field. The biological efficiency was equal to 83.2. In the control variant, the percentage of infection of plant (without introducing the antagonist into it) was 92.3%. The experimental results have shown that the harvest and economic efficiency respectively are increasing, which were equal to 29.3% in a field.

2.1.2. Early blight of potato - *Alternaria solani*

Across the Adjara, early blight (foliar infection) is the most problematic of the disease. The disease first develops on mature and senescing foliage, and early maturing cultivars are the most susceptible. Potato is the primary host, but the disease also can be severe on tomatoes, and occur on other solanaceous plants.

Symptoms

The first symptoms of early blight appear as small, circular or irregular, dark-brown to black spots on the older (lower) leaves (Figure 9).

Initial lesions on young, fully expanded leaves may be confused with brown spot lesions. These first lesions appear about two to three days after infection, with further sporulation on the surface of these lesions occurring three to five days later.

Early blight lesions can be diagnosed in the field easily due to the dark concentric rings alternating with bands of light-tan tissue, giving them a distinctive target spot appearance.

Elongated, brown to black lesions also may develop on stems and petioles of infected plants.

Symptoms of early blight infection on tubers appear as dark and sunken lesions on the surface (Figure 9). Tuber lesions may be circular or irregular in shape and can be surrounded by a raised dark-brown border.

Disease Cycle

The primary infection of potato foliage by *A. solani* is caused by inoculum provided from other infected hosts or inoculum that overseasoned on infected plant debris. Overwintering spores that serve as the initial inoculum move within and between fields carried by air currents, windblown soil particles, splashing rain, and irrigation water.

Following initial infection, sporulation occurs on lesions, and spores are dislodged under conducive environmental conditions. Alternating wet and dry periods are most favorable for sporulation and dispersal. The spores produced by primary inoculum are responsible for secondary spread of the fungus to healthy tissue, which leads to an exponential increase of foliar infection.

In addition to survival on infested plant debris, spores and mycelia of *A. solani* can survive between growing seasons in infected potato tubers and in the overwintering debris of other susceptible solanaceous crops and weeds, including tomatoes and hairy nightshade. Additionally, spores can survive freezing temperatures on or just below the soil surface.

During harvest, tubers often are contaminated with *A. solani* spores that accumulated on the soil surface during the growing season or were dislodged from desiccated vines. Germinated spores penetrate the tuber epidermis through lenticels and through wounds on the tuber surface caused by mechanical injury.

Secondary spread of infection does not occur on stored potato tubers and, unlike late blight tuber lesions, early blight tuber lesions usually do not serve as infection courts for other decay organisms.

Fig. 9. Symptoms of Early blight on the leaves and tuberes of potato

Management

Removal of infected plant debris. Use of disease free seeds. Crop rotation with non solanaceoues crops. Spraying Mancozeb 2g/lit. or copper oxychloride 2.5 g/lit twice at 12 days interval

2.1. 3. Potato cancer - *Synchytrium endobioticum*

Introduction

Potato cancer is the second most prevalent disease in potatoes, which is caused by the obligate biotrophic, soil-borne fungal pathogen Synchytrium endobioticum. As potato producers in Georgia do not practice the local selection and seed production, potatoes are imported from Armenia, Turkey, Germany, Iran, the Netherland, and other countries. Some potato cultivars Marfona, Picasso, Agria, Finka, Impala introduced in Georgia in 90th years of the previous century still are cultivated despite their susceptibility to the wart.

Synchytrium endobioticum is thought to be indigenous to Peru, where the potato originated. In the early 1900's S. endobioticum spread throughout Western Europe by infected seed tubers. The pathogen included on A2 quarantine list of EPPO occurs locally in almost all countries in the EPPO region, including Georgia where it was first reported in Georgia in 2009, without knowing the pathotypes, at the villages of Tabakhmela and Didajara in Khulo Municipality. In 2010-2012, the disease was found in other villages in Khulo on varieties Agria, Finka, Picasso and Marfona.

Potato wart (PW) is a very harmful disease. The diseased tubers are unmarketable because of proliferating warts on potato tubers, formed during the growing season that may continue developing after harvest. The resting spores of the causative agent survive in soils and can be infectious for 20-50 years. Therefore, infested plots cannot be used for potato production for more than 20 years after the detection of the pest. Yield losses may vary between 50-100 % under conditions favorable to the disease development.

Furthermore, the fungus develops new pathotypes that are a serious threat to disease control because a new pathotype can infect already existing resistant potato varieties to PW.

Syptoms

Large tubercles appear on diseased tubers, that are small at initial stage, the size of maize grains, then gradually grow to the extent that thay are larger than tubers. On the same tuber, there may be a few tubercles causing the destruction of the tubers.

During the potato field surveys conducted in the Municipalities of Khulo and Shuacxevi cauliflower-like warty proliferations of different shapes and sizes were observed on potato stolons, stem bases and tubers. Warts of various sizes (2-20 mm) occurred on potato tubers obtained initially whitish color and then gradually were darkened and eventually were rotten and decayed (Figure 10). Above-ground warts occurred on potato plant stem bases were initially green but they became black later in the season.

Symptoms were not observed on the roots and leaves of the potato plants. The presence of the pathogen in samples of infected plants was determined by microscopic analysis.

As a result of microscopic analysis, the spherical to ovoid in shape, 50 μm in diameter, aseptate, and golden brown, thick-walled winter sporangia were observed in plant tissue.

Development and Spreading

In order to study the disease incidence and severity, we conducted systematic surveys of potato fields during the growing seasons, harvest and storage in 2016-2018 in 2 geographical areas of Adjara (Khulo, Shuakhevi). The examined fields were located at an altitude of 900-1500 m above sea level. 64 and 5 fields were respectively infected in Khulo and Shuakhevi municipalities. Therefore, the disease intensity was 74% in Khulo and 38% in Shuakhevi. According to the potato fields and storages studied in the Khulo region, the disease severity varied between 1–9 klasses. Small (2-4 classes) and medium (5 class) proliferation of warts distributed mainly in the fields. According to field trials conducted in Khulo in 2019–2020, the average disease index was 53.8%. Specifically, samples were taken in 18 villages of Khulo district: Bodzauri, Begleti, Geladze, Gorgadzebi, Gurdzauri, Daniparauli, Dekanashvilebi, Diakonidzeebi, Didachara, Dioknisi, Vanadzeebi, Mtisthina, Mintadzeebi, Okruashvilebi, Rakvta, Vernebi, Skvana and Baco.

Fig. 10. Symptoms of Potato cancer on the tuberes of potato

Control

Due to the fact that chemical control of the pathogen in the soil is almost imposible, the only available strategy to prevent further spread of the disease is to apply strict phytosanitary measures combined with the cultivation of potato varieties resistant to the pathotypes present in the infested fields.

2.1.4. Dry rot - *Fusarium solani*

Dry rot is probably the most important cause of postharvest potato losses in the Adjara. Dry rot is caused by several fungal species in the genus Fusarium, thus the name Fusarium dry rot. The most important dry rot pathogen in the Adjara is Fusarium solani.

Symptoms and Signs

Fusarium dry rot is characterized by an internal light to dark brown or black rot of the potato tuber- and it is usually dry. The rot may develop at an injury such as a bruise or cut. The pathogen penetrates the tuber, often rotting out the center. Extensive rotting causes the tissue to shrink and collapse, usually leaving a dark sunken area on the outside of the tuber and internal cavities. Yellow, white, or pink mold may be present (Figure 11).

Disease Cycle

F. solani are commonly found on seed tubers but also survive for very long periods in the soil. Seed pieces decay when the pathogens infect cut or injured surfaces or when seed tubers are infected before cutting. Tubers begin to rot either while they are being held after cutting or after they are planted. Precutting seed puts the tubers at risk for Fusarium dry rot. The pathogen can move into the tuber through the cut surface and quickly rot the seed piece.

The severity of dry rot in storage depends on the magnitude of injury. In storage the progress of the disease is limited primarily by temperature: the colder the temperature, the slower the disease will progress. Young tubers appear to have some resistance to dry rot which slows disease. Dry rot progresses noticeably faster during the last half of the storage season.

It was found that tuber rotting, wilting and drying of separate vegetative organs are caused by the following pathogenic fungi: *Spongospora subterranean, Rhizoctonia solani, Oospora pustulans, Vericillium alb – atrum, Fusarium oxysorum f. Solani, Macrosporium solan, Alternaria solani and* Cercospora concors.

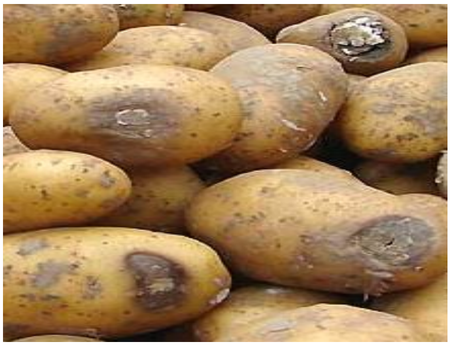

Fig. 11. Symptoms of Dry rot on the tuberes of potato

Management

Most techniques for managing dry rot are aimed at preventing injury to the tubers, either seed or the harvested crop.

2.2. Bacterial diseases

Bacterial Wilt - *Ralstonia solanacearum*

Introduction

Bacterial wilt also known as brown rot is caused by Ralstonia (Pseudomonas) solanacearum E. F Smith, a soil-borne bacterial species. It is one of the most destructive plant diseases which is predominantly distributed in the tropical, subtropical and warm temperate regions of the world. It affects as many as 200 plant species representing more than 50 families of particularly members of solanaeceous plants such as potato, tomato, eggplant, pepper and tobacco.

In Adjara, R. solanacearum is one of the most important pathogens, threatening the production of potato and tomato in different parts of the region.

Factors Favoring the Disease

The Ralstonia solanacearum can survive for various periods of time in the soil, depending on the conditions to which it is subjected. Pathogen can survive in the soil for a few months to a few years. Wet soil conditions and moderate temperatures usually favor the survival of the bacteria. Moreover, plant debris and rotting tubers help the pathogen to survive from season to season in the absence of host crops. Pathogen is more adapted to cooler climates but its virulence and density will decline when temperatures drop below 14°C and drastically below 3°C.

Therefore, long-term survival ability of the brown rot pathogen in soils of temperate countries is significantly reduced. R. solanacearum can spread in waterways, and is known to survive for long periods of time in water. Contaminated irrigation waters help in the spread of the pathogen from field to field. Some weeds can act as reservoir plants allowing the pathogen to survive, multiply and spread to contaminate new lands. Like almost all bacterial phytopathgens, R. solanacearum enters into plants via wounds made by tools during post emergence cultivation, and by nematodes and insects in the soil or natural openings. The presence of the bacteria inside the xylem coupled with the production of exopolysaccharides will block the vascular vessels inducing a water shortage throughout the plant. This causes the plant to wilt and eventually die.

Management

The control include the use of resistant variety, crop sanitation, crop rotation, selection of disease free planting material and other cultural practices as single or integrated disease management have met, if at all, with only limited success.

2.3. Viral diseases

Introduction

Potatoes may be infected with many different viruses that can reduce tuber quality and yield. Mosaic virus of potatoes is one such disease that actually has multiple strains. Potato mosaic virus is divided into three categories. Symptoms of the different mosaic virus of potatoes may be similar.

The presence of more than one of the viruses in a plant usually affects the types of symptoms and increases symptom severity. Symptoms caused by different viruses can be similar, so the type of virus usually cannot be identified by symptoms alone. Field diagnosis is often limited to calling it “mosaic virus”. Positive identification o f the exact virus (es) requires the use of indicator plants, serological or DNA techniques.

2.3.1. Potato virus A

Potato virus X (PVX, genus Potexvirus, family Alphaflexiviridae) was one of the first potato (Solanum tuberosum) viruses described.

Infection of Potato virus A appears as light yellow mottling with slight crinkling on potato plants with mild mosaic (Figure 12a). Margins of affected leaves may be wavy, and leaves may appear slightly rugose (i.e., rough) where veins are sunken and interveinal areas are raised. Affected plants tend to open up because the stems bend outward. Severity of symptom expression depends on weather conditions, the potato cultivar, and the strain of Potato

It is one of over 50 viruses now found infecting potato crops around the world and, historically, has been the subject of much research. It is spread by contact between healthy and infected foliage or roots of potato, tobacco and tomato plants. It also spreads by contact when PVX-contaminated machinery moves through potato crops and from tuber-to-tuber when potato tubers are cut with PVX-contaminated knives before planting. No specific PVX vectors have been found despite a wide range of invertebrate species being tested, and it is not transmitted via true seeds of infected potato plants. PVX strains differ in virulence, mostly causing mild leaf mosaic symptoms, but severe strains cause obvious mosaics. PVX infection usually depresses the yield of potato tubers by 5–20%, but up to 40% with severe PVX strains.

Fig.12a. Syptoms of potato virus x on leaf

2.3.2. Potato Virus Y

Potato virus Y (PVY) is a plant pathogenic virus of the family Potyviridae, and one of the most important plant viruses affecting potato production.

Potato virus Y can have the most severe impact of the mosaic viruses, depending on the virus strain and potato cultivar. Symptoms include mottling or yellowing of leaf lets, leaf crinkling, and sometimes leaf drop.

In the mountainous municipalities of Adjara (Khulo, Shuakhevi and Keda), PVY infection of potato plants results in a variety of symptoms depending on the viral strain. The mildest of these symptoms is production loss, but the most detrimental is 'potato tuber (Figure 12b) necrotic ringspot disease' (PTNRD). Necrotic ringspots render potatoes unmarketable and can therefore result in a significant loss of income. PVY is transmissible by aphid vectors but may also remain dormant in seed potatoes. This means that using the same line of potato for production of seed potatoes for several consecutive generations will lead to a progressive increase in viral load and subsequent loss of crop.

An increase in potato plant infection with viruses over the past few years has led to considerable losses to the Agjara potato industry. The increased rate of infection may be attributed to several factors. These include a marked decrease in the effectiveness and administration of chemicals used in vector control, the use of infected seed potatoes in cultivation, incorrect irrigation and farming methods as well as a lack of a sensitive, rapid and reliable method of detection.

An increase in the average temperature of winters as a consequence of global warming has also led to an increase in aphid numbers, which in turn has led to an increase in viral distribution.

Fig.12b. Syptoms of potato virus Y oleaf and tuber

Control

Use of disease-free potato seeds; Use of resistant crop varieties; Proper practices of integrated pest management. For example removal of any potato plant that is showing symptoms of the disease.

This method will prevent the spread of disease into the field; Use of insecticide to kill the aphid population from the field that may serve the virus inoculations into the plant and spread: Use of natural predators of aphids to prey on them because a small number of aphids can transmit virus over the whole potato crop.

Chapter III. Major Diseases of Tomato - *Lycopersicon esculentum Mill*

Introduction

Tomato is the second most important remunerable solanaceous vegetable crop after potato. Tomato is commonly consumed in our daily life and it is a good source of antioxidants (Sgherri et al., 2008). With high nutritional value, it provides a balance source of Vitamin A, C and E needed to maintain good human health (Olaniyi et al., 2010). Varied climatic adaptability and high nutritive value made the tomato cultivation more popular in the recent years. At present, in Georgia average production of tomato is 9.8 tons per hectare which is quite low as compared to other tomato growing countries such as USA (89.33 t/ha), China (52.98 t/ha), Egypt (43.53 t/ha), Turkey (36.44 t/ha) India (21.30 t/ha) and Pakistan (10.51 t/ha) (Gondal et al., 2012; Shainidze, 2009, 2014).

Unfortunately, the yield of tomatoes is sharply reduced by fungal, bacterial and viral diseases.

On tomatoes *Lycopersicum esculentum* Mil. (Solanaceae) 32 species and 6 formes of fungi, 2 species bacteri and 3 species virus were identified as a result of phytopathological and mycological study of different areas (coastal and mountain agrocenosis) Georgia and its neighboring Artvin (Turkey).

Among the diseases found in Agjara, the most dangerous and widespread is Tomato vilt - *Fusarium sp. new*., Leaf blight - *Phytophthora Infestans, Ph. parasitica,* Septoria leaf spot - *Septoria lycopersici*, Bacterial spot - *Xanthomonas campestris pv. vesicatoria*, Bacterial canker - *Clavibacter michiganensis subsp. Michiganensis*, Tomato Mosaic Viruses (TMV), Tomato Spotted Wilt Virus (TSWV) and Cucumber Mosaic Virus (CMV).

3.1. Fungal diseases

3.1.1. Tomato vilt - *Fusarium sp. new*.

Were held by scientific expeditions to determine the distribution of Fusarium wilt in Georgia in 2012-2016. The annual disease survey was conducted across 2 geographic zones and 5 regions of Georgia.

The etiology of Fusarium wilt study revealed that the main causative agents of disease were *Fusarium sp. new.* (56 %), in the second place is *Fusarium oxysporum f. Sp. lycopersici* (41%), slightly spread *Fusarium oxysporum f. sp. radicis-lycopersici* (13%) (Figure 13). Experiments show that *Fusarium sp. new.* mostly is found in the subtropical zone of Adjara (Georgia).

In particular, it causes the withering of leaves, the rapid swelling of roots, the fruits falling off and rotting, the wilting of an entire plant for the period of ripeness. The same data were noted by various researchers (Etebarian, 1992). According to their data, the members of the genus - Fusarium spreading to tomato plants are able to reduce not only the harvest, but also to wither an entire plant in the different parts of the world.

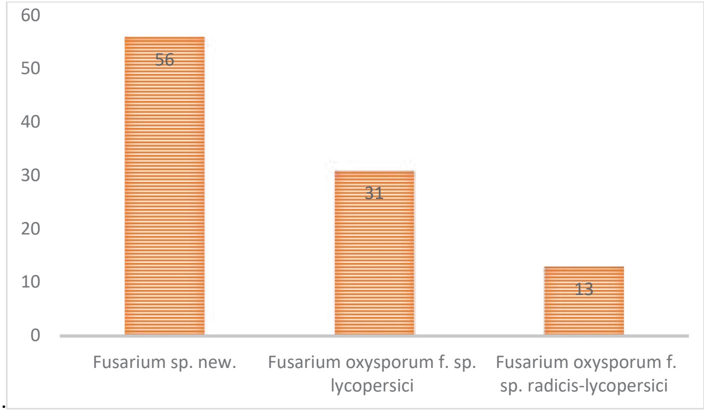

Fig. 13. Distribution of Fusarium wilt by species in Georgia, %

Laboratory studies showed that the fungus is characterized by rapid growth in pure culture. Carnation leaf pieces on agar (of CLA), the fungus forms slimy colonies, and then it is covered with a thick, aerial hyphae of white to light purple color (Figure 14). The fungus produces three types of spores: Macroconidia (Fig. 15, A) Microconidia (Figure 15, B), and chlamydospores (Figure 15,C). Macroconidia are spindle-shaped, less ellipsoidal, 20-65×2.5-5 mm, with pointed tips at both ends with five-septate (by determinant 3-5 septate less); whereas micro-conidia are non-septate, elliptical, less cylindric, 20-21.3×1.5-3 mm (by determinant, microconidias are oval, colorless and one-two-celled). Micro - conidia are born on simple phialides arising laterally, elliptical, less cylindrical, 20-21.3 × 1.5-3 mm (by determinant, microconidias are oval, colorless and 1-2 septate). Chlamydospores colorless, oval, elliptic, 5-15 mm, smooth and rough walls, abundant and form terminally or on the basis of a leap. They are usually solitary but sometimes in pairs or chains.

Fig.14. Cultures of *Fusarium sp.* showing purple and pink pigmentation

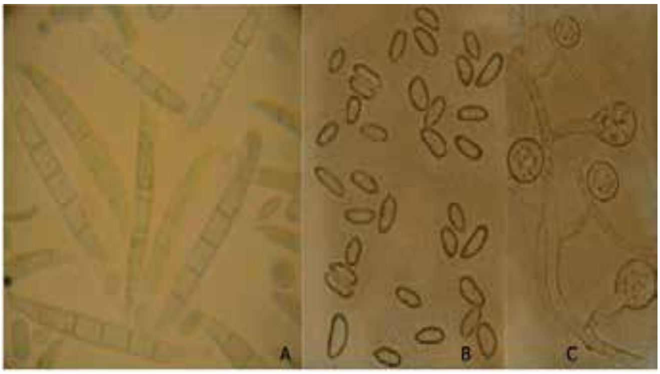

Fig. 15. Spores of *Fusarium sp.*

A – Macroconidia, B – Microconidia, C - Chlamydospores.

Symptoms

Long-term observations have shown that the first signs of infection appear before ripening the fruit. The symptoms appear on older leaves and then they turn yellow, wilt and die. Yellowed and wilted leaflets drop early. A plant wilts and dies rapidly in a case of the strong development of disease. An entire plant may wilt in hot, cloudy and wet weather conditions within a day (Figure 16).

The root system of the diseased plant gradually turns brown and the tap-root begins to rot off (Figure 17). The brownish spots appear on the stem close to the soil surface. If the main stem is cut, dark brown streaks may be seen running lengthwise through the stem. This discoloration often extends far up the stem and is especially noticeable in a petiole scar (Figure 18).

The observations have shown that the disease is not initially seen on the fruits. Then water-soaked spot appears on basal ends of the unripe fruits and they begin to fall off. However, this process can be visible before the symptoms appear. Infected fruits become soft and wet, and then they rot. Their surfaces are covered with grayish-black mycelium and they remain on the trees for a long time. Sometimes, infected fruits can be covered with different colored mycelia (Figure 19).

Fig. 16. The yellowness of leaves caused by *Fusarium sp.*

Fig. 17. Root rot caused by *Fusarium sp.*

Fig. 18. Browning of the vascular system on stem

Fig. 19. Fruit rot caused by *Fusarium sp.*

Biology, Ecology and disease cycle

Observations have shown that the fungus can survive as a chlamydospores (fungal resting structure) for many years (10-12) in soil or in plant debris. Can be seed borne, but rare in commercial seed. The fungus can be introduced on infected transplants or spread on equipment contaminated with infested soil. Long distance dispersal by air borne spores only occurs very rarely. The pathogen most often enters through root wounds caused by cultivation or by nematode feeding. The pathogen moves up the plant through the vascular system. Only one infection cycle occurs each growing season; once a plant is infected, it usually will not spread to another plant in the same growing season.

The fungus is soil borne and makes its way into the plant through the roots. Once inside, it clogs and blocks the xylem, the tissue that moves water and some nutrients through the plant, preventing water from traveling up the stem and out into the branches and leaves.

Observations showed that *Fusarium sp*. often involves the formation of a consortium, which includes 10 species of fungi *(Alternaria solani, Aspergillus niger, Botritis cinerea, Fusarium solani, Mucor sp., Penicillium citrinum, Phytophtora parasitica, Sclerotium rolfsi, Rhizoctonia solani, R. nigricans).* Formation of the consortium begins when air and soil temperatures are 24 to -30°C, and an optimum temperature is about 27°C. High humidity (90-95%) hastens the formation of the consortium.

At present, the studies are being continued to detect the initiator fungus taking part in the formation of a consortium and to determine the relationship between the fungi taking part in it.

As a result of the study of specialization of Fusarium sp. new. by the way of the artificial inoculation, it has been found that the fungus has a wide range of specialization. The local macrocarpous cultivars – PINK, etc., appeared to be less resistant to diseases, but the microcarpous cultivars were relatively resistant.

Fusarium wilt is a warm-weather disease, most prevalent on acid, sandy soils. The pathogen is soilborne and remains in infested soils for up to ten years. Soil and air temperatures of 29°C are optimum for disease. Too warm (35°C) or too cool (18-20°C) soils retard wilt development. If soil temperatures are optimum but air temperatures below optimum, the pathogen will extend into the lower parts of the stem, but the plants will not exhibit external symptoms. In general, factors favoring wilt development are: soil and air temperatures of 28-29°C, soil moisture optimum for plant growth, plants preconditioned with low nitrogen and phosphorus and high potassium, low soil pH, short day length, and low light intensity. Virulence of the pathogen is enhanced by micronutrients, phosphorus, and ammonium nitrogen and decreased by nitrate nitrogen. The pathogen enters the plant through the roots and is then spread throughout the plant by the vascular system.

Dissemination of the pathogen is via seed, tomato stakes, soil, and infected transplants or infested soil adhering to transplants. The pathogen could be disseminated long distance through seed and transplants. Local dissemination is by transplants, tomato stakes, windborne and waterborne infested soil, and farm machinery.

The distribution area of Fusarium wilttt, level of disease incidence and severity were determined during observation of tomat sowings.

Table 2 shows that the average values of infected field were high (67.6%-58.5) in subtropical zone (Xhelvachauri and Kobuleti). The lowest number of infected fields (28.6%) were in mountainous zone (Khulo). Nearly equal number of infected fields (32.4-33.1%) were determined in Keda and Shuakhevi.

Tab. 2. Spread of Fusarium wilt in the different geographic zones in Georgia (2012-2016)

Years	**Geographic zones**					**% Average**
	Subtropical zone		**Mountainous zone**			
	Kobuleti	**Xhelvachauri**	**Keda**	**Shuakhevi**	**Khulo**	
2012	75.7	83.3	37.1	36.2	34.0	53.2
2013	65.6	73.0	36.6	40.0	21.0	47.2
2014	41.3	57.7	31.0	32.9	26.7	37,9
2015	73.4	78.8	38.9	37.8	39.0	53.6
2016	36,3	45,4	18.4	18.7	22.1	23.3
Average	58,5	67.6	32.4	33.1	28.6	43.1

Notwithstanding that the vegetation period of 2013 was unfavorable for Fusarium wilt diseases development as suitable, the highest of 2012-2016 years mean value (53.2%) of field infected by Fusarium wilt was described (Tab. 1). However, overall mean of incidence and severity were low (20,3% and 21.8%), especially in non-irrigated region of Shuahkevi (12,5-14.4%). Drought and hot dry weather during April and May limited development of Fusarium wilt and that significantly contributed to the Fusarium wilt development. In 2012 and 2015 years overall mean of infected fields by Fusarium wilt were similar (53.2% and 53.4%, respectively) and lower, than in previous years. Also, there was a very low overall mean of incidence and severity of diseases - 20.3% and 21.8% in 2013, 23.0% and 24.0% in 2014, 25.1 and 25.4 in 2015 respectively.

Low levels of disease incidence during 2014-2016 can be explained by influence of unfavorable environmental conditions as well as by using the fungicides for disease control on large proportion of the commercial tomato fields. The highest mean incidence and severity of diseases were recorded in the subtropical zone (Kobuleti) - 29.4% and 34.5% in 2012, 30.3% and 31.6% - in 2013, 31.4% and 31.1% - in 2014 and 36.6% and 35.5% - in 2015, 33.7% and 36.8% - in 2016. The lowest incidence rates were recorded in the Mountainous Zone (Khulo -14.9 and 16.2 - in 2012-2016 (Table 3).

Tab. 3. Overall mean values of incidence and severity levels of Fusarium wiltt, %

Geographical zones	2012		2013		2014		2015		2016		Average	
	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %
Kobuleti	29.4	34.5	30.3	31.6	31.4	33.1	36.6	35.5	33,7	36.8	32.3	33.9
Khelvachauri	25.5	32.8	28.3	30.8	30.2	30.7	30.5	30.6	34,7	36.2	29.8	32.2
Keda	21.3	23.4	20.1	21.8	22.9	23.8	20.0	20.9	22,5	25.5	21.4	23.1
Shuakhevi	18.4	25.0	12.5	14.4	16.5	17.1	23.8	25.0	16.8	17.9	17.6	19.9
Khulo	20.5	21.0	10.2	10.4	14.2	15.5	14.8	15.1	14.8	19.0	14.9	16.2
Average	20.0	27.3	20.28	21.8	23.04	24.04	25,14	25.42	24.5	27.08	23.2	25.1

Biological Control

Development of reliable, environmentally benign, and economically feasible management tactics is the immediate goal of many investigators and this goal is also the motivation for longer range basic investigations of many scientists.

Biologically active plant derived fungicides are expected to play an increasingly significant role in crop protection strategies. Considering this as the first step in the present investigation.

Different concentration i.e. 3000ppm, 5000ppm of 14 different methanolic extract from 10 different medicinal plant species was tested for their efficacy against Fusarium sp.nov. These plants were selected based on traditional medicine knowledge and random choosing from the local flora. All the extract were found to inhibit the growth of fungi.

Antifungal activity of tested plant extract was investigated at different concentration (Table 4) against Fusarium sp.nov.The result revealed that highly significant percent inhibition (79.84%) of mycelial gro wth of Fusarium sp.nov. was observed in PDA media amended with the 5000ppm concentration of extract of Inula racemosa, followed by Rubia coradifolia (76.59%), Panax ginseng (R) (75.84%), Hippophae rhamnoides (69.06%), Galium aparine (65.37%) respectively.

Moderate or low activity was observed in the extract of Rubia iberica(R) (58.67%), Foeniculum vulgare (55.44%), Mentha longifolia (48.81%), Mentha silvestris (L) (44.60 and Salvia officinalis (L) (34.52%) showed least activity.

The percentage inhibition showed significant at $p<0.05$. The antifungal activity was observed to be dose- dependent i.e. with increase in concentration of plant extract percentage inhibition of mycelium growth increases.

Antifungal activity of 14 different plant extracts showed significant activity when compared with the leaf/root extract against Fusarium sp.nov. Root extract of Inula racemosa (R) 80.84%, Rubia coradifolia (R) 78.63%, Panax ginseng (R) 76.69% exhibit highest activity and least activity was observed in Salvia officinalis (R) 36.12% against Fusarium sp.nov. when compared with leaf extract.

Among the 14 extracts evaluated, 5 extract showed mycelia inhibition above 76-80.8%, 4 showed moderate effect of 55 -76% and 5 showed least 34%- 54% (Table 4).

Remaining 3 extract from root and leaf extract of Jasminum officinale, root and leaf extract of Althaea officinalis of, leaf extract of Betonica officinalis showed no antifungal activity against Fusarium sp.non. This may be due to lack of antifungal compound in the above mentioned 3 extracts. The percentage growth inhibition of Fusarium sp. nov. was found maximum with Inula racemosa. The plant Inula racemosa, Rubia coradifolia, R. iberica, Hippophae rhamnoides, Galium aparine, Panax ginseng and Foeniculum vulgare which inhibit the mycelia growth above 50% would probably can be an important candidates plants for prevention of biodeterioration of vegetable against *Fusarium sp. new.* The finding of the present investigation is an important step towards crop protection strategies for antifungal activity against important phytopathogen *Fusarium sp. new.*

Tab. 4. Inhibition of Fusarium sp. by solvent extract of high altitude medicinal plant

Percent mycelia inhibition					
Concentration (ppm)					
	3000 ppm		**5000 ppm**		
Species	Colony Diameter	% Inhibition	Colony Diameter	% Inhibition	F value
Hippophae hamnoides (L)	1.53±0.03	67.34±0.69b	1.5±0.05	69.06±1.23b	108.77
Panax ginseng (L)	1.3±0.057	74.43±1.22b	1.16±0.05	75.84±0.72b	307.49
Panax ginseng (R)	1.3±0.05	72.91±1.2ab	1.16±0.03	76.69±0.69b	5.27
Mentha silvestris (L)	3.2±0.03	31.20±0.7a	2.76±0.03	44.60±0.7b	52.66
Mentha longifolia (L)	3.06±0.06	34.75±1.42a	2.5±0.05	48.81±1.22b	49.84
Galium aparine (L)	1.96±0.03	58.15±0.71b	1.63±0.03	65.37±0.8c	367.08
Foeniculum vulgare (L)	2.66±0.03	43.26±0.71b	2.1±0.05	55.44±1.22c	127.15
Rubia coradifolia (L)	1.43±0.03	70.13±0.69b	1.1±0.05	77.08±1.2 c	274.22
Rubia coradifolia (R)	1.43±.033	69.5±0.7b	1.1±0.05	78.63±1.23c	233.81
Rubia iberica (R)	2.2±0.05	53.19±1.22b	2.1±0.05	51.26±1.27b	72.98
Inula racemosa (L)	1.03±0.06	78.47±1.4ab	0.96±0.06	79.86±1.3b	7.62
Inula racemosa (R)	1.03±0.06	78.01±1.41b	0.96±0.06	80.84±1.42b	20.76
Salvia officinalis (L)	3.7±0.06	20.56±1.4a	3.13±0.06	34.52±1.4b	54.86
Salvia officinalis (R)	3.46±0.03	27.77±0.69b	3.06±0.11	36.12±1.38c	93.54

The value means of three replicates ± standard error. The values followed by different alphabets differ significantly whensubjected to Tukey HSD at 0.5 subset; R: Root; L: Leaf.

Further investigation will carried out to determine the biologically active ingredient present in extracts which are responsible for antifungal activity as well as its mode of action; for the development of commercial formulation by field trail and toxicological experiment. The finding will help in managing eco-friendly way to combat against selected phytopathogenic fungi.

In particular, the antagonist fungus Trichoderma lignorum was used against Fusarium (Shainidze and Ghoghoberidze 2015). Soil was tilled with 4% of the suspension (400 gm of T. lignorum per 10 L in 5 m2 area) prior to planting the tomatoes. In this case, the percentage of infection of plant was 5.3% in a nursery garden and 4.6% in a field. The biological efficiency was equal to 80.1 and 71.7. In the control variant, the percentage of infection of plant (without introducing the antagonist into it) was 62.0% in a nursery and 57.0% in a field. The experimental results have shown that the harvest and economic efficiency respectively are increasing, which were equal to 27.2% in a nursery garden and 19.6% in a field.

During 2019 and 2020 the field study was conducted at In Khelvachauri district (village Sameba) of Adjara, Georgia. Blight caused by *Phytophthora infestans* and *Ph. parasitica* is an important disease of Tomato *(Lycopersicon esculentum* Mill.). Study was aimed to determine the efficacies of different doses of biopreparation of Gaupsin against Phytophthora of tomato. Five tomato varieties (*Jina, Florida 47, Shady-Lady, Adlia* and *Choportula)* were sown in five replications with one standard check in tunnel. Gaupsin were applied after 7 days intervals. Disease data was recorded after ten days interval from flowering stage to onward. Average yield of each variety was calculated afters pickings.

Studies show that over both years, all doses of gaupsin reduce disease severity compared to untreated plants. The highest reduction in the disease was achieved by applying gaupsin 12 mg/ml and 14 mg/ml of water at an interval of 7, 14, 21 and 31 days. Plants had increased leaf, shoot, fruit and root biomass. Among the five cultivars tested, *Jima* produces higher yields (6150g) per plant, followed by *Florida '47'* (6000g) and *Shady Lady* (5150g) compared to *Choportula* (4300g) and *Adlia* (3750g).

Overall results revealed that weekly sprays of gaupsin at 12 mg/ml of water were cost effective and eco-friendly for the management of Phytophthora blight of tomato.

Based on a general analysis, it is very clearly shown that the investigation is an important step towards developing plant bioprotection strategies for antifungal activity against the important phytopathogen. That can be beneficial for farmers and researchers who involve in agriculture.

3.1.2. Leaf blight of tomato - *Phytophthora Infestans* and *Ph. parasitica*

Introduction

Among the diseases, Phytophthota leaf blight of tomato caused by *Phytophthota infestans* and *Ph. Parasitica* (*Ph. nicotianae*) is the worst damaging one that cause reduction in quantity and quality of the tomato crop. Phytophthora is an oomycete or water mould, not a fungus. Although they look like fungi, *Phytophthora* species are related to algae. In the study areas (Adjara) the Phytophthora in the field causes considerable yield losses, ranging from 60 to 100% (Shainidze et al., 2015). This disease is controlled mainly with agro chemicals. However, the world wide trend towards environmentally-safe methods of plant disease control in sustainable agriculture calls for reducing the use of these synthetic chemical fungicides. In an attempt to modify this condition some alternative methods of control have been adopted. Recent efforts have focused on developing environmentally safe, long lasting and effective biocontrol methods for the management of plant diseases.

It is now known that various natural bioproducts can reduce populations of pathogens and control disease. A number of biopreparations toxic to several plant pathogenic fungi. In recent decades, significant progress has been made in their use for the biological protection of plants from pathogens (Weller et al., 2007; Mercado-Blanco et al., 2007). At the Institute of Microbiology and Virology of the National Academy of Sciences of Ukraine, the complex biopreparation "Gaupsin" based on two strains of *P. chlororaphis subsp.*

aureofaciens, which inhibits the growth of phytopathogenic bacteria and fungi, was created and patented in Ukraine in 2005. Biopreparation based on this strain was patented by the Swedish company Bio Agri AB under the trade name Cedomon, registered and used in many European countries (Tomboliniet al., 1999). According to the US Environmental Protection Agency conclusion, P. chlororaphis strains are non- pathogenic and non-toxic to humans, biota and environment biopreparation possesses antimicrobic, antifungidalny, entomopathogenic and rostostimuliruyushchy action.The biological product is not toxic for the person and animals, do not collect in plants, the soil, does not influence taste of the grown-up production (Kiprianova et al., 2017.

Pseudomonas chlororaphisbelong to one of the most active producers of antibiotic substances among various species of pseudomonads (Aroma et al., 1964; Bernd et al., 2008; Chincholkar et al,2013). Preparations containing strains of this species are widely used throughout the world for plants protection of fungal diseases. Pseudomonas chlororaphis subsp. aurantiaca is able to colonize the root-system of several crops and behaves as an excellent growth promoter in wheat, alfalfa, soybean, sugar beet, corn, et al. (Shanahan et al., 1992; Duffy and Défago,1999; Mandryk et al., 2007; Carlier et al., 2008; Kiprianova et al., 2011; Rosas et al., 2005, 2006,2009, 2012; Mehnaz, 2013; Rovera et al., 2014; Shahid et al., 2017). Inhibits a wide range of phytopathogenic fungal species including Macrophomina phaseolina, Rhizoctonia spp., Fusarium spp., Alternaria spp., Pythium spp., Sclerotinia minor, Sclerotium rolfsii and et al. (Carlier et al., 2008; Rosas, 2001; 2014). Gaupsin promotes the transition of the hardly soluble nutrients in the soil to the state assimilable for plants; suppresses pathogenic microorganisms by excreted indole acetic acid, promotes the propagation in soil of rhizobia, fixing atmospheric nitrogen through them and providing the plants with atmospheric nitrogen. In one year, 200-300 kg of nitrogen is accumulated per hectare. Gaupsin, as a bacterial fungicidal preparation, also exhibits the insecticidal propertiesests. Its use is effective in the processing of containers and boxes **(**Gabrilovich et al., 1989; Kuznetsov et al., 2006; Goral et al., 1999; Nagornaya et al., 2015; Mikeladze et al., 2021).

Gaupsin is an effective means for protection of orchards against moths and fungi. A method for production of Gaupsin in the liquid form with a titer of not less than 1 x 10 (10) cells/ml under aeration conditions was elaborated.

The universal dvukhshtammovy preparation of broad action intended for processing of gardens, berry-pickers, vineyards, kitchen gardens, fields, melon cultures, and also for protection of houseplants against mushroom diseases and wreckers. Gaupsin perfectly proved in greenhouse facilities. After spraying, the preparation remained on apple leaves for seven days. The efficiency of gaupsin (1:50, for strong defects 1:40) against diseases was 90 — 92%, against wreckers of 92 — 94% (Gondal, 2012; Kiprianova et al., 2017). Consequently, Present study was aimed to determine the efficacies of different doses of biopreparation (Gaupsin) against Phytophthora of tomato.

Results and Discussion

Long-term observations have shown that the first signs of late blight appear leaves even before the flowering of the tomato. Late blight pathogens spread under a wide temperature range from 4°C to 27°C, optimal conditions 19°C–23°C, humidity or high relative humidity 82–100%. Similar results are also obtained from other studies (Mateeva et al., 1985; Bahariev et al., 1988; Nakov et al., 2007; Alexandrov, 2011).

Leaves the diseased plant wither and die off; the root system of gradually turns brown; brownish spots appear on the stem near the soil surface; infected fruits become soft and their surface is covered with grayish-black mycelium. Some disease-noresistant varieties have been observed to dry out within a day (Figure 20).

Fig. 20. Affected organs (82 -100%) of tomatoes in an untreated area

Figure 21 show that different doses of an insectofungicidal biologic (Gaupsin) against tomato late blight significantly reduced the severity of the disease. Data regarding percent disease severity in different varieties 10 days after the application of fungicide demonstrated that minimum disease (28%) was recorded in Jina followed by (29%) in Florida 47 and Shady-Lady (30%) by the application gaupsin 10 mg/ml of water. Disease severity recorded by the application of 14 mg/ml was almost same as hat of 10 g/L of water.

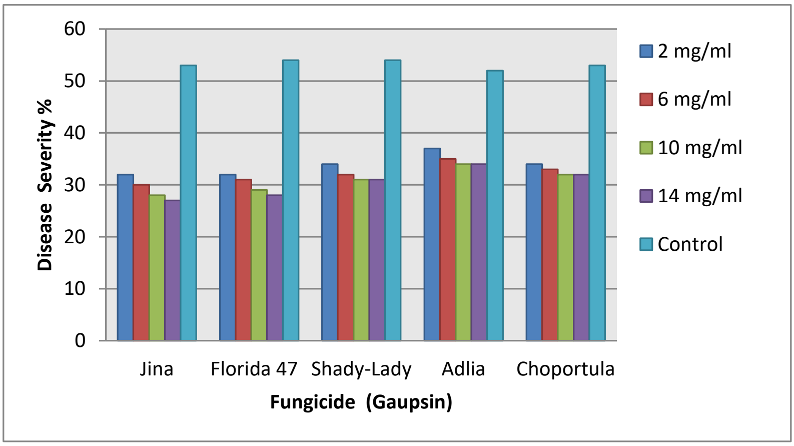

Fig. 21. Disease severity of five tomato cultivars 10 days after the application of biopreparation (Gaupsin), on the average for 2019 and 2020

The response of all other cultivars fungicide treatment mg/ml L and 6 mg/ml of water was also satisfactory as compared to control but less than 10 mg/ml of water. In the control plants, this percentage was high and reached 53.6%. Figure 22 illustrates the fungicidal effect of the 17 days after the application of gaupsine. Minimum disease severity (26%) was recorded in Jina followed by (27%) in Florida 47 by the application gaupsin 10 mg/ml of water. Disease severity recorded by the application of 14 mg/ml was almost same as hat of 10 mg/ml of water. All other gaupsine treatments were less effective as compared to 10 mg/ml of solution.

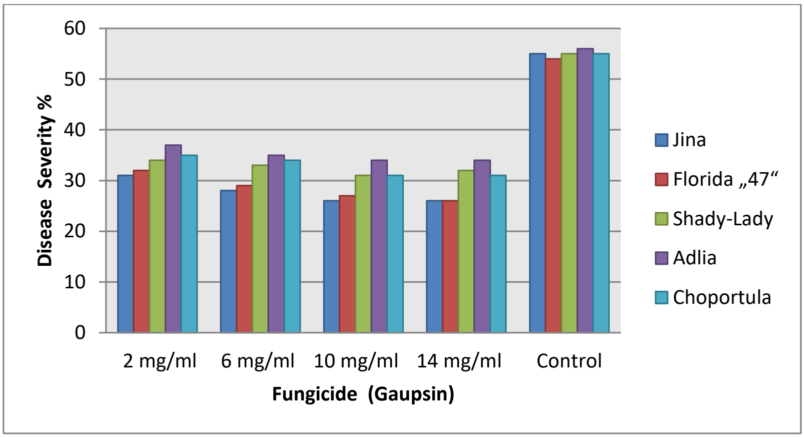

Fig. 22. Disease severity of five tomato cultivars 17 days after the application of biopreparation (Gaupsin), on the average for 2019 and 2020

Disease severity percentage 31 days after the application of gaupsin treatments revealed that biopreparation 10 mg/ml of solutionshow maximum disease reduction (19%) in variety Jima followed by (20%) in Florida “47”. All other biopreparation treatments were less effective. Among all five varieties, Jima and Florida “47” remained best as compared to Shady-Lady, Adlia and Choportula as shown in the Figure 23.

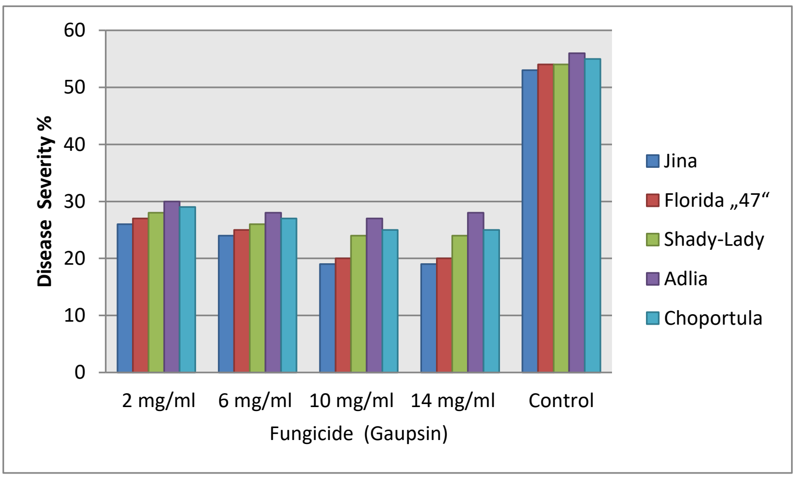

Fig. 23. Disease severity of five tomato cultivars 31 days after the application of biopreparation (Gaupsin), on the average for 2019 and 2020

As shown in the table 5 show that Among the five cultivars tested, Jima produces higher yields (6150g) per plant, followed by Florida 47 (6000g) and Shady Lady (5150g) compared to Choportula (4300g) and Adlia (3750g).

Overall results revealed that weekly sprays of gaupsin at 10 mg/ml of water were cost effective and eco-friendly for the management of Phytophthora blight of tomato.

Based on a general analysis, it is very clearly shown that the investigation is an important step towards developing plant bioprotection strategies for antifungal activity against the important phytopathogen. That can be beneficial for farmers and researchers who involve in agriculture.

Tab. 5. Average yield of each variety from one tomato bush, 2019-2020

Tomato varieties	2019				2020			
	2mg/ ml	6 mg/ ml	10mg/ ml	14mg/ ml	2 mg/ ml	6 mg/ ml	10 mg/ ml	14 mg/ ml
Jima	5400	5600	6900	6950	4400	4800	5400	5400
Florida 47“	5300	5500	6800	6880	4300	4700	5200	5360
Shady-Lady	4500	5200	5900	5900	3700	4600	4400	4420
Adlia	3800	3900	4200	4250	3200	3800	3300	4120
Choportula	4200	4300	4500	4500	3800	3900	4100	4300
Control	1080	900	970	990	600	850	830	640

The use of chemicals against plant pathogens deteriorates the environment. The present concern of the sci¬entists is to find a sustainable solution to the above problem. Therefore, emphasis has been laid on eco-friendly alternative to biopreparation for crop protection. Biopreparation have great potential to overcome plant pathogens as they comprise of biologically active compounds which limit the disease. Further research is required for making biopreparation available to the farms either individually or integrated with bio control agents.

Results of the present study showed that all gaupsin treatments significantly controlled the infection on tomato as compared to untreated control. There was a significant difference in all the treatments. Application of gaupsin 10 g/L and 14 g/L of solution showed best result.

Among the five cultivars tested, Jima gave maximum yield (6150g) per plant under the gaupsin application 10 g/L of solution followed by Florida 47 (6000g), Shady-Lady (5150g), Choportula (4300g) and Adlia (3750 g), that the harvest and economic efficiency respectively are increasing.

Based on a general analysis, it is very clearly shown that the investigation is an important step towards developing plant bioprotection strategies for antifungal activity against the important phytopathogen. That can be beneficial for farmers and researchers who involve in agriculture.

3.1.3. Septoria leaf spot - *Septoria lycopersici*

Host and symptoms

Septoria leaf spot, caused by the fungus Septoria lycopersici, is the most common foliar disease of tomatoes in Adjara. The lesions are generally 2-5 mm in diameter and have a greyish center with brown margins. The lesions gradually develop grayish white centers with dark edges. The light-colored centers of these spots are the most distinctive symptom of Septoria leaf spot. When conditions are favorable, fungal fruiting bodies appear as tiny black specks in the centers of the spots. Spores are spread to new leaves by splashing rain. Heavily infected leaves turn yellow, wither, and eventually fall off. Lower leaves are infected first, and the disease progresses upward if rainy weather persists. Defoliation can be severe after periods of prolonged warm, wet weather (Figure 24).

Fig. 24. Septoria leaf spot symptoms

When the lesions become numerous often the leaves turn yellow, then brown, shriveling up and eventually dropping off the plant altogethe.The fungus survives the winter in tomato debris.

Environment

Disease development occurs within a wide range of temperatures however, the optimal temperatures lie between 18 and 26^{O}C. High humidity and leaf wetness are also ideal for disease development. The initial source of inoculum for *S. lycopersici* results from overwintered resting structures such as mycelium and conidia within pycnidia which can be found on and in infected seed and within infected tomato debris left in the field. Spores spread to healthy tomato leaves by windblown water, splashing rain, irrigation, mechanical transmission, and through the activities of insects such as beetles, tomato worms, and aphids. Provided the environment is conducive for disease development, lesions usually develop within 5-6 days of infection.

Management

To control Septoria leaf spot a combination of cultural practices is often needed. These practices, which also will help to reduce the risk of many other diseases. First and foremost, each season should begin as pathogen-free as possible. This can be accomplished by burning or destroying all infected plant tissues to prevent the spread of the primary innoculum. Crop rotation is also encouraged to avoid the re-infection of new foliage from overwintered inoculum. Improving air circulation around the plants through separation of rows and use of cages can also promote faster drying and reduction of splashing, thus reducing the spread of fungal spores.

3. 2. Bacterial diseases

3. 2. 1. Bacterial spot - *Xanthomonas campestris pv. vesicatoria*

Bacterial spot, caused by the bacterium Xanthomonas campestris pv. vesicatoria, infects both tomato and pepper. Spots that appear on leaves and stems, circular to irregular in shape, and have a slightly greasy feel. Unlike similar-sized spots caused by the fungus Septoria lycopersici, those caused by the bacterial spot pathogen do not develop grayish brown centers. As lesions enlarge, they often become surrounded by a yellow halo. If spots are numerous, they begin to grow together (Figure 25).

Fig. 25. Bacterial spot on leaflet

The leaves wither and turn brown (Figure 26). Fruit symptoms are more distinctive than leaf or stem symptoms. Spots on green fruit first appear as black, raised, pimple-like dots surrounded by water-soaked areas. The bacterium overwinters on the surface of seeds, in infected debris, and in soil. It is commonly brought into fields on infected transplants. Warm, rainy weather favors rapid spread of bacterial spot.

Fig.26. Bacterial spot on fruit

Control

Control measures are essentially the same as for Septoria leaf spot. However, obtaining disease-free transplants is particularly crucial for controlling this and other bacterial diseases, since the bacteria can be transmitted to seedlings from contaminated seeds. Sprays of a fixed copper product can reduce spread of the disease in the garden if applications begin when first symptoms appear.

3.2.2. Bacterial canker - *Clavibacter michiganensis subsp. michiganensis*

Bacterial canker, caused by the bacterium Clavibacter michiganensis subsp. michiganensis, has caused serious losses in some tomato plantings in the Adjara.

Symptoms

Aboveground parts of tomato plants of all ages are susceptible to bacterial canker. Wilting is often the first symptom observed on mature plants. Later, infected stems split, resulting in open cankers that give this disease its name (Figure 27). When cut lengthwise, the vascular system of diseased stems has a reddishbrown discoloration. Stem centers (pith) may be discolored and grainy or pitted.

Fig. 27. Bacterial canker on stem

Fruit may fall from the tree without developing or may not ripen evenly. A characteristic symptom of bacterial canker is bird's eye spots which occur on fruits and reduce their quality. The spots are white to yellow and about 3 to 4 mm in diameter with raised light brown centers (Figure 28).

Fig 28. Bacterial canker on fruit

Control

Control measures for bacterial canker are the same as for bacterial speck, except that copper sprays have minimal impact on slowing the spread of bacterial canker.

3.3. Viral diseases

Identification and management of tomato diseases is an important step in obtaining a successful tomato harvest. Viral diseases can negatively affect tomatoes by drastically reducing yield and/or fruit quality. In adjara highlights 3 viral diseases of tomato that are commonly encountered by home gardeners: Tomato Mosaic Virus Tomato Spotted Wilt Virus (TSWV), and Cucumber Mosaic Virus (CMV) (Figure 29), Information designed to aid in diagnosis and management of these viral diseases is provided.

3.3.1. Tomato Mosaic Viruses (TMV)

These viruses are common in home gardens, affecting a vegetables such as tomato, pepper, and eggplant. Infected tomato plants are characterized by a light- and dark-green mottling and possibly upward curling and malformation of leaves. Mottling is best viewed by partially shading a leaf. Other symptoms may include plant stunting, uneven fruit ripening, and reduced fruit set. Diagnosis of this disease is particularly difficult because symptom expression can vary depending on virus strain, tomato cultivar, time of infection, and environmental conditions.

3.3.2. Tomato Spotted Wilt Virus (TSWV)

Infected tomato plants are characterized by a light- and dark-green mottling and possibly upward curling and malformation of leaves. Mottling is best viewed by partially shading a leaf. Other symptoms may include plant stunting, uneven fruit ripening, and reduced fruit set. Diagnosis of this disease is particularly difficultbecause symptom expression can vary depending on virus strain, tomato cultivar, time of infection, and environmental conditions.

2.3.3. Cucumber Mosaic Virus (CMV)

Mosaic virus is one of the most widespread of all viral diseases. It is particularly damaging to home gardens because it infects many other familiar vegetables (e.g. carrot, cucurbits, lettuce, and pepper). Symptoms on tomato may vary depending on severity and time of infection but typically include plant stunting and yellowing and/or mottling of leaves. The most characteristic feature of this disease is wrinkling of leaves such that stems appear prominent, forming a ‘shoestring’ appearance.

Fig. 29. Tomato Mosaic Viruses, Tomato Spotted Wilt Virus (TSWV), Cucumber Mosaic Virus (CMV)

Control

Control measures are the same as in the case of potato viral diseases.

Chapter IV. Major Diseases of Eggplant - *Solanum melongena* L.

Introduction

Eggplant, Solanum melongena, is a tropical, herbaceous, perennial plant, closely related to tomato, in the family Solanaceae which is grown for its edible fruit.

Like the tomato, its skin and seeds can be eaten, but, like the potato, it is usually eaten cooked. Eggplant is nutritionally low in macronutrient and micronutrient content, but the capability of the fruit to absorb oils and flavors into its flesh through cooking expands its use in the culinary arts.

Studies have shown that the Eggplant pathogenic fungi is quite rich and diverse. In total, 10 species of parasitic fungi were found on Eggplant (*Verticillium dahliae, Verticillium spp., Fusarium oxysporum f.sp.melongenae, Cercospora melongenae, Phytophthora capsic, Pythium spp., Rhizoctonia spp., Alternaria tomatophili, Phomopsis vexans, Leveillula taurica*).

Among them, the maior diseases arewilt of eggplant - *Verticillium dahliae* and *Fusarium oxysporum f.sp.melongenae,* Phomopsis blight - Phomopsis vexans and Leaf spot - *Cercospora melongenae*.

4.1. Fungal diseases

4.1.1. Wilt of Eggplant - *Verticillium dahliae* and *Fusarium oxysporum f.sp.*

Symptoms

Initial symptoms of Verticilium wilt include yellowing of the lower leaves, wilting, stunted growth, and v-shaped lesions that extend inward from the margin of the leaf (Figure 30). Brown, necrotic tissue begins to develop within the lesions as the disease progresses. Symptoms of wilting may only occur late in the season or once the disease is advanced. Because the pathogen affects the vascular tissue. Plants may wilt in the afternoon when they are actively transpiring and appear to "recover" in the morning, only to wilt again. Lower leaves will begin to die and fall off, eventually leading to plant death.

Similar to Fusarium wilt, longitudinal light brown to cream colored streaks can be seen underneath the outside stem tissue and are most prominent at the base of the plant (Figure 31). Vascular streaking can also be observed in the leaves, and this is a characteristic symptom of Verticillium wilt. Plants that do persist in spite of infection will have greatly reduced fruit yields.

Fig. 30. Verticilium wilt on leaf and stem

Fig. 31. Syptoms of Verticilium wilt on leaf and on stem

Control

Control measures are essentially the same as for Fusarium vilt of tomato.

4.1.2. Phomopsis blight on eggplant - *Phomopsis vexans*

Phomopsis blight, caused by the fungus Phomopsis vexans, is a major disease of eggplant in Adjara. It occurs primarily on the fruit and occasionally on leaves or stems.

Symptoms

Stem symptoms of this fungal disease include brown or dark sunken lesions slightly above the soil surface, and can result in cankers. Seedlings eventually collapse and die.

The pathogen attacks leaves but older ones are more susceptible. Lesions are typically circular, gray to brown, and develop a light center. In the center of older lesions, numerous fruiting bodies, called pycnidia, can be observed as small, black pimples, embedded in the host tissue.

Affected leaves may turn yellow and drop prematurely. Spots and cankers can form on mature stems and branches. The most important symptoms are on the fruit.

Fruit injury begins as a pale, sunken, oval area(s) on the surface. These subsequently enlarge and become depressed. With one lesion or several spots coalescing, large portions of the fruit are affected (Figure 32).

Fig. 32. Phomopsis blight on leaves, stems and fruit of eggplant

Causal Agent Phomopsis blight is caused by the fungus *Phomopsis vexans.* The pathogen can be visually and microscopically observed on infected tissue, especially if pycnidia are present.

Inoculum Source and Conditions Phomopsis vexans survives between crops in plant debris in the soil. Spores of the fungus are released from the pycnidia. The major means of spread is by rain splashing. Wind dispersal is usually considered to be of minor importance.

Disease is favored by hot and wet weather. The optimum temperature for fungal growth is 28-29°C .

Control

Destruction of infected plant material to reduce initial inoculum; A 3-4 year crop rotation is beneficial, since the fungus does not infect other crops; Weed control is advisable since pathogen can survive on solanaceous weeds such as nightshades.

A spray program with a protectant fungicide is necessary to maintain yield and quality. Various copper fungicides are labeled for this purpose. Newer fungicides, such as Cabrio (pyraclostrobin, BASF), Quadris (azoxystrobin, Syngenta), and Endura (boscalid, BASF).

4.1.3. Leaf spot of eggplant - *Cercospora melongenae*

Pathogen and Disease

A plant-pathogenic fungus, Cercospora melongenae, causes Cercospora leaf spot of eggplant in Adjara. The genus Cercospora is a hyphomycete fungus comprised of many plant-pathogenic species. They produce leaf spot diseases on a wide range of agriculturally important plants. These diseases are major problems for large-scale growers and backyard gardeners. *C. melongenae* can survive for at least one year in plant debris or in soil. The disease process begins when the fungal spores are dispersed to susceptible plants by rain, irrigation water, or wind, or on agriculture equipment or by people. Leaf wetness and high relative humidity favor infection and disease development.

Symptoms

Symptoms appear on the leaves, petioles, and stems of eggplant (Table 33). Initially, small, circular to oval chlorotic spots appear that may develop angular or irregular shapes. The spots on leaves can easily be confused with spots caused by a bacterial disease. On closer inspection, however, the spots due to Cercospora show distinguishing features. They are generally circular with light to dark tan centers, and the stomata have black spots that can be readily observed using a hand-held magnifying lens. Elliptical to oval lesions may occur on the leaf blades, veins, and petioles. Bacterial leaf spots, conversely, are irregularly shaped or circular spots with clear stomata. The leaf spots on eggplant caused by *C. melongenae* are 4–10 mm in diameter and visible on both leaf surfaces, though they may appear more abundantly on the lower surface. They are brown to steel-gray on the upper surface and light brown on the lower surface.

During the later stages of disease, lesions become grayish brown, with excessive sporulation at their centers.

Concentric rings of diseased tissue may appear as the lesions gradually expand in size. As a lesion dries, the tissue in the center may crack and drop out.

Fig. 33. Leaf spot symptoms

Management

Both organic and inorganic approaches can be used for the management of this disease. Maintain proper field sanitation - Collect and bury infected crop residues; remove and destroy severely diseased leaves.

A calendar-based spray program using a protectantfungicide, combined with cultural practices, can reduce losses from Cercospora leaf spot on eggplant.

Chapter V. Major Diseases of Cucumber - *Cucumis sativus* L.

Introduction

Bacterial, Viral and fungal diseases of Cucumber are of economic importance in the Georgia where the loses were estimated at, 5% for the virus, 10% for the bacteria and up to 80 % for the fungi.

Cucumber is diseased by 13 species of microbiota (*Pseudoperonospora cubensis, Erysiphe cichoracearum f. cucurbitacearum, Sphaerotheca fuliginea f. cucurbitae, Oidium erysiphoides, Alternaria cucumeriana, Colletotrichum lagenarium, Ascochyta cucumis, Sclerotinia sclerotiorum, Cladosporium cucumerinum, Rhizoctonia solani, Verticillium albo-atrum, Fusarium oxysporum* and *Botrytis cinerea*). Almost 10 similar species are registered on the pumpkin - Cucurbita pepo L. The dominant pathogen for both feeding plants is *Pseudoperonospora cubensis*, *Podosphaera xanthii, Sphaerotheca fuliginea, Colletotrichum lagenarium, Bacterial wilt and Mosaic virus*.

5.1. Fungal diseases

5.1.1. Downy mildew - *Pseudoperonospora cubensis*

Downy mildew is a common disease that occurs on most cucurbits. It is an aggressive, fast-moving disease that is very difficult to manage once it gets started. Downy mildews is caused by the fungus-like oomycete pathogen.

Symptoms

Symptoms first appear as pale-to-bright yellow spots on the upper surface of leaves in the crown area of the plant. Leaf spots are irregular or "blocky" in appearance and tend to be limited by leaf veins. As lesions expand and the number of lesions increases, leaves become necrotic and plants will appear scorched. On the undersides of leaves, lesions will be water-soaked and slightly sunken. A profuse sporulation (light-to-dark gray or even purple in color) will be evident as a fuzzy or "downy" growth on lower leaf surfaces when humidity is high (Figure 34). As downy mildew progresses, infected leaves will take on a scorched appearance

Cause and Disease Development Downy mildew is caused by the fungus-like organism, Pseudoperonospora cubensis. Primary infections result when spores are blown in from overwintering sites further south. Although downy mildew is more common in wet weather, fogs and heavy dews can contribute enough moisture to allow infection during "dry" weather. Secondary infections occur when spores are moved via air currents or rain splash to susceptible tissues.

Fig. 34. Downy Mildew symptoms and signs on the underside of Cucumber leaves

Chemical Control

Chemical control is highly recommended because downy mildew is an aggressive and destructive disease and satisfactory control without the use of fungicides is unlikely. Both protectant and systemic products should be applied. Fungicides are most effective when applied prior to infection and reapplied at 5- to 7-day intervals. The following products have proven to be the most effective fungicides in cucumber downy mildew control in Adjara: Previcur Flex (propamocarb, Bayer), Tanos (fenamidone + cymoxanil, DuPont), Ranman (cyazofamid, FMC), and Gavel (zoxamide + mancozeb, Dow AgroSciences). These products should be applied in a program to prevent pathogen resistance (i.e., rotated with fungicides of a different mode of action). Protectant fungicides such as chlorothalonil and mancozeb should be used as mixing partners.

5.1.2. Powdery mildew - *Podosphaera xanthii*

Symptoms

Powdery mildew irst appears as talc-like colonies on the upper and lower surface of leaves that are older or on shaded portions of the plant (Figure 35). The first signs of the disease develop on the leaves, when the cucumber is still in the phase of 3 - 5 leaves. As the disease progresses, the entire leaf surface will be colonized by the fungus. Severely infected leaves become yellow and then necrotic; these leaves die within a short period of time and may result in large-scale defoliation. Powdery mildew is most severe after fruit-set and in densely planted fields. Symptoms and signs can also develop on stems and fruit.

Fig. 35. Symptoms of *Podosphaera xanthii*

Cause and disease development

The causal fungus, Podosphaera xanthii overwinters in crop residue. The fungus produces two spore types: the white powdery spores present on the plant surface are conidia and those produced in tiny round fruiting bodies (cleistothecia) are ascospores. Conidia are carried from plant to plant or field to field by air currents. Unlike many fungal diseases that require leaf wetness for infection, moisture on plant surfaces actually inhibits the powdery mildew fungus. High humidity, however, is required for infection.

5.1.3. Cucurbits Powdery mildew – *Sphaerotheca fuliginea*

The disease is spread in all of the cucurbits cultivating countries and generates serious damages due to the fast drying of the leaves.

Symptoms

The disease is present on the aerial plant parts (stems, leaves, fruits in all development stages). A white, powdery mycelium felt (Figure 36), more or less extended, can be observed on the infested plant’s body parts surface. The stains present on the leaf blade can unite and cover a big surface leading to its drying. The tissues under the mycelium felt turn yellow and then brown.

Affected plants

During drought, the infestation extends and affects the leaves' tail, the stems and even the fruits. The best conditions for the fungus' installation and evolution are temperatures of 15-21°C and excess moisture.

Sphaerotheca fuliginea, the fungus spreads during the vegetation period through spores carried by wind, water or insects. The most commonly affected leaves are the mature ones, while the newly formed ones are more resilient.

The resilient fruitions have the shape of small, black dots, located on the leaves and ensure the fungus survival until the next year.

Fig. 36. Sphaerotheca fuliginea on leaves of Pumpkins and Cucumber

Prevention and control

It is recommended to use a crop rotation system, to gather and destroy the plant debris, to grow crossbreed and durable species.

During the vegetation period it is recommended to use fungicides such as Bravo (1.5-2 l/ha), Bumper 250 EC (0.15 l/ha), Kumulus DF (0.4%), Orius 25 EW (0.05%), Ortiva (0.75 l/ha), Shavit F 72 WP (2 kg/ha), Thiovit Jet (3-4 kg/ha), Topas (0.025%).

5.1.4. Anthracnose of Cucumber - *Colletotrichum lagenarium* (Pass.) Ellis and Halsted

Symptoms

The disease usually begins with the defeat of the leaves, which initially appear small, light green between the veins, then weeping spots that acquire a reddish-brown hue when dried. Such spots deepen, crumble with the formation of ulcers. With a strong development of the disease, the leaves completely turn brown and dry out, the entire aerial part of the plant dies.

The symptoms of the disease on the shoots are light brown oblong spots, which gradually expand, deepen, darken and are bordered by a dark purple or brown rim, constrictions form when dried, the stem thins and dries. Sometimes the disease manifests itself in seedlings, causing the death or rotting of seedlings in or on the soil.

Among the vegetative and generative organs, fruits suffer the most, on which small deep spots first appear, later turning into blurred rounded or oval spots with deep ulcers with pink pads (acervuli). The spots merge over time, the fruit tissue rots and later a consortium appears around it. Such fruits often become ugly (Figure. 37), unattractive, their taste becomes bitter.

Cause and Disease Development

The development of the disease is promoted by high humidity, high soil pH, lack of phosphorus and potassium. The source of infection is mycelium and sclerotia, which remain on the affected plant debris and seeds. The optimal temperature for the development of the fungus is 22-27.C, the relative humidity is 88-92% (at 54% humidity, the disease does not develop), the incubation period is 3-6 days. Anthracnose is more harmful in the subtropical zone (Kobuleti, Khelvachauri and Kedski regions). In these regions, plant damage reached 30-90%, with a disease development rate of up to 50%, and a decrease in yield up to 48.

Fig. 37. Anthracnose symptoms on Cucumber leaves and ftuits

Control

It is necessary to select and use resistant varieties. During the vegetation period it is recommended to use fungicides such as Bravo (1.5-2 l/ha), Bumper 250 EC (0.15 l/ha), Kumulus DF (0.4%), Orius 25 EW (0.05%), Ortiva (0.75 l/ha), Shavit F 72 WP (2 kg/ha), Thiovit Jet (3-4 kg/ha), Topas (0.025%).

5.2. Bacterial Diseases

5.2.1. Bacterial wilt - *Erwinia tracheiphila* (Smith) Berg.

Symptoms

Bacterial wilt is a serious threat to commercial cucumber. Cucumber are severely affected by the disease. Individual runners or whole plants wilt and die rapidly. Affected runners appear dark green at first and then become necrotic as the wilt becomes irreversible. Symptoms appear at all stages of plant development, but wilting is most severe early in the season, when the plants are growing rapidly. Young pumpkin plants normally lose vigor and die within 2 weeks of the initial signs of wilt.

Pathogen

The causal agent of bacterial wilt is Erwinia tracheiphila (Smith) Bergey et al., a gram-negative, rod-shaped, motile bacterium with peritrichous flagella. It is transmitted by insect vectors, primarily the striped cucumber beetle (Acalymma vittatum (Fabricius)) and the spotted cucumber beetle (Diabrotica undecimpunctata howardi Barber).

Disease Cycle

The pathogen is transmitted mechanically by contact with contaminated beetle mouthparts; it does not reproduce within the insects. The adult beetles feed on stems and leaves. The bacteria multiply at the wound site, enter the xylem vessels, and then move down the petiole and stem. Vascular plugging by masses of bacteria and the subsequent formation of gums and resins are the primary mechanisms of wilting.

E. tracheiphila remains viable in dried plant debris for very short periods of time. In plant stems, the pathogen dies as the stems deteriorate. It is not seed-transmitted, and there is no evidence that it survives in soil.

Control

Control of bacterial wilt depends on control of the cucumber beetle vectors. The use of a systemic, soil-applied insecticide and well-timed foliar application of contact insecticides are prerequisite to profitable cucumber production.

5.3. Viral diseases

5.3.1. Cucumber Mosaic virus (CMV)

Syptoms

Leaves become brittle and puckered, with patches in different shades of yellow and dark green. Fruits have kinks, puckered spots or are not fully formed, and tend to taste bitter (Figure 38).

Damage

Like other plant viruses, cucumber mosaic virus interferes with genetic signaling within the plant. Leaves that are distorted by the virus cannot function normally, so plants struggle to grow and stop gaining size. The yellow patches on leaves turn to brown as the disease advances.

Managing

Choose resistant varieties, which are widely available. Measures that reduce aphid populations will cut the risk of CMV and other viral diseases in the garden. Grow plenty of nectar-producing flowers to attract aphid predators including ladybeetles, use row covers to protect young plants from aphids.

Pull up infected cucumber or squash plants and compost them in an active compost pile. If an entire planting is infected, also dispose of any unused seeds, because it is possible that the seeds were infected with the virus.

Fig. 38. Mosaic Virus on Cucumber leaves and ftuits

Chapter VI. Major Diseases of Pumpkins - *Cucurbita pepo* L

Introduction

As a result of phytopathological and mycological studies from different areas (coastal and mountainous agrocenosis of Georgia), the following was found on pumpkins (*Cucurbita pepo* L.): Ascochyta blight - *Ascochyta cucumis* Fautr. et Roum., Anthracnose - *Colletotrichum lagenarium* E. et H., Olive blotch - *Scolecotrichum melophthorum* Pr. et Del., Powdery mildew - *Erysiphe cichoracearum* DC. *f. cucurbitacearum* Pot., Downy mildew - *Pseudoperonospora cubensis* Rostofz., Fusarium root rot - *Fusarium sp*., Blackleg (pithyous) - *Pythium de Baryanum* Hesse., Fusarium wilt - *Fusarium oxysporium* Schl., White rot - *Sclerotinia libertiana* Fuck., Gray rot - *Botrutis cinerea* Pers., Blackleg (bacterial) – *Erwinia phytophthora* Berg. et All., Bacterial wilt - *Erwinia tracheiplila* Holl., Bacteriosis - *Pseudomonas lachrumans* Terraris., *Cucumber mosaic virus* (CMV) - various strains.

Among the diseases found in our country, the most dangerous and widespread is Anthracnose pumpkin - *Colletotrichum lagenarium* and powdery mildew - *Golovinomyces cichoracearum.*

6.1. Fungal diseases

6.1.1. Anthracnose pumpkin - *Colletotrichum lagenarium*6.

Symptoms and Signs

The disease usually begins with the defeat of the leaves, which initially appear small, light green between the veins, then weeping spots that acquire a reddish-brown hue when dried. Such spots deepen, crumble with the formation of ulcers. With a strong development of the disease, the leaves completely turn brown and dry out, the entire aerial part of the plant dies (Table 39).

The symptoms of the disease on the shoots are light brown oblong spots, which gradually expand, deepen, darken and are bordered by a dark purple or brown rim, constrictions form when dried, the stem thins and dries. Sometimes the disease manifests itself in seedlings, causing the death or rotting of seedlings in or on the soil.

Among the vegetative and generative organs, fruits suffer the most, on which small deep spots first appear, later turning into blurred rounded or oval spots with deep ulcers with pink pads (acervuli). The spots merge over time, the fruit tissue rots and later a consortium appears around it. Such fruits often become ugly (Figure. 40), unattractive, their taste becomes bitter.

Cause and Disease Development

The development of the disease is promoted by high humidity, high soil pH, lack of phosphorus and potassium. The source of infection is mycelium and sclerotia, which remain on the affected plant debris and seeds. The optimal temperature for the development of the fungus is 22-27.C, the relative humidity is 88-92% (at 54% humidity, the disease does not develop), the incubation period is 3-6 days. Anthracnose is more harmful in the subtropical zone (Kobuleti, Khelvachauri and Kedski regions). In these regions, plant damage reached 30-90%, with a disease development rate of up to 50%, and a decrease in yield up to 48%.

Fig. 39. Stages of development of anthracnose on leaves and fruit on pumpkins

Control

The fighting measures are the same as those used against cucumber anthracnose.

6.1.2. Powdery mildew - *Golovinomyces cichoracearum*

Powdery mildew is a common fungal disease of cucurbits and the major cause of losses in cucurbit production worldwide Golovinomyces *cichoracearum* (syn. *Erysiphe cichoracearum*) and *Podosphaera xanthii* (syn. *Sphaerotheca fuliginea*) are the two main pathogenic fungi that cause powdery mildew in the cucurbits. Impacts of powdery mildew on crop production include reduced photosynthesis, impaired growth, premature senescence, and yield loss). The powdery mildew pathogen lives with the obligate biotrophic lifestyle.

Symptoms

Powdery mildew symptoms first appear as pale, chlorotic spots on leaves that soon turn powdery-white in appearance (fungal spores) and start on the crown and lower leaves, mainly on the under-leaf shaded surface. Young plants may turn yellow, stunted, and may die, and then severely infected leaves become brown and brittle (Table 40), resulting in foliage loss.

Fig. 40. Powdery mildew growth on pumpkin foliage

Control

The fighting measures are the same as those used against cucumber Powdery mildew.

Chapter VII. Major Diseases of Cabbage - *Brasica oleraceae* L.

7.1. Fungal diseases

7.1.1. Downy mildew - *Hyaloperonospora brassica*

Introduction

Cabbage (*Brassica oleracea*) has long been cultivated as an important vegetable crop and a source of vitamins, minerals and fibre, particularly during cold seasons in temperate climates (Lee et al., 2015). More recently, cabbage and other cruciferous vegetables (members of the Brassicaceae) have been recognized as important sources of chemoprotective phytochemicals in the diet. Cabbage is a productive vegetable based on biomass per area of cultivation. However, this crop is affected by many diseases, particularly those caused by fungi.

In Georgia Among agricultures, Cabbage is considered one of the main cultures. The orography of the region and the edaphic - climatic conditions (frequent rain, warm humid temperature, excess of soil moisture, etc.) can forward the wide spread and development of disease-causing agents. In the first years the harvest Cabbage was considered practically painless.

Information on diseases of Cabbage is found in various works (Bérénice, et al., 2003; Bahcevandziev et al.,2015; Dickinson et al., 1977; Dickson,1993; Göker, et al.,2009; Jensen, et al.,1999; Shainidze, 2019).

The main pathogens of Cabbage cause considerable damage to the Cabbage crop especially in subtropical plains. It is increasingly becoming a limiting factor for successful cultivation of Cabbage in these regions.

Several fungicides recommended to control these pathogens not only add up to human and environmental hazards, but also have been found to be inconsistent and insufficient to deal with this disease. However, the application of this agrochemical is increasingly restricted due to the harmful effects of pesticides on human health and the environment (Harris, et al., 2001). In many countries the use of synthetic fungicides has been banned due to polluting nature. In order to have safe methods for plant disease control in sustainable agriculture there is a need for reducing the use of synthetics chemicals fungicides there by replacing it with biocides with plant origin. Plants are known to produce a variety of compounds to protect themselves against a variety of pathogens. The plants are rich sources of numerous bioactive secondary metabolites such as alkaloid, flavonoids, terpenoids, saponins, tannins and phenolic compounds which are the important sources of microbiocides, antifungal activity and many pharmaceutical compound (Mahesh, et al., 2008; Arif, et al., 2009). Plants are rich sources important organic compounds, pharmaceuticals and pesticidal compounds. Many reports on the antiviral, antibacterial, antifungal, anthelmintic, antimolluscal and anti-inflammatory properties of plants have reviewed. Thus plant extracts which is a source of natural pesticides can be developed into new biocidal pesticides (Samy, et al., 2000; Palombo, et al., 200; Behera, et al., 2005; Govindarajan, et al., 2006).

Therefore, this study was intended to determine the composition of pathogenic microbionts on Cabbage in all agrocenoses in Georgia; study of the symptoms, etiology and harmfulness of three fungal Cabbage pathogens and application of the biological method (various extracts of high medicinal plants) against the most common fungi *Hyaloperonospora brassicae* in Adjara, Georgia.

Results

On the Cabbage, 20 species of microbionts (*Olpidium brassicae, Plasmodiophora brassicae, Hyaloperonospora brassicae, Phytophthora porri, Pythium de baryanum, Albugo candida, Mucor sp.,Rhizopus psapzzh, Erysiphe sp. brassicae, Penicillium sp., Thielaviopsis basicola, Fusarium oxysporum f. sp.conglutinans, Fusarium moniliforme, f. sp., Botrytis cinerea, Sclerotinia sclerotiorum, Alternaria* *brassicae, Alternaria solani, Phoma lingum, Rhizoctonia solani* and *Xanthomonas campestris pv. campestris)* were identified as a result of phytopathological and mycological studies conducted in different places of agrocenosis in Georgia. Sometimes, during storage, the infected cabbage can be covered with a multi-colored mycelium which includes 9 species of fungi *(Hyaloperonospora brassicae, Alternaria solani, Alternaria sp., Aspergillusniger, Fusarium moniliforme, Mucor sp., Penicillium sp., Sclerotiumrolfsi, Rhizoctonia solani, Rhizopus psapzzh)* in Figure 41.

Fig, 41. Symptoms of consortium on cabbage leaves and fruit

Observations have shown that the formation of the consortium begins when air and soil temperatures are 24 to -30°C, and an optimum temperature is about 27°C. High humidity (90-95%) hastens the formation of the consortium. At present, the studies are being continued to detect the initiator fungus taking part in the formation of a consortium and to determine the relationship between the fungi taking part in it.

The results of the studies showed that among the mycobionts found on cabbage, the most common, dangerous and harmful are 6 pathogen*: Hyaloperonospora brassicae* (49%), *Plasmodiophora brassicae* (21%) *Rhizoctonia solani* (19%), *Phoma betae* (18%), ***Pythium debaryanum*** (10%) and ***Fusarium oxysporum f. sp conglutinans*** (9%) in Figure 42.

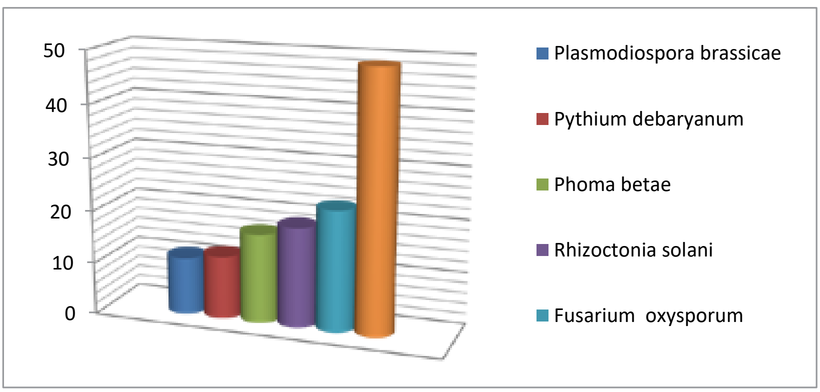

Fig. 42. Spreads of the main pathogens of Cabbage in Georgia, %

As the Figure shows fungi, the dominant species is *Hyaloperonospora brassicae* Syn.: *Peronospora brassicae, Peronospora parasitica*. It belongs to the Kingdom Chromista, the phylum Oomycota, and the family Peronosporaceae. It causes downy mildew. In the past, the cause of downy mildew in any plant in the family Brassicaceae was considered to be a single species *Peronospora parasitica*. However, this has recently been shown to be a complex of species with narrower host ranges, now classified in the genus Hyaloperonospora. From the perspective of plant pathology, *Hyaloperonospora brassicae* is now the name of the most important pathogen in this complex. Pathogen are more common in seedbeds. Under wet conditions favorable for the disease, yellow to pale brown spots develop rapidly into large irregular patches, on the upper surface of the young leaves.

A grayish white growth occurs on the underside of the leaves, and may be present, too, on the upper surface during cool and moist conditions. The infected areas turn brown and papery in dry weather. Severely affected seedlings are stunted and killed. The older leaves may have a speckled appearance in Figure 43.

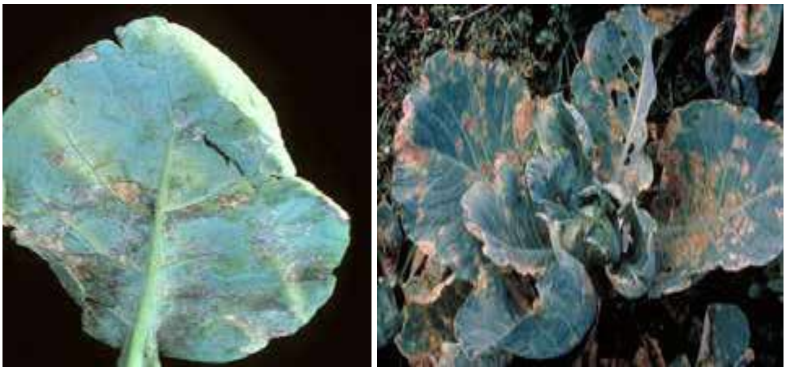

Fig. 43. Syptoms *Hyaloperonospora brassicae* in theseedbeds

Nearly similar symptoms appear in the field and lead to early death of the leaves; in moist weather the spots grow larger, join together and form large dead patches. The infections can lead to bacterial rots developing in storage. Large dark brown rots develop on cauliflower heads.

Similar symptoms appear in the field and lead to early death of the leaves; in moist weather the spots grow larger, join together and form large dead patches in Figure 44.

Fig. 44. Symptoms of *Hyaloperonospora brassicae* in the field on cauliflower heads

The distribution area of Downy mildew, level of disease incidence and severity were determined during observation of Cabbage sowings.

As shown in Table 6, the average values of infected field were high (67.6%-58.5) in subtropical zone (Xhelvachauri and Kobuleti). The lowest number of infected fields (28.6%) were in mountainous zone (Khulo). Nearly equal number of infected fields (32.4-33.1%) were determined in Keda and Shuakhevi.

Tab. 6. Spread of *Hyaloperonospora brassicae* in the different geographic zones in Georgia (2012-2016)

Years	Geographic zones					Average
	Subtropical zone		Mountainous zone			
	Kobuleti	Xhelvachauri	Keda	Shuakhevi	Khulo	
2012	75.7	83.3	37.1	36.2	34.0	53.2
2013	65.6	73.0	36.6	40.0	21.5	47.2
2014	41.3	57.7	31.0	32.9	26.7	37,9
2015	73.4	78.8	38.9	37.8	39.0	53.6
2016	36,3	45,4	18.4	18.7	22.1	23.3
Average	58,5	67.6	32.4	33.1	28.6	49.2

Drought and hot dry weather during April and May limited development of Downy mildew and that significantly contributed to the Downy mildew development. In 2012 and 2015 years overall mean of infected fields by Downy mildew were similar (53.2% and 53.4%, respectively) and lower, than in previous years. Also, there was a very low overall mean of incidence and severity of diseases - 20.3% and 21.8% in 2013, 23.0% and 24.0% in 2014, 25.1 and 25.4 in 2015 respectively (Table 7).

Tab. 7. Overall mean values of incidence and severity levels of *Hyaloperonospora brassicae*, %

Geographical zones	2012		2013		2014		2015		2016	
	Incidence%	Severity%	Incidence %	Severity%	ncidence %	Severity%	ncidence %	Severity %	ncidence %	Severity %
Kobuleti	29.4	34.5	30.3	31.6	31.4	33.1	36.6	35.5	33,7	36.8
Xhelvachauri	25.5	32.8	28.3	30.8	30.2	30.7	30.5	30.6	34,7	36.2
Keda	21.3	23.4	20.1	21.8	22.9	23.8	20.0	20.9	22,5	25.5
Shuakhevi	18.4	25.0	12.5	14.4	16.5	17.1	23.8	25.0	16.8	17.9
Khulo	20.5	21.0	10.2	10.4	14.2	15.5	14.8	15.1	14.8	19.0
Average	20.0	27.3	20.3	21.8	23.04	24.04	25,14	25.42	24.5	27.08

Low levels of disease incidence during 2014-2016 can be explained by influence of unfavorable environmental conditions.

The highest mean incidence and severity of diseases were recorded in the subtropical zone (Kobuleti) - 29.4% and 34.5% in 2012, 30.3% and 31.6% - in 2013, 31.4% and 31.1% - in 2014 and 36.6% and 35.5% - in

2015, 33.7% and 36.8% - in 2016. The lowest incidence rates were recorded in the Mountainous Zone (Khulo -14.9 and 16.2 - in 2012-2016.

The fungus spreads in wind and water. Long distance spread occurs on seedlings, and also there is evidence for spread as spores on seed. The disease does best when there is high humidity, fog, drizzling rains, and heavy dew. Leaf wetness of 5-7 hours at 19-21°C and 7-8 hours at 15-16°C are necessary for significant infection and development of downy mildew.

Control

As has been clarified, among the discovered mushrooms the most common and dangerous is the mushroom Hyaloperonospora brassicae. Therefore, the purpose of this study was to evaluate and apply a biological method (various extracts of tall medicinal plants) against the most common and dangerous fungal pathogen *Hyaloperonospora brassicae*. Biologically active plant derived fungicides are expected to play an increasingly significant role in crop protection strategies. Considering this as the first step in the present investigation.

Different concentration i.e. 1000ppm, 3000ppm, 5000ppm of 27 differentmethanolic extract from 24 different medicinal plant species was tested for their efficacy against *Hyaloperonospora brassicae*. These plants were selected based on traditional medicine knowledge and random choosing from the local flora. All the extract were found to inhibit the growth of fungi. Antifungal activity of tested plant extract was investigated at different concentration against Hyaloperonospora brassicae. The result revealed that highly significant percent inhibition (85.94, 89.96, 97.96, respectively) of mycelial of fungus was observed in PDA of *Alium cepa*, followed by Stevia rebaudiana (83.74, 87.76, 96.78, respectively), *Inula racemosa* (79.04, 80.01, 86.84%, respectively), *Buxus colchica* (76.45,78.85, 86,63, respectively), *Rubia coradifolia* (76.59, 76.45, 82.41%, respectively), *Panax ginseng* (75.84, 77.82, 81.80%, respectively), *Corylopsis sinensis* (75.5, 77.82, 81.7%, respectively), *Galium aparine* (65.37, 76.34, 78.32 %, respectively), *Hippophae rhamnoides* (61.80, 62.66, 68.34 %, respectively).

Moderate or low activity was observed in the extract of *Rubia iberica* (36.18, 53.13, 58.27%, respectively), *Foeniculum vulgare* (34.75, 43.26, 47.44%, respectively), *Mentha longifolia* (31.20, 34.75, 46.81%, respectively), *Mentha silvestris* (L) (30.65, 31.63, 37.60%, respectively), *Salvia officinalis* (L) (29.52, 31.52, 35.72 %, respectively), *Hamamelis mollis* (25.83, 32.86, 35.5%, respectively), and *Eucalyptus cinerea* (23.94, 27.95, 30,43%, respectively) showed least activity.

The antifungal activity was observed to be dose - dependent i.e. with increase in concentration of plant extract percentage inhibition of mycelium growth increases. Antifungal activity of different plant extracts showed significant activity when compared with the leaf/root extract against *Hyaloperonospora brassicae* Root extract of *Inula racemosa* (R) (82.91, 88.47, 92.86%, respectively), *Rubia coradifolia* (R) (76.59,79.48, 82.41%, respectively) and *Panax ginseng* (R) (75.84, 77.82, 81.80%, respectively) exhibit highest activity.

Among the 27 extracts evaluated, 8 extract showed mycelia inhibition above 81.8-97.96%, 4 showed moderate effect of 68,3 -78.6% and 7 showed least 30,43% - 51.3% (Table 8). Remaining 8 extract from leaf extract of *Agave americana, Althaea officinalis, Betonica officinalis, Jasminum officinale, Pimpinella anisum, Pyrethrum vulgare, Ricinus communis* and *Sambucus ebulus*s howed no antifungal activity against the *Hyaloperonospora brassicae*.

This may be due to lack of antifungal compound in the above mentioned 8 extracts. The percentage growth inhibition of *Hyaloperonospora brassicae* was found maximum with Alium *cepa* (97.96%), *Stevia rebaudiana* (96.78%) and *Inula racemosa* (R) (92.86%). The plant *Buxus colchica*, Inula *racemosa* (L), *Rubia coradifolia*, Galium *aparine*, *Panax ginsenget* all which inhibit the mycelia growth above 70% would probably can be an important candidates plants for prevention of against Fungi.

In end can say that of the present investigation is an important step towards crop protection strategies for antifungal activity against important phytopathogen *Hyaloperonospora brassicae*.

Tab. 8. Efficacy of herbal extracts of medicinal plants against *Hyaloperonospora brassicae*

	1000ppm		**3000 ppm**		**5000 ppm**	
Species	Colony Diameter	% Inhibition	Colony Diameter	% Inhibition	Colony Diameter	% Inhibition
Aliumcepa (L)	1.7±0.08	85.94±1.2	1.03±0.06	89.96±1.5	0.97±0.07	97.96±1.92
Buxuscolchica (L)	2.2±0.07	76.45±1.4	1.4±0.07	78.85±1.4	0.86±0.06	86,63±1.84
Corylopsissinensis (L)	1.9±0.09	75,5±1.1	1.02±0.05	76.45±1.6	0.78±0.08	81,7±1.56
Eucalyptus cinerea (L)	3.2±0.05	23.94±0.9	2.03±0.06	27.95±1.4	1.96±0.07	30,43±1.37
Hamamelismollis (L)	3.1±0.08	25.83±0.8	2.09±0.09	32.86±1.55	1.97±0.05	35.5±1.24
Hippophaerhamnoides (L)	2.7±0.07	61.80±1.84	1.6±0.05	62.66±0.67	1.4±0.06	68.34±1.23
Panax ginseng (L)	1.4±0.05	70.69±1.2	1.3±0.05	73.67±1.2	1.16±0.03	74.56±0.69
Panax ginseng (R)	2.5±0.04	75.84±0.7	1.3±0.04	77.82±1.22	1.16±0.05	81.80±0.72
Menthasilvestris (L)	3.12±0.07	30.65±1.42	3.2±0.02	31.63±0.7	2.73±0.04	37.60±0.7
Menthalongifolia (L)	3.4±0.04	32.3±0.8	2.9±0.05	37.6±1.37	2.3±0.04	47.9±1.13
Galiumaparine (L)	3.3±0.07	65.37±1.1	1.75±0.04	76.34±0.82	1.52±0.04	78.32±0.7
Foeniculumvulgare (L)	3.05±0.06	35.82±0.6	2.52±0.02	44.26±0.62	2.2±0.05	47.44±1.3
Rubiacoradifolia (L)	2.43±0.03	72.64±0.8	1.44±.04	76.5±0.8	1.2±0.06	78.63±1.23
Rubiacoradifolia (R)	2.35±0.04	76.59±0.69	1.21±0.07	79.48±0.69	1.1±0.07	82.41±1.2
Rubiaiberica (R)	3±0.02	36.18±1.25	2.2±0.05	53.13±1.22	2.1±0.05	58.27±1.27
Inularacemosa (L)	1.3±0.05	79.04±1.23	1.03±0.02	80.01±1.43	0.97±0.03	86.84±1.42
Inularacemosa (R)	1.4±0.07	82.91±1.3	1.04±0.07	88.47±1.44	0.95±0.05	92.86±1.3
Salvia officinalis (L)	3.7±08	29.52±0.5	3.5±0.06	31.52±1.5	3.04±0.06	36.12±1.5
Stevia rebaudiana (L)	2.37±0.04	83.74±1.3	2.03±0.08	87.76±1.7	1.7±0.08	96.78±1.7

The value means of three replicates ± standard error. The values followed by different alphabets differ significantly whensubjected to Tukey HSD at 0.5 subset; R: Root; L: Leaf.

7.1.2. Clubroot of Cabbage - *Plasmodiophora brassicae*

Clubroot of Cabbage has a wide host range in the brassica family including numerous weed species.Is a root-infecting protist pathogen that causes clubroot disease in brassica species. The organism is soil-borne and has long-lived resting spores that can survive in soil for more than 15 years. Local spread of motile zoospores can be facilitated by wet conditions but most dispersal of the pathogen is through the movement of infested soil. Cool, wet and acidic soils favours the development and spread of the disease. Roots develop clubs (swellings) that can be 12-15 cm wide (Figures 45). The largest clubs are usually on the larger roots just below the soil surface. Affected seedlings do not show any root swellings until about 3 weeks after infection. Infection in the nursery stage results in the death of seedlings. When plants are attacked at a later stage, the disease rarely kills the plant, but the capacity of the affected roots to absorb minerals and water gets reduced.

Plants wilt in hot weather but partly recover at night. Finally, leaves become stunted, yellowish and prematurely bolt in hot weather. Yield losses range from 10 to 20% but can exceed 60% under disease conducive environmental conditions.

Fig. 45. Symptoms of *Plasmodiophora brassicae*

Control

Is important to use only uninfected seedbeds and clean equipment. Long rotations (5-6 years or longer) help prevent a pathogen buildup and reduce disease incidence.

Improved agronomic practice such as improved drainage and the application of lime of related products to raise pH which can limit the effects of the disease. There are currently no effective fungicides for the widespread control of clubroot.

7.1.3. *Wire Stem - Rhizoctonia solani*

This disease is more serious in nursery beds. The affected young seedlings show reddish brown discolouration of the stem near the ground level. This area gets constricted and the plants bent or twist without breaking. In some cases, the seedling continues to grow even though the lesion girdles the stem. The lesion is quite sunken, and the stem resembles a wire, hence the name 'wirestem'.

The girdled seedling eventually dies. Cool, cloudy weather, high humidity, wet and compact soil, and overcrowding especially favours development of the disease.

Control

Soil used for preparing raised beds should be well- drained. Excessive irrigation should be avoided to reduce humidity around the plants. The seedlings in the seedbed should be adequately spaced to allow maximum air movement. While transplanting, the seedlings showing symptoms of 'wirestem' disease should be discarded.

Preventive measures such as seed treatment with antagonist fungal culture of Trichoderma viride (3-4 g/kg of seed) or Thiram (2-3 g/kg of seed) are effective. Soil around the affected seedling should be drenched with Dithane M 45 (0.2%) or Bavistin (0.1%) to control the spread of the disease.

7.1.4. Black Leg - *Phoma lingum*

Pale, irregular spots develop on leaves, which later become ashy gray with scattered black dots on the surface. Stem lesions are elongated with purple borders near the ground level and extend below the soil surface, causing a black rot of lower stem and roots.

Severely affected plants remain stunted and finally wilt. As plants mature, they fall sideways from lack of root anchorage. Seed crop symptoms include occasional cankers on stem bases and spots may appear on overwintered leaves.

Symptoms on seed pods are rare and inconspicuous. Infection can spread to the base of leaves of cabbage heads in storage.

Control

Disease free seeds should be used for planting. As the main infection is through seeds, hot water treatment of seeds is recommended. For seed production plots, seed stock used should be free from fungal pathogen. Cultivation in the fields where crucifers have been continuously grown during last 2 years should be avoided. Seedbeds and seed plots should be regularly inspected for obvious foliar infections. Seedlings before transplanting should not be dipped in water. Plant debris and disease susceptible weeds should be removed and destroyed.

7.1.5. Damping off - *Pythium debaryanum*

The disease causes severe damage in the nursery. Cool, cloudy weather, high humidity, wet soils, compacted soil, and overcrowding especially favor development of damping-off [. Damping-off kills seedlings before or soon after they emerge. Infection before seedling emergence results in poor germination. If the decay is after seedlings emergence, they fall over or die which is referred to as "damp-off." The destructiveness of the disease depends on the amount of pathogen in the soil and on environmental conditions. Seedlings that emerge develop a lesion near where the tender stem contacts the soil surface. The tissues beneath the lesion become soft due to which the seedlings collapse.

Control

In the nursery, soil used for preparing raised beds should be well- drained. Excessive irrigation should be avoided to reduce humidity around the plants. Seed treatment with antagonist fungal culture of Trichoderma viride (3-4 g/kg of seed) or Thiram (2-3 g/kg of seed) and soil drenching with Dithane M 45 (0.2%) or Bavistin (0.1%) affords protection against the disease. The nursery should be regularly inspected for the disease affected seedlings. Such seedlings should be removed and destroyed.

7.1.6. Yellows or Fusarium Wilt - *Fusarium oxysporum f. sp conglutinans*

Disease development is promoted by warm weather conditions. Initial symptom appears as the development of yellowish green colour on one side of the plant. A lateral warping or curling of the stem and leaves occurs.

The lower part of the leaf blade adjoining the petiole or midrib wilts and dies. The lower leaves turn yellow and later the upper leaves are affected. With time, the yellow leaves turn brown and the affected tissue becomes dry and brittle (Figure 46). The speed of progress of disease in the plant depends upon the degree of varietal susceptibility and the soil temperature.

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Fig. 46. Syptoms of Fusarium wilt

Control

The conventional controls such as rotation, seed treatment, fungicide sprays, and destruction of crop refuse are of little value once the fungus has established itself on a farm or in a specific field. Therefore, the use of resistant varieties is the only control. However, as a preventive measure the vulnerable stage of the young seedlings to the infection can be avoided by very early sowing of cabbage.

Chapter VIII. Major Diseases of Beet - *Beta vulgaris* L.

8.1. Fungal diseases

Introduction

Long-term observations have shown us that the beet mycobiota is quite rich and diverse. In total, 11 species of parasitic fungi were found on beets (*Pythium de barianum, Peronospora farinosa, Erysiphe communis f. betae, Pleospora bjoerlinglii, Uromyces betae,* Thielaviopsis *basicola, Ramularia beticola, Alternaria alternata, Cercospora beticola, Ascochyta betae, Rhizoctonia aderholdii*). Among them, the main diseases are Cercospora leaf spot - Cercospora beticola, Powdery mildew - Erysiphe polygoni, Downy mildew – Peronospora farinose and Beet Rust - Uromyces beticola.

8.1.1. Cercospora leaf spot - *Cercospora beticola*

Cercospora beticola is a fungal plant pathogen which typically infects plants of the genus Beta, within the family of Chenopodiaceae. It is the cause of Cercospora leaf spot disease in sugar beets, spinach and Swiss chard. Of these hosts, Cercospora leaf spot is the most economically impactful in sugar beets (Beta vulgaris). Cercospora beticola is a deuteromycete fungus that reproduces using conidia. There is no teleomorph stage. C. beticola is a necrotrophic fungus that uses phytotoxins specifically Cercospora beticola toxin (CBT) to kill infected plants. CBT causes the leaf spot symptom and prevents root formation. Yield losses from Cercospora leaf spot are around 20 - 25%.

Hosts and symptoms

Hosts of Cercospora beticola include sugar beets (*Beta vulgaris*), Swiss chard (Beta vulgaris L. subsp. cicla) and other leafy greens. Symptoms include the random distribution of spots with brownish red rings which eventually cause leaf collapse (Figure 47). Older leaves will have spots of larger diameters as rings grow outward. Conidia are not observable by the unaided eye.

Fig. 47. Cercospora leaf spot on leaves of Beet

Disease cycle

Stromata (a sclerotia-like survival structure containing conidia when made) in field debris starts the life cycle. Under favorable wet conditions, conidia are rain-splashed and insect-carried to new hosts, where, under humid and wet conditions, they germinate and penetrate through stomata. These conidia germinate in polycyclic microcycles until the end of the growing season. At the end of the growing season, *C. beticola* produces stromata again as a survival structure. Microcycles like the one used by *C. beticola* are very effective at producing many conidia. Because these conidia are effective at penetrating the host, mycelium is not necessary, and conidia produce their own conidia at each new infection (microcycle). There have been no direct observations of sexual spores in *C. beticola.*

Management

Copper was historically used to control C. beticola in the field, though today fungicides are more common. C. beticola has been shown to have some resistance to benzimidazole and thiophanate class fungicides. As a result, experts often have recommended fungicide rotation to kill any potential fungicide resistant strains. Some varieties of sugar beet also show resistance to C. beticola, unfortunately they have all had low yields in lab tests. Today the most common fungicides used are QoI, Headline, Proline, Inspire SB, Eminent and Super Tin or Agri Tin.

8.1.2. Powdery mildew - *Erysiphe communis f. betae*

Powdery mildew is caused by Erysiphe polygoni. The fungus occurs worldwide in all regions where sugar beet.

Morphology and biology

Plants of beet of the first and second year are affected. Disease appears on all above-ground parts of plant (on leaves, stalks, and glomes of beet) as a white bloom. In the beginning the bloom is gentle and web-like; then it quickly expands, becoming white, dense, and powdering (Figure 48). The affected parts of plants get a powdered kind. In the second half of vegetation the brown, later black dots are formed on a white strike black points of fungal cleistocarpia are formed on white bloom. The affected leaves turn yellow and die off. Primary infection of beet plants is formed by ascospores.Distribution.

Disease is recorded in all areas of industrial cultivation of sugar beet in the Georgia. High severity was reported in Adjara (55 to 100% plants were affected).

Ecology

The pathogen winters as cleistocarpia on plant residues, on soil surface, on heads of parent beet, on glomes of beet seeds. The disease intensively develops at sharp fluctuations of humidity (63-93%) and air temperature, being especially developed at dry and hot weather when the average air temperature reaches 20-25^{o}to 34-35^{o}C.

Economic significance.

The disease results in decrease of yield of sugar beet roots by 20-30%, of seeds by 5-16%, of sugariness by 1-5.3%, of seed germinating capacity by 11-38%.

Fig. 48. Symptoms of *Erysiphe communis f. betae*

Control

Control measures include crop rotation; placement of beet crops at a distance of 1 km and more from seed fields; deep autumn plowing of fields; application of phosphoric-potash fertilizers; agronomical actions directed on improvement of water supply of plants; treatment of crops by system fungicides; spraying 0.2%

wettable sulphur or 0.1% Kerathane L.C. or 0.05% Calixin at the rate of 500-700 l/ha. Spraying or dusting should be repeated after 15 to 20 days.

8.1.3. Downy mildew - *Peronospora farinosa*

Downy mildew is a moderately important disease of sugar beet (Beta vulgaris). The pathogen persists as oospores in the soil, or on beet seed crops, or on overwintered volunteer beet plants. Attacks are most important at the seedling stage. The cotyledons are systemically infected, becoming discoloured and distorted. Loss of seedlings causes uneven crop development.

Disease symptoms

Symptoms appear as dirty white, circular, floury patches on either sides of the leaves (Figure 49). Under favourable environmental conditions, entire leaves, stems, floral parts and pods are affected. The whole leaf may be covered with powdery mass. If persistent, mild chlorosis or necrosis can also occur

Survival and spread

The pathogen survives overwinter through cleistothecia which are present in crop debris in the field and which contain ascospores (sexual spores). Infection occurs when ascospores or conidia (asexual spores) are able to germinate and penetrate the plant's leaf. After infection, the pathogen, now growing as hyphae within the leaf, begins producing conidia on short conidiophores. Both ascospores and conidia can be the source of a primary inoculum or "first infection".

Fig. 49. Downy mildew on leaves of Beet

Control

Control relies on adequate crop rotation and avoidance of sources of infection (e.g. adequate control of the disease on beet seed crops), as oospores survive only 2–3 years in the soil. Individual infected plants may also be removed. It is not generally necessary to apply fungicides.

8.1.4. Beet Rust -*Uromyces beticola*

Favoured in cool and wet seasons, Beet rust (*Uromyces beticola*) is commonly seen in beet crops.

Symptoms

On leaves, the symptoms of U. *beticola* infection depend on the period of the growing season and the subsequent stage of the fungus. The spermogonial stage can be recognised by the appearance of honey-coloured sunken spots on the adaxial leaf surfaces in spring. The aecial stage is marked by the development of yellowish-orange 'cluster cups' on the abaxial leaf surface.

The most obvious symptoms are at the uredial stage, when both sides of the laminae and petioles of the leaves are covered by russet-coloured pustules (Figure 50) that erupt through the epidermis and are usually surrounded by a yellow halo. These pustules are the uredia, producing vast numbers of uredospores that accumulate as a russet-coloured powder in leaf depressions and crevices. On susceptible plants, the infection quickly progresses, causing the older leaves to wilt and die prematur. The telial stage of the fungus occurs in late autumn and is represented by the uredia becoming dark brown as the leaves senesce

On inflorescences, the symptoms are similar except that it is highly unlikely that spermogonial and aecial development would occur.

On seedlings, the spermogonial, aecial and uredial stages can be seen, but not the telial stage.

Life cycle

To overwinter, beet rust must have living beet material to survive. From early spring the beet plant is susceptible to attack by beet rust, but it is the late season attack that has the greatest effect. In the late summer or early autumn, beet rust can increase very quickly, causing older leaves to wilt and die.

Weather Conditions

Disease development is favoured by cool (16-20ºC), moist weather.

Economic Impact

Reduces the palatability of leaves and in Georgia, beet rust infections have been shown to lead to moderate yield reductions in sugar beet.

Fig. 50. Beet Rust on leaves of Beet

Control

Treatment with Opera 0.5 l/ha 2 x effective.

Chapter IX. Major Diseases of Bans - *Phaseolus vulgaris* L.

Introduction

Common bean (*Phaseolus vulgaris* L.) is the most important food grain legume in Adjara. The crop is a source of food nutrients (proteins, minerals, fiber, and vitamins) and also a source of cash. Economic significance of bean is quite considerable since it represents one of the major food and cash crops.

Our long-term studies in Adjara have shown us that various fungal, bacterial and viral diseases prevent the growth of bean yield.

The fungal diseases that affect bean are anthracnose caused by *Colletotrichum lindemuthianum*; rust caused by *Uromyces appendiculatus*; downy mildew due to *Phytophthora phaseoli*; seedling diseases triggered and root rots due to *Rhizoctonia solani* and *Pythium spp*., dry rot caused by *Fusarium solani*; white mold caused by *Sclerotinia sclerotorium* and *Sclerotinia trifoliorum*; charcoal rot or ashy stem blight due to *Macrophomina phaseolina*; scab caused by *Elsinoe canavaliae*, and the foliar disease due to *Didymella sp*.

The most virulent viral diseases are mosaics caused by Bean Common Mosaic Virus (*Potyviridae, Potyvirus*).

Some bacteria also infest lima bean in culture and are responsible for leaf necrosis and stem cankers. The most important are common and halo bacterial blights due to *Xanthomonas campestris pv. phaseoli* and *Pseudomonas syringae*.

Among the listed pathogens, *Colletotrichum lindemuthianum, Uromyces appendiculatus, Erysiphe polygoni* and *Xanthomonas phaseoli pv. phaseoli,* are considered the main diseases of beans in Adjara.

9.1. Fungal diseases

9.1.1. Antracnose - *Colletotrichum lindemuthianum* L.

Symptoms

Symptoms appear initially on the lower leaf surfaces as dark-red to black lesions along the veins; however, lesions may occur on any plant part. Rust-colored specks appear on cotyledons, while petioles, leaves, and leaf veins show brick-red to purple or black lesions (Figure 51). On pods, symptoms look like brown sunken cankers delimited by black rings. On stems, the lesions are sunken and usually elongate. Lesions on seeds are brown with a white or reddish center. On severely infected plants the lesions coalesce, causing the death of all or part of the plant. Yield losses due to the disease are usually high when infection occurs in the seedlings. The primary sources of inoculum include plant debris and infected seed—particularly the seed coat and cotyledons. Intermittent moderate rainfall and temperatures between 14 and 27°C are conducive for spread of the disease. Anthracnose is prevalent in smallholder farmers' fields mainly because farmers harvest seeds that are already infected and use them for planting a new crop.

Management

Cultural practices can be effective in managing this disease. Fungicide such as tebuconazole and triadimenol or boscalid and pyraclostrobin or fenamidone and propamocarb or carbendazim at recommended rates. Spray every seven to 12 days depending on how badly the crop is affected by the disease.

Fig. 51. **Anthracnose on leaves and** pods **of beans**

9.1.2. Rust - *Uromyces appendiculatus*

Rust is an important disease that affects dry beans in Adjara. The disease is caused by the fungus *Uromyces appendiculatus*, which has caused periodic epidemics in this region during the last 60 years. Recent losses from the disease have exceeded 40-45 percent in some areas.

Symptoms

Rust symptoms initially appear as small yellow or white slightly raised spots on upper and/or lower surfaces of leaves (Figure 52). These spots enlarge and form reddish-brown or rust-colored pustules that are about 1/8 inch in diameter and contain thousands of microscopic summer spores (urediniospores). Spores are readily released from the pustule and give a rusty appearance to anything they contact. Rust can be distinguished from other leaf spots in that these spores rub off onto your fingers, while blights and bronzing do not.

Pustules may be surrounded by a yellow border. Severe infection may cause leaves to curl upwards, dry up, turn brown and drop prematurely. A severely damaged bean field often looks like it has been scorched. Pod set, pod fill and seed size can be reduced if early infection is severe. Green pods, and occasionally stems and branches, also may become infected and develop typical rust pustules. However, bean rust is not seed-borne.

Near the end of the season, pustules undergo a subtle change and form brownish-black winter spores (teliospores) that signify the end of the current infection cycles. This overwintering phase has been confirmed to occur or contribute to rust epidemics in eastern Colorado and western Nebraska and Kansas. It is a factor in northern states such as North Dakota and Minnesota by producing sexual stages the following season

The initial appearance of rust in Adjara occurs in midsummer, apparently after urediniospores from local or distant bean production regions are transported here by wind currents and deposited on leaves. These spores germinate and enter a leaf through the plant stomates (breathing pores). They develop within the host tissue to form a small white spot or blister in five to seven days and mature reddish-brown pustules in 10 to 12 days.

Factors Favoring Epidemics

Rust development is favored by cool to moderate temperatures with moist conditions that result in prolonged periods of free water on the leaf surface for more than 10 hours. Weather conditions during late July and August usually are the most favorable because of cooler nights. Repeating disease cycles may occur at 10- to 14-day intervals under favorable conditions.

The earlier the plant becomes infected during its development, the greater the chance for yield loss. Anything that delays plant maturity, such as late planting, herbicide damage, excess nitrogen or hail damage, may increase the potential for significant yield loss in the event that a rust epidemic occurs. This potential also may be increased by planting on or adjacent to old bean ground.

Fig. 52. Rust on leaves and pods of beans

Rust Management

No single control or disease management measure prevents rust fungus infection. Cultural practices such as crop rotation (two to three years) and soil incorporation of bean debris remove potential sources of rust spores. If coverage is thorough, some fungicides can prevent or reduce rust infection if applied early in the season before the epidemic becomes severe. Apply fungicides in at least 5 gallons of water per acre to thoroughly contact plant foliage. It is advisable that spreader sticker agents be applied with the fungicide. Protectant fungicides include chlorothalonil and maneb formulations.

9.1.3. Powdery mildew in beans - *Erysiphe polygoni* DC.

Powdery mildew, caused by the fungal organism *Erysiphe polygoni*, is one of the most commonly occurring diseases on many types of beans. Green bean, pole bean, and long bean. Accurately identifying this disease and immediately taking action for control are critical to effectively prevent spread of powdery mildew in order to reduce significant losses of yield and quality.

Symptoms

Powdery mildew can affect all above-ground parts of bean plants. Initial symptoms appear as small and white talcum-like spots, which most commonly are seen on the upper surface of leaves. These spots increase in size and run together to form a whitish, powdery growth, gradually spread over a large area of the leaves, and can spread even farther to the stems (Figure 53). As the symptoms developed, infected leaves may gradually curl downward, pale yellow or brown, die, and fall off. Under severe conditions, the entire leaves and plants could be covered by white cottony mycelial growth of the fungus. Symptoms on infected leaves may vary with bean varieties. The powdery mildew fungus usually does not grow on bean pods except pea pods. However, powdery mildew spots can develop on snap bean pods. Severely infested plants may have reduced yields, shortened production periods, and even completely die.

Infection and Spread

The pathogens of powdery mildew grows as thin layers of mycelium on the surface of the affected leaves. Spores, which are the primary means of dispersal, make up the bulk of the visible white, powdery growth. Powdery mildew spores can be easily carried by wind to new hosts. The spores can germinate and infect beans in the absence of free water. Powdery mildew growth generally does not require moist conditions; however, increased humidity can increase the severity of the disease. Moderate temperatures and shady conditions generally are the most favorable environmental factors for the development of powdery mildew.

Fig. 53. Powdery mildew on leaves of beans

Control

Control measures are required every year to produce a crop. Dusting the plants with sulfur has given good results.

By formulation of wettable Sulphur such as Sulfex and Thiovit at 3 kg/ha Elosal 8 WP three time at 10 days interval Karathane (Dinocap - 0.05%), Dikar (Manocap), Mososide (Binapacryl) and Morestan (Quinomethionate) 0.03 % Calixin followed by Karathane (0.2%) and Bavistin (100 ppm).

The first dusting should be done as soon as there is any sign of the disease. Another application should be made a week or 10 days later.

Sometimes as many as six or seven dustings are necessary to insure a crop. Crop rotation and the immediate turning under of the refuse left in tlie field after harvest by deep plowing are practices growers should follow.

9.2. Bacterial diseases

9.2.1. Bacterial blight in common bean - *Xanthomonas phaseoli pv. phaseoli*

Symptoms

Small water-soaked spots are the first symptoms observed on leaves and appear within 5 to 10 days of infection. These spots enlarge and the centre turns necrotic and brown (Figure 54). Areas around the lesion may become flaccid. The lesion is surrounded by a narrow band of bright yellow tissue. However, yellowed tissue is occasionally absent.

Stem infection is less common. It begins as a water-soaked spot, which becomes a reddish-brown lesion, usually without chlorosis. Stem girdling may develop at the cotyledonary node. The bacteria can invade the xylem, and wilting may occur if sufficient bacterial numbers develop in the xylem.

Pod lesions begin as water-soaked spots which become sunken and dark to red brown. Under humid conditions, a yellowish bacterial ooze will develop from the lesion.

Severely infected seed may be shrivelled and show poor germination or produce weakened plants. On white-seeded varieties, yellow or brown spots may appear on the seed coat, particularly near the hilum area.

X. axonopodis pv. phaseoli can survive in seed, infected plant debris and epiphytically on host and non-host plantsInfection

Infection occurs through natural openings and wounds. Severe epidemics can occur following storms with wind-blown rain, which can force the bacteria through openings, such as stomata, into the intercellular spaces. Wounds due to hail or insect feeding can create favourable sites for infection. Once inside the plant, *X. axonopodis pv. phaseoli* multiplies rapidly in the intercellular spaces and it can take as little as 10-14 days from initial infection until secondary spread occurs). The optimal temperatures for disease development are 27-33°C. Plants appear to be more susceptible in the reproductive stage than in the vegetative stage. As the bacterial population increases, it can ooze onto the leaf surface and be spread further by water. The bacteria can also enter the vascular system of many varietiesof beans and then spread systemically in the plant. Wilting can result from vascular infection. Bacteria in the vascular system can also enter the developing pods and pass into the seeds. Infection of the seed coats can also occur from pod infections.

Fig. 54. **Field symptoms of common bacterial blight on common bean**

Chemical Control

Chemical control may reduce leaf infection but usually has little improvement on yield.

Chapter X. Major Diseases of Peas - *Pisum sativus* L.

Introduction

Peas is popular around the world for food and feed purposes. Unfortunately, lettuce is sensitive to a wide range of bacterial, viral and fungal pathogens.

Among the pathogens identified by us on peas in Adjara, the most widespread are Ascochyta blight of peas – *Ascochita pisi,* Powdery mildew of field peas - *Erysiphe pisi,* Roof Rots of peas and Bacterial Blight - *Psetidomonas pisi* Sackett.

10.1. Fungal diseases

10.1.1. Ascochyta blight of peas – *Ascochita pisi*

Symptoms

The disease affects all above ground parts of plants. Irregularly-shaped grayish-smoky or brown spots are formed on leaves, of 1-2 mm (Figure 55). Rounded or oval spots with dark brown limb and lighter center are formed on stalks and beans. In the center orange-pink or reddish pads of sporiferous fungus are formed, having numerous setae.

Fig. 55. Ascochyta blight on leaves and fruit of peas

Control

It is recommended to cultivate resistant species, using healthy seeds and a balanced soil fertilization.

During the vegetation period, there are 3 preventive treatments that can be applied: during the beginning of the stem’s branching, before flowering and after flowering, using fungicides such as Dithane M45 (0.2%), Zeama bordeleza (0.5%), Champ (0.3%).

10.1.2. Powdery mildew of field peas - *Erysiphe pisi*

Disease cycle

The disease powdery mildew, caused by the pathogen *Erysiphe pisi*, oversummers on infected pea trash and produces spores which are blown by wind into new crops. The disease may also be seed-borne, but this source of infection is less important.

Under favourable conditions, the disease may completely colonise a plant in 6 to 7 days. Once a few plants become infected, the disease rapidly spreads to adjacent areas. Warm (16-26°C), humid (over 75 per cent RH) conditions for 4 to 5 days late in the growing season, during flowering and pod filling, favour disease development.

However, heavy rainfall is not favourable for the disease as it will actually wash spores off plants. Night time dews are sufficient for the disease to develop.

Syptoms

Infected plants are covered with a white powdery film, and severely infected foliage is blue-white in colour, and the tissue below these infected areas may turn purple (Figure 56). All aerial parts of the plant may become infected resulting in withering of the whole plant.

Severe pod infection can cause a grey-brown discolouration of the seeds. These seeds have an objectionable flavour that lowers the quality of the grain.

Economic importance

Severe infections can reduce yield by 10–20 per cent. Powdery mildew is most prevalent late in the season. Crops sown late are more likely to be affected by powdery mildew than early sown crops. Severe pod infection can lead to poor seed quality.

Fig. 56. Powdery mildew on leaves of peas

Control

Same as bean ash disease.

10.1.3. Roof Rots of peas

Description

Eoot rots are caused by several different parasites (*Fusarium solani f. pisi, Aphanomyces eufeiches, Rhizoctonia solani, Pytluum ulfhnum, Ascochyta pinodea, Mycosphaerella pinodes, Sclerofinia sclerotiomum, Thielaviopsis basicola and Sclerothim rolfsii)* that produce symptoms so much alike that it is not always easy to distinguish them by a casual examination.

Root rots, as the name indicates, occur on the roots or on all the underground parts of the plants and sometimes extend a short distance above the surface of the soil. Most of the lesions are gi-ayish brown or almost black, but occasionally some are reddish; and definite streaks form on the taproot or on the stem near the soil line. Root rot may begin when the plant is in the seedling stage, or before it comes through the ground. Death of the plant soon follows such some instances, all the roots are destroyed, leaving nothing, or only shreds, below the attacliment of the seed (Figure 57). Sometimes, however, tlie main root is the first to be affected.

Fig. 57. Roof Rots of peas

Control

Measures for all root rots are about the same. Root rots are usually more se\'ere during seasons of heai'y rainfall than during dry seasons and on low-lying fields that are poorly drained tlian on well-drained fields. Excessive soil moisture, regardless of tlie location of the field, favors root rots. Where root rots have been troublesome, it is advisable to select well-drained fields and to prepare the soil thoroughly before planting. Plants that start growth poorly, as they do on impoverished soils, are mucli more subject to attack of root rots than are plants grown on rich soils where a good, vigorous growth is maintained from the beginning. Thus a fertilizer should be added to tlie soil where needed. Crop rotation is recommended as a good practice, but it is of no particular \-alue in controlling pea diseases except in the case of those organisms that attack only peas. However, most of the fungi are about as parasitic on other crops that might be grown in rotation as they are on peas.

10.2. Bacterial diseases

10.2.1. Bacterial Blight - *Psetidomonas pisi*

Description

Bacterial blight is caused by a parasite *Psetidomonas pisi*. Pathogen of peas is found on all parts of tlie plant above the ground. Infection established later may reduce the yield considerably. The extent of the injury depends largely on weather conditions. Bacterial blight causes water-soaked lesions on the pods, stems, leaves (Figure 58), and stipules. These lesions enlarge under humid conditions, and sometimes spots of considerable size appear.

A white to cream-colored, slimy ooze may also collect on the surface of the lesions. On the other hand, if the weather turns dry, the infection maj' dry up. The infected tissue of the leaves and stipules eventually turns brown and becomes papery in texture.

Fig. 58. Bacterial blight on leaves and fruit of peas

The water-soaked, irregularly shaped spots are slightly sunken. The seed may be invaded by the parasite and serve as a source of infection for the new crop. Such seed should not be planted.

Bacterial blight on pea leaves. These spots start as small, water-soaked areas which gradually kill part of the leaf. Sometimes the injury is so extensive that the plant dies.

Extensive infection of tlie pods reduces tlieir market value considerably because of their unsightly appearance. The germs may spread through the pods and infect the seed. Thus, the infection would be transmitted to a new crop if the infected seed were later planted.

Bacterial blight has been reported from many States but is more commonly found east of the Continental Divide than west of it. The extent of loss from the disease is not known, but at times the estimated damage has been 30 to 35 percent or more in some fields. The disease is most severe when humidity is high.

Cause

Bacterial blight tliat lives over winter in tlie seed. It is not known if the parasite lives on tlie refuse left in tlie field from harvesting. If tlie germs do not survive the winters in the field, tlie seed is practically the only source of infection.

Management

Bacterial blight can be avoided by using an integrated approach to management that encompasses: planting disease-free seed; crop rotation; variety selection and avoiding early sowing.

Chapter XI. Major Diseases of Pepper - Capsicum annuum

11.1. Fungal diseases

11.1.1. Late Blight of Pepper - *Phytophthora Infestans*

Introduction

Pepper (*Capsicum annum* L.) is one of the most important constituent of the cuisines Adjara. Apart from the explicit importance of the crop in the diet, is also used in other forms like medicines and beverages and also as an ornamental plant in the gardens. Nutrition wise these are enriched with high Vitamin A and C content; high iron, potassium, and magnesium content with the ability to boost the immune system and lower the cholesterol levels.

On the pepper-Capsicum annuum in the study region the following representatives of fungi and fungus-like organisms are identified: *Phytophthora capsici, Ph.Infestans, Pythium debaryanum, Leveillula taurica, Verticillium dahliae,V. melongena, Alternaria solani, Colletotrichum capsici, Cercospora capsici*. Among them the *Phytophthora capsici, Colletotrichum capsici, Cercospora capsici* and Bacterial leaf spot, caused by *Xanthomonas campestris pv. Vesicatoria*.

Among the detected pathogens, Late Blight of Pepper - Phytophthora Infestans, Anthracnos - Colletotrichum capsici and Bacterial leaf spot - Xanthomonas campestris pv. vesicatoria is the most widespread in Adjara.

11.1. Fungal diseases

11.1.1. Late Blight of Pepper - *Phytophthora Infestans*

Phytophthora capsici is an oomycete plant pathogen that causes blight and fruit rot of peppers and other important commercial crops. In Greek, Phytophthora capsici means "plant destroyer of capsicums".

Syptoms

Infection of the pepper commonly starts at the soil line leading to symptoms of dark, water soaked areas on the stem. Dark lesions of the stem may girdle the plant resulting in death. Roots of the pepper plant appear brown and mushy. Leaf spots start out small and become water soaked, and as time progresses may enlarge turn tan and crack. Blighting of new leaves may also take place. The fruit of the pepper is infected through the stem giving way to water soaked areas on the fruit that are overgrown by signs of the pathogen which appear as, "white-gray, cottony, fungal-like growth" (hyphae). The fruit mummifies and stays attached to the stem (Figure 59).

Disease cycle

Phytophthora capsici produces both a male and a female type gametangia. The oospores may directly germinate into a germ tube or indirectly germinate and give rise to sporangia which then indirectly germinates and gives rise to zoospores. Zoospores are biflagellate motile spores with one long tinsel flagella directed forward and one shorter whiplash flagella directed backward. These zoospores are responsible for the polycyclic qualities of this disease.

Fig. 59. ***Phytophthora on Capsicum annuum leaves, root and ftuits***

Environment

P. capsici grows best at 27 °C. It rapidly spreads in warm wet conditions. The asexual spore bearing structures called sporangia are spread by irrigation water, drainage water, and rain. P. capsici indirectly germinate and release zoospores.

Management

Crop rotation may reduce the number of pathogens in the soil and, "a minimum of a 3 years crop rotation. Mefenoxem is the active enantiomer contained in the racemic fungicide metalaxyl used to defend against Phytophthora capsici. Sexual recombination provides the genetic diversity to promote resistance towards fungicides in *P. capsici.*

11.1.2. Anthracnos - *Colletotrichum capsici*

Anthracnos has a broad host range but prefers peppers, yams and eggplants. It damages pepper the stem, fruit, and leaves of the plant, causing anthracnose, die-back and ripe fruit rot. C. capsici infection tends to infect ripe red fruit and lead to the development of brown necrotic lesions containing concentric acervuli that will eventually appear black from the setae and sclerotia (Figure 60). Additionally, the fruit content of capsaicin and oleoresin is reduced, which results in a decrease of its medicinal potency.

Fig. 47. Leaf, Fruit and Stem symptoms *Colletotrichum capsici*

Management

Leave at least 3 years between crops after the disease has occurred. Do not plant new crops near those with frog-eye disease.

Warm wet conditions favour the disease, and fungicides chlorothalonil, copper oxychloride or mancozebmay be needed to give adequate control. Treatment should start when the spots first appear, and continue at 10-14 days intervals until 3-4 weeks before last harvest.It is important to spray both sides of the leaves.

11.2. Bacterial diseases

11.2.1. Bacterial leaf spot on pepper - *Xanthomonas campestris pv. vesicatoria*

Bacterial leaf spot, caused by *Xanthomonas campestris pv. vesicatoria*, is the most common and destructive disease for peppers in the Adjara. Different strains or races of the bacterium are cultivar-specific, causing disease symptoms in certain varieties due to stringent host specificity. Bacterial leaf spot can devastate a pepper crop by early defoliation of infected leaves and disfiguring fruit. In severe cases, plants may die as it.

Symptoms

Disease symptoms can appear throughout the above-ground portion of the plant, which may include leaf spot, fruit spot and stem canker. Over time, these spots can dry up in less humid weather, which allows the damaged tissues to fall off, resulting in a tattered appearance on the affected leaves (Figure 61).

The size of the lesions can be quite variable with irregular and somewhat angular margins. On some cultivars, leaves may display several small lesions – 1/4 to 1/2 centimeter – covering over 65% of the leaf's area, whereas on others, fewer large lesions – larger than 1/2 centimeter – may be visible. In some cases, a combination of small and large lesions may be found on the leaves. Yield can be drastically reduced as affected leaves turn yellow and drop off prematurely, thus reducing plant productivity and exposing fruit to potential sunscald.

Disease Cycle & Epidemiology

Bacterial spot develops most rapidly during periods of warm temperatures and prolonged wet conditions. The pathogen survives in and on seeds and in plant debris. Although persistence of debris and the pathogen depend on environmental conditions, it is very common for the pathogen to survive in debris for at least a year. However, once infected debris gets decomposed and the organism is exposed to soil, it cannot stay alive for more than a few weeks. Infected weeds and volunteer host plants also can be sources of inoculum.

Management

For bacterial leaf spot, the following methods can be used to reduce the survival, spread and reproduction of bacteria and to minimize the infection of plants: using resistant varieties, seed treatment, foliage treatment and using an integrated strategy.

Fig. 61. Appearance on the affected pepper plant leaves due to bacterial leaf spot

Chapter XII. Major Diseases of Radish - *Raphanus sativus* L.

Introduction

Radish (*Raphanus sativus* L.) is a vegetable cultivated mostly in the temperate areas for the root, which is succulent. It is very popular in Adjara (Georgia), mostly in the cold areas, due to its storage capacity. More recently, radish and other cruciferous vegetables (members of the Brassicaceae) have been recognized as important sources of chemoprotective phytochemicals in the diet. Radish is a productive vegetable based on biomass per area of cultivation. However, this crop is affected by many diseases, particularly those caused by fungi.

Among fungi Radish downy mildew is an economically important disease in main production areas worldwide. Information on downy mildew of Radish is found in various works (Bonnet and Blanchard, 1987; Coelho and Monteiro, 2018; Glits, 1977; Goker *et al.,* 2009; Lee *et al.,* 2017; Wang *et al.,* 2014, 2017; Xu *et al.,* 2014).

The orography of the Adjara and the edaphic-climatic conditions (frequent rain, warm humid temperature, excess of soil moisture, etc.) can forward the widespread and development of Radish downy mildew causing agents.

In Adjara the main pathogens of Radish cause considerable damage to the crop, especially in subtropical plains (Shainidze, 2014, 2019, 2021). It is increasingly becoming a limiting factor for the successful cultivation of Radish in these regions. Several fungicides recommended for controlling these pathogens not only add up to human and environmental hazards but also be inconsistent and insufficient to deal with this disease. However, the application of this agrochemical is increasingly restricted due to the harmful effects of pesticides on human health and the environment (Harris *et al.,* 2001). In many countries, the use of synthetic fungicides has been banned due to their polluting nature. To have safe methods for plant disease control in sustainable agriculture there is a need for reducing the use of synthetics chemicals fungicides thereby replacing them with biocides with plant origin. The plants are rich sources of numerous bioactive secondary metabolites such as alkaloid, flavonoids, terpenoids, saponins, tannins and phenolic compounds which are the important sources of microbicides, antifungal activity and many pharmaceutical compound (Mahesh *et al.,* 2008; Arif *et al.,* 2009). Plants are rich sources of important organic compounds, pharmaceuticals and pesticide compounds. Many reports on the antiviral, antibacterial, antifungal, anthelmintic, anti-molluscal and anti-inflammatory properties of plants have reviewed. Thus plant extracts which is a source of natural pesticides can be developed into new biocidal pesticides (Samy *et al.,* 2000; Palombo *et al*., 2001; Behera *et al.,* 2005; Govindarajan *et al.,* 2006). Therefore, this study was intended to determine the composition of pathogenic microbionts on Radish in all agrocenoses in Georgia; study the symptoms, aetiology and harmfulness of main f ungal Radish pathogens and application of the biological method (various extracts of high medicinal plants) against the most common fungi *Hyaloperonospora brassicae f. sp. raphani* in Adjara.

12.1. Fungal diseases

12.1.1. Downy mildew of Radish - *Hyaloperonospora brassicae f. sp. raphani*

Results

Isolation and identification of the microbionts

The microbionts was isolated from Radish tissues showing spot symptom on leaf and root vegetable. On the Radish, 17 species of microbionts *(Hyaloperonospora brassicae f. sp. raphani, Albugo candida, Pythium de baryanum, Aspergillus niger, Phytophthora sp., Erysiphe sp., Penicillium sp., Alternaria blight, Alternaria sp., Aphanomyces raphani, Cercospora cruciferarum, C. atrogrisea; Thielaviopsis basicola, Fusarium moniliforme f. sp., Sclerotinia sclerotiorum, Phoma sp., Rhizoctonia solani* and Bacterial Leaf Spot-*Xanthomonas campestris pv. campestri)* were identified as a result of phytopathological and mycological studies conducted in different places of agrocenosis in Georgia.

Formation of the consortium fungus on leaf and root vegetable

The infected oleaf and root vegetableradish can be covered with a multi-coloured mycelium which includes 8 species of microbionts *(Hyaloperonospora brassicae f. sp. raphani, Aphanomyces raphani, Alternaria blight, Alternaria sp., Aspergillus niger, Sclerotium rolfsi, Rhizoctonia solani* and Bacterial Leaf Spot-*Xanthomonas campestris pv. Campestri*) in Figure 62.

Fig. 62. Symptoms of consortium on radish root vegetable

Observations have shown that the formation of the consortium begins when air and soil temperatures are 25 to -31°C, and an optimum temperature is about 26-27°C. High humidity (89 -96%) hastens the formation of the consortium.

Results of the studies showed that among the mycobionts found on radish, the most common, dangerous and harmful are 4 pathogens: *Hyaloperonospora brassicae f. sp. raphani* (51%), Rhizoctonia *solani* (28%), *Alternaria* sp. (27%) and *Xanthomonas campestris* (12%) in Figure 63.

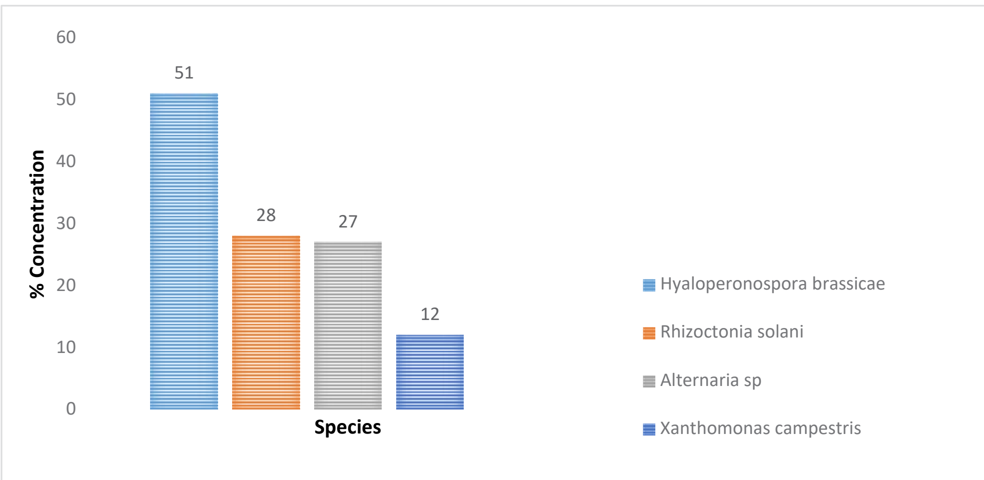

Fig. 63. Spreads of the main pathogens of Radish in Georgia, %

Analyis main pathogen of radish and symptoms diseases

As Figure 63 shows fungi, the main species is *Hyaloperonospora brassicae f. sp. raphani Syn.: Peronospora brassicae, Peronospora parasitica*. It causes downy mildew. In the past, the cause of downy mildew in any plant in the family Brassicaceae was considered to be a single species *Peronospora parasitica.* However, this has recently been shown to be a complex of species with narrower host ranges, now classified in the genus Hyaloperonospora. From the perspective of plant pathology, *Hyaloperonospora brassicae brassicae f. sp. raphani* is now the name of the most important pathogen in this complex. The pathogen is more common in seedbeds. In Adjara (favourable for the disease), yellow to pale brown spots develop rapidly into large irregular patches, on the upper surface of the young leaves. A greyish growth occurs on the underside of the leaves and may be present, too, on the upper surface during cool and moist conditions. The diseases areas turn brown and papery in dry weather. Severely affected seedlings are stunted and killed. The older leaves may have a speckled appearance in Figure 64.

Fig. 64. Symptoms of *H. brassicae f. sp. raphani* on leaves

As figure 65 shows symptom on radish root vegetable is a white to gray dusty material. The fungus quickly spreads to completely cover the root vegetable surface. This disease is favored by high humidity, nearly similar symptoms appear in the field and lead to the early death of the leaves; in moist weather the spots grow larger, join together and form large dead patches.

Figure 65. Symptoms of *H. brassicae f. sp.* on radish root vegetable

Level of disease incidence and severity of Radish sowings

The distribution area of Downy mildew, level of disease incidence and severity were determined during observation of Radish sowings in Table 9.

As shown in Table 9, the average values of the infected field were high (62,3-54,6%) in the subtropical zone (Xhelvachauri and Kobuleti). The lowest number of infected fields (27.4%) were in the mountainous zone (Khulo). A nearly equal number of infected fields (37.2-34.7%) were determined in Keda and Shuakhevi.

Tab. 9. Spread of *H. brassicae f. sp. raphani* in the different geographic zones in Georgia (2017-2020)

Years	Spread of *H. brassicae f. sp. raphani* in the different geographic zones (%)					Average
	Subtropical zone		Mountainous zone			
	Kobuleti	Xhelvachauri	Keda	Shuakhevi	Khulo	
2017	66.0	71.7	38.4	38.6	21.8	47.3
2018	40.5	56.7	36.5	31.9	25.8	38.3
2019	74.7	76.3	38.8	38.9	37.4	53.2
2020	34.3	44.4	35.4	29.5	24.5	33.6
Average	54.6	62.3	37.2	34.7	27.4	43.2

As shown in Table 10, the overall mean of incidence and severity were low (20,1% and 23,0%), especially in the non-irrigated region of Shuahkevi (12,2-15,3%). Drought and hot dry weather during April and May limited the development of Downy mildew and that significantly contributed to the Downy mildew development. In 2018 and 2019 years overall mean of infected fields by Downy mildew were similar (53.2% and 53.4%, respectively) and lower, than in previous years. Also, there was a very low overall mean of incidence and severity of diseases - 20,1% and 23.0% in 2018, 23.7% and 25.3% in 2019, 26.1% and 28.8% in 2020 respectively.

Antifungal activities of the extracts

Different concentration i.e. 1000ppm, 3000ppm, 5000ppm of 21 different metabolic extract from 18 different medicinal plant species was tested for their efficacy against *H. brassicae f. sp. raphani*. Antifungal activity of tested plant extract was investigated at different concentration against *H. brassicae f. sp. raphani*. The result revealed a highly significant percent inhibition.

The antifungal activity was observed to be dose-dependent i.e. with an increase in the concentration of plant extract percentage inhibition of mycelium growth increases. Antifungal activity of different plant extracts showed significant activity when compared with the leaf/root extract against *H. brassicae f. sp. raphani* Root extract of *Inula racemosa* (R), *Rubia cordifolia* (R) and *Panax ginseng* (R) exhibit the highest activity.

Tab. 10. Overall mean values of incidence and severity levels of *H. brassicae f. sp. raphani*, %

Geographical Zones	2017		2018		2019		2020		Average	
	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity%
Kobuleti	8.9	4.3	7.2	1.60	0.9	2.4	34.4	6.7	0.35	33.75
Xhelvachauri	5.9	1.7	8.3	1.2	1.2	1.8	33.3	5.8	9.67	32.62
Keda	1.7	4.7	0.1	1.5	2.4	4.2	21.2	6.9	1.35	24.33
Shuakhevi	8.4	2.3	2.5	5.4	6.6	9.8	22.9	5.7	7.60	20.80
Khulo	9.5	1.6	2.2	5.3	7.2	8.5	18.8	9.7	4.90	16.93
Average	2.9	6.9	0.1	3.0	3.7	5.3	26.1	8.8	9.0	25.1

Among the 21 extracts evaluated, 5 extract showed mycelia inhibition 80.75-98.33%, 3 showed moderate effect of 75.56 -79.32% and 6 showed least 31,4 % - 57.27% (Table 11). The remaining 7 extracts from leaf extract of *Althaea officinalis, Betonica officinalis, Jasminum officinale, Pimpinella anisum, Pyrethrum vulgare, Ricinus communis* and *Sambucus ebulus* showed no antifungal activity against the *H. brassicae f. sp. raphani*.

This may be due to the lack of antifungal compound in the above mentioned 8 extracts. The percentage growth inhibition of H. *brassicae f. sp. raphani* was found maximum with Stevia *rebaudiana* (98.33%) and *Inula racemosa* (R) (91.86%). The plant Galium *aparine*, *Inula racemosa* (L), Panax *ginseng, Rubia cordifolia et* al which inhibit the mycelia growth above 75% would probably be important candidates for plants for prevention of against Fungi. The investigation is an important step towards crop protection strategies for antifungal activity against important phytopathogen *H. brassicae f. sp. raphani.*

Tab. 11. Efficacy of herbal extracts of medicinal plants against *H. brassicae f. sp. raphani*

	1000ppm		3000 ppm		5000 ppm	
Species	Colony Diameter	% Inhibition	Colony Diameter	% Inhibition	Colony Diameter	% Inhibition
Eucalyptus cinerea (L)	3.2±0.05	23.94±0.9	2.03±0.6	27.95±1.4	1.96±0.07	31.43±1.41
Hamamelis mollis (L)	3.1±0.08	25.83±0.8	2.09±0.9	32.86±1.5	1.97±0.05	34.5±1.33
Panax ginseng (L)	1.4±0.05	70.69±1.2	1.3±0.05	73.67±1.2	1.16±0.03	75.56±0.89
Panax ginseng (R)	2.5±0.04	75.84±0.7	1.3±0.04	77.82±1.2	1.16±0.05	80.75±0.90
Mentha silvestris (L)	3.12±0.7	30.65±1.4	3.2±0.02	31.63±0.7	2.73±0.04	38.60±0.75
Mentha longifolia (L)	3.4±0.04	32.3±0.8	2.9±0.05	37.6±1.37	2.3±0.04	46.9±1.12
Galium aparine (L)	3.3±0.07	65.37±1.1	1.75±0.0	76.34±0.8	1.52±0.04	79.32±0.82
Rubia cordifolia (L)	2.43±0.3	72.64±0.08	1.44±.04	76.5±0.84	1.2±0.06	77.63±1.32
Rubia cordifolia(R)	2.35±0.4	76.59±0.6	1.21±0.7	79.48±0.9	1.1±0.7	83.41±1.27
Rubia iberica (R)	3±0.02	36.18±1.2	2.2±0.05	53.13±1.2	2.1±0.05	57.27±1.28
Inula racemos (L)	1.3±0.05	79.04±1.3	1.03±0.2	80.01±1.43	0.97±0.3	87.84±1.43
Inula racemosa (R)	1.4±0.7	82.91±1.3	1.04±0.7	88.47±1.44	0.95±0.5	91.86±1.35
Salvia officinalis (L)	3.7±08	29.52±0.5	3.5±0.06	31.52±1.5	3.04±0.6	37.12±1.53
Stevia rebaudiana (L)	2.37±0.4	83.74±1.3	2.03±0.8	87.76±1.7	1.7±0. 8	98.33±1.72

The value means of three replicates ± standard error. The values followed by different alphabets differ significantly when subjected to Tukey HSD at 0.5 subsets; R: Root; L: Leaf.

12.1.2. Rhizoctonia of Radish - *Rhizoctonia solani* Kuhn

Rhizoctonia solani is with a wide host range and Adjara worl distribution. Host plants include almost all vegetables, flowers, shrubs and trees. It can cause serious damage by affecting the roots, tubers, stem, plant base, and other parts of the plant in and on the soil. The most common symptoms are root and stem rot and it can also cause sunken spots on fruit (Figure 66).

The fungus is also responsible for damping off, which affects seedlings and causes the stems to rot at the base. The pathogen overwinters as mycelium or in the form of sclerotia which produce new mycelium under favourable conditions. The fungus spreads through water, tools with soil particles and other contaminated materials. The optimum temperature for infection is 17-20ºC.

Fig.66. Sunken spots on fruit of radish

Control

It is necessary to carry out timely and correct agrotechnical measures.

12.1.3. Leaf spot - *Alternaria sp.*

Leaf spot and blight caused by Alternaria blight is on of the most important disease of Brassica species through out the world, which often results in severe yield losses. In Adjara it is considered as a number third disease of radish affecting both fresh vegetable and seed production.

The disease is more severe when the plants are left for seed production in the field and causes significant reduction in seed yield.

Symptoms

Alternaria symptoms once infection begins include small, dark, circular spots that regularly reach ½ inch (1 cm.) in diameter. As they spread, Alternaria leaf spots may change in color from black to tan or gray, with a yellow halo around the outside (Figure 67). Since spot development is heavily influenced by the environment, there are frequently noticeable concentric rings that spread from the initial point of infection. Sporulation causes these spots to develop a fuzzy texture.

Fig. 67. Symptoms of Alternaria sp. on leaves of radish

Control

The results revealed that seed treatment with lemon grass oil and foliar spray with garlic extract could be the option for management of Alternaria leaf spot and blight for radish seed production

12.2. Bacterial diseases

12.2.1. Bacterial Leaf Spot-*Xanthomonas campestris pv. campestris*

Bacterial Leaf Spot causes Bacteria *Xanthomonas campestris pv. campestris*. Discrete, water-soaked to greasy spots were observed on leaves, with some spots surrounded by a narrow yellow halo (Figure 68). The spots on the leaf petioles are black, sunken and elongated. Severe infection results in defoliation and, in extremely severe cases, death may occur. The causal organism is carried over in the crop residue and in infected seed. Once a plant is infected, further spread is by insects, rain, etc. During warm spring days, lesions are visible four to five days after infection. In cooler periods development is slower.

Fig. 68. Symptoms of Bacterial leaf spot on leaves of radish

Control

Field sanitation is important in preventing infection. Rotation will also reduce the possibility of the disease becoming a problem.

Chapter XIII. Major Diseases of Carrot - *Daucus carota*

Introduction

The carrot is a root vegetable, typically orange in color, though purple, black, red, white, and yellow cultivars exist, all of which are domesticated forms of the wild carrot.

The most commonly eaten part of the plant is the taproot, although the stems and leaves are also eaten. The roots contain high quantities of alpha and beta carotene, and are a good source of vitamin A, vitamin K, and vitamin B6.

The most commonly eaten part of the plant is the taproot, although the stems and leaves are also eaten. The roots contain high quantities of alpha and beta carotene, and are a good source of vitamin A, vitamin K, and vitamin B6.

Unfortunately, the Carrots yield is significantly reduced by various diseases. Among them, the main diseases are White mold on Carrots - Sclerotinia sclerotiorum, Crown Rot - Rhizoctonia carotae and Cavity Spot and Pythium Root Dieback - Pythium sulcatum

13.1. Fungal diseases.

13.1.1. White mold on Carrots - *Sclerotinia sclerotiorum*

Sclerotinia disease on carrots is becoming a serious economic disease in Adjara. It is considered to be the most destructive disease of stored carrots. Significant losses can occur during the long storage over the winter. Under the right conditions for the pathogen, the losses can be as high as 50% due to sclerotinia rot and secondary bacterial soft rot infections.

The fungal pathogen, Sclerotinia sclerotiorum, has a very wide host range, including canola, sunflower, soybeans, beans and a number of vegetable crops. It appears that increasing acres of susceptible crops may be correlated with higher disease levels in carrots. Sclerotia of the fungus overwinter in soil and crop residue.

Disease Symptoms

In the field the early signs of the disease would be a water soaked lesion at the base of the foliage, and if humidity is high, the infection could be accompanied with cottony white mycelial growth on the carrots and crop residue. In the storage, the white mycelium of the pathogen grows rapidly and infects carrots over large areas (Figure 69).

Disease Cycle

The disease is favoured by high soil moisture and a dense canopy. In summer with warm and moist soils within a crop canopy, the sclerotia germinate and produce apothecia. These apothecia produce millions of microscopic ascospores, which get disseminated over long distances with wind and rains, especially by thunder storms. Ascospores landing on wet leaves can lead to infection. Foliage infection is often followed by crown infection. Many of the sclerotia germinate directly producing mycelial structures which can infect the crop residue, carrot leaves and crowns. Under favourable conditions the leaves may turn brown and die-off. Damage to foliage tops prevent mechanical harvest of such carrots. A few weeks after infection black sclerotial bodies, normally 5-15 mm in size, develop on old infections.

Field warm carrots brought into the storage building are cooled down as soon as possible and held for long term storage under conditions of high humidity. The optimum temperature for disease development ranges from 12-17oC, but temperatures above 0oC will allow the disease to progress in storage if there is free moisture on carrots and RH >90%.

In storage the disease development starts from infections initiated in the field, from un-cleaned pallet boxes or storage walls. High humidity in the storage allows the white mycelium of the pathogen to grow rapidly and infect carrots over large areas. During storage many of the infected carrots develop sclerotia bodies, and are diagnostic. Infected spots in the carrot pile with poor air circulation could develop a secondary infection by soft rot bacteria and lead to greater storage losses.

Fig. 69. White mold on Carrots in the field and during storage

Management

Cultural methods include crop rotation with non-host crops. Improving air movement within the crop canopy can prevent conditions favourable for disease development. Air movement within a crop can be reduced by effective weed control, increasing row-row spacing, growing on ridges or raised beds and/or cutting excess foliage between rows using mechanical cutters. In wet growing seasons or periods of frequent rains, the chopped foliage residue may cover the ground and provide favourable conditions for mycelial development and growth on the residue.

Frequent inspection in storage, low temperatures, aeration and washing in a final water of 2-5 % diluted bleach solution may give adequate control (1 part bleach, (sodium hypochlorite) to 20 parts water.

13.1.2. Crown Rot - *Rhizoctonia carotae*

Symptoms

On carrot roots, early symptoms are horizontal dark brown lesions; as the crop matures the tops may die in patches in the field. It is believed that infections can occur early in the growing season during wet periods, however, symptoms may not be detected until later in the season. Near harvest the lesions join to form large, deep, rotten areas on the top part of the root (Figure 70). R. carotae can also cause crater rot and violet root rot but these diseases are less common.

Fig. 70. Symptoms of *Rhizoctonia carotae*

Control

Crown rot is favored by moist conditions, so planting on ridges, harvesting early and without wounding, cleaning equipment, and maintaining clean and proper storage conditions may minimize impact.

14.2.3. Cavity Spot and Pythium Root Dieback - *Pythium sulcatum*

Cavity spot and Pythium root dieback are common diseases of carrots. Cavity spot caused by Pythium sulcatum is most severe in summer and autumn harvested crops. Infections from Pythium can occur early in the carrot's development and are generally favoured by moist soil conditions. Root dieback symptoms appear as rusty-brown lateral root formation, forking and stunting (Figure 71). These symptoms can be easily confused with damage from nematodes, soil compaction or soil drainage problems. Cavity spot often shows up near harvest. Horizontal lesions varying in size from 1 to 10 mm appear on the surface of the root and can form into larger decayed areas if invaded by other fungi or bacteria. Cavity spot does not tend to reduce yield, however, it does affect the appearance and the marketability of the carrot.

Disease cycle Pythium sulcatum only infects carrots and closely related plants, it can survive for at least two years between carrot crops.

Fig. 71. Symptoms of Pythium on stem and root

Control

Metalaxyl will reduce pythium diseases when used at, or shortly after, seeding. If used frequently, metalaxyl may become ineffective due to enhanced microbial degradation.Maintain soil pH in the range 6.5-7 in water (5.8-6.3 in CaC_{l2}).

Chapter XIV. Major Diseases of Celerys, Coriander and Dill

Introduction

Our long-term studies in Adjara have shown us that various fungal, and viral diseases prevent the growth of of Celerys, Coriander and Dill yield.

Among the pathogens, Colletotrichum acutatum, early blight - *Cercospora apii,* Sclerotinia Stem and Crown Rot - *Sclerotinia sclerotiorum*, Peronosporosis - *Peronospora parasitica*, Phomosis - *Phoma anethi* and Mosaic Virus (CeMV), are considered the main diseases of Celerys, Coriander and Dill.

14.1. Fungal diseases

14.1.1. Powdery mildew - Erysiphe heraclei

It has been found out that one of the dominant diseases of Umbelliferae (celery, coriander, dill) is caused by the fungus - Erysiphe heraclei (syn.Erysiphe umbelliferarum). Pathogen is considered an obligate biotroph, which means it needs a living host to survive and feeds on living plant tissue. This characteristic is an important part for why the powdery mildew life cycle is what it is. The first stage in the disease cycle starts in the spring where the overwintering inoculum become exposed to ideal conditions. The inoculum overwinter in fungal fruiting bodies called cleistothecia. The cleistothecia then releases airborne spores called ascospores into the environment, which will serve as the primary inoculum during the growing season. The ascospores are then dispersed by the wind, or water where they then germinate on any leaf tissue they can find. It enters the plant by the use of a germ tube, giving the spore access to the inside of the plant. Once on the host plant another type of spore called, conidia are produced. The conidia then serve as the "secondary inoculum" for the disease and infect the plant further or other nearby plants for the rest of the growing season. Due to having this "secondary inoculum" this makes powdery mildew of carrots a polycyclic disease since it is able to infect further on in the growing season past the primary inoculum. The surviving conidia then overwinter and serve as primary inoculum in the spring to start the cycle all over again.

Symptoms

The disease affects the foliage, stems, and umbels of celerys, coriander and dill. Patches of the white felt-like fungus appear on lower leaves first, and then spread to the terminal growth. The fungus often covers entire leaves with its masses of white mycelium and powdery spores (Figure 72). Infected foliage becomes brittle and may eventually turn brown, shrivel, and die. Diseased pedicels may turn brown, resulting in the florets' premature death.

Powdery mildew fungi clog up leaf pores and block light to photosynthetic cells, so the plants are weakened in their ability to use light as an energy source. New growth stops, old leaves fall off, and the plants struggle to stay alive.

Fig. 72. Syptoms of Powdery Mildew (from left to right) on celerys, coriander and dill

Control

Multiple management strategies are used for the control of Erysiphe heraclei. Chemical controls are the most popular method of control and include a variety of fungicides. Common fungicides used by growers include Bravo, which provides contact control of the disease. While other fungicides provide mobile control such as Quilt, Endura and Tilt. You can also fight mold in the following ways:

Dusting of sulphur powder at the rate of 20-25 kg/ha.

Spraying 0.2% wettable sulphur or 0.1% Kerathane L.C. or 0.05% Calixin at the rate of 500-700 l/ha. Spraying or dusting should be repeated after 15 to 20 days.The harvesting of the mature crop should not be delayed; the seeds may be stored in gunny bags with paper lining and cloth bags for seed purposes.

Mulching can also be used to minimize drought stress the plant may get during the growing season, by reducing the stress on the plant it makes it less susceptible to diseases overall.

14.1.2. Anthracnose of Celery - *Colletotrichum acutatum*

Syptoms

Curled, distorted leaves and twisted petioles are characteristic of celery anthracnose—this symptom gave this disease its other name, celery leaf curl. Plants may be stunted and chlorotic. Small, light brown, oval lesions on petioles turn dark reddish brown to black as the disease progresses (Figure 73). Lesions displaying gall tissue and adventitious roots are sometimes observed. Invasion by secondary bacteria may lead to heart rot, which can resemble black heart, a physiological disorder of celery caused by calcium deficiency.

Life Cycle

Recent research indicates that the celery anthracnose pathogens are seedborne. Survival of C. fiorinae and C. nymphaeae in soil is currently not well understood, but it is likely that these species do survive in infected plant debris.

Infection and disease development is most common and severe in warm, wet conditions, when celery leaves remain wet for long periods of time. In ideal conditions, symptoms may appear as little as 3-5 days after infection; however, infections may also remain asymptomatic for some time, until conditions become favorable for the pathogen.

Spores are spread primarily by splashing rain or irrigation water. The disease can continue to spread through the crop as long as environmental conditions are conducive to spore development and infection.

Several common weeds, including common lambsquarters, redroot pigweed, yellow nutsedge, oakleaf goosefoot, and common groundsel may also serve as hosts.

Management

Sanitation is critical to management of celery anthracnose.

Fig. 73. Syptoms of Antracnose on celerys

14.1.3. Early blight of celery - *Cercospora apii*

Early blight of celery plants is caused by the fungus Cercospora apii. Cercospora blight commonly affects celery and carrots with leaf-disfiguring and crop-reducing results. Referred to as early blight for these two vegetables, Cercospora blight hits young carrot and celery plants during early periods of rapid growth.

As with many fungal plant diseases, long periods of wet leaves provide ideal conditions for Cercospora blight infections. The fungal spores spread by wind and water. Gardeners also spread the disease on tools and hands when working in infected gardens while leaves and stalks are wet.

Symptoms

Primarily a leaf-spotting disease, Cercospora blight's first symptoms arrive as small leaf spots. As the disease progresses, leaf spots multiply, enlarge, and merge together, until blight-encompassed leaves shrivel and die. Though early blight doesn't directly affect carrot roots, the loss of leaves diminishes growth and harvests.

In celery, early blight symptoms begin as small, circular yellow or brown leaf spots (Table 74). When conditions support this disease, it spreads rapidly across leaves and through crops. On leaf undersides, spot centers turn gray and fuzzy with fungi. Close examination reveals Cercospora blight's characteristic threadlike, silvery spores.

Fig. 74. Symptoms of Cercospora on celery

Control

Prevention is key to protecting your crops from this disease. Daconil fungicides from GardenTech brand offer highly effective protection to prevent, stop, and control Cercospora blight in celery. These products treat celery up to seven days before harvest and treat carrots right up to harvest day.

14.1.4. Sclerotinia Stem and Crown Rot of coriander - *Sclerotinia sclerotiorum*

Sclerotinia sclerotiorum is a fungus that overwinters as small black structures (sclerotia) attached to decomposing infected plant portions. Sclerotia may survive more than several years. After a moisture-conditioning period of at least 70 days, they produce a small, stalked, cup-shaped fruiting structure (apothecium), which releases spores into the air. Spores may infect blossoms and senescing leaves. After colonizing, the fungus can invade healthy parts of the plant. Moist conditions within the plant canopy during bloom favor infection, as do rain, dew, and/or irrigation practices that keep foliage wet for long periods.

Symptoms

The disease is mainly on the lower portion of stems, producing a cottony white mold under wetter conditions or a light-brown appearance to the affected stem area. As the stems decay, small dark sclerotial bodies appear inside. Plants may die before seed harvest.

Cultural control

Rotate using nonsusceptible crops such as grass or grains. Encourage maximum air movement between rows.

14.1.5. Peronosporosis of Dill - *Peronospora parasitica*

Peronospora parasitica of dill is very dangerous due to its rapid development, to which the agrarian does not always have time to react. Peronosporosis can destroy a healthy plant within a few days. Frequent precipitation and temperature changes are a favorable factor for this disease. The root cause of the disease is the abundance of weeds and the remnant of the old crop in the ground. The main carriers of pathogenic fungus spores are aphids and whiteflies. And there is also a risk of encountering infected planting material.

In the initial stage, yellowish spots appear on the outer part of the foliage, which after a while begin to acquire a brown tint. The inside is covered with a white-gray bloom. The leaves wither and wrinkle, as a result, the shoot dies completely.

Control

For treatment, you can use preparations of biological origin at intervals of 2 weeks - Fitosporin-M, Planriz, Bayleton, Baikal-EM. If the situation is critical, then heavy chemicals are used to save the crop - Acrobat MC, Oxyhom, Ridomil Gold. After their use, dill should not be eaten for a month. Folk methods of struggle in this case will be useless, even at the very beginning.

14.1.6. Phomosis of Dill - *Phoma anethi* Sacc.

Phomosis is a fungus that progresses on an infected bush for only 2 weeks. Because of this, infection can be repeated several times per season. Phomosis affects both young shoots and rooted mature plants, which also become a source of infection. The lack of boron in the soil, high humidity and intense heat are excellent conditions for the development of the disease. Harmful spores are spread by insects, wind and water. The fungus is able to maintain its vital activity on weeds, dead residues and fallen leaves.

Symptoms

The main symptom of phomosis is dark brown oblong spots with black patches and a black border. The lower leaves may turn pink, and the roots become covered with depressed brown erosion.

Control

Sick bushes cannot be treated with chemicals, so they should be destroyed, and then the soil should be disinfected. The remaining beds must be regularly treated with Bordeaux mixture. Prevention is the main method of protection against phomosis. A solution of "Rovral", "Tiram" or "Fundazol" should treat the soil before sowing. Enrichment of the soil with potassium and phosphorus, foliar application of boron-containing preparations during the growing season - all this will strengthen the immunity of plants.

14.2. Viral diseases

14.2.1. Celery Mosaic Virus (CeMV)

Syptoms

Leaves develop unusual patches of yellow and green colour, with thickening and puckering of the leaves. Stems may twist, and stalks may show light yellow soft spots. New leaves may be thin, dark green, and slightly cupped (Figure 75).

Damage

Like other viruses, celery viruses interfere with genetic signalling within the plant. Leaves that are distorted by the virus cannot function normally, so plants struggle to grow and stop gaining size.

Control

To prevent the spread of the virus, it is necessary to remove and destroy diseased plants.

Fig. 75. Syptoms of Celery Mosaic Virus

Chapter XV. Major Diseases of Onion - *Allium cepa,* Leek - *A. porum* and Garlic - *A. sativum*

15.1. Fungal diseases garlic

Introduction

Allium (Amaryllidaceae) contains approximately 780 species, many of which are agriculturally important, used almost daily in every home it is an essential ingredient.

There are at least ten valid names for species of Puccinia and Uromyces (Pucciniaceae, Pucciniales) that have been reported on species of Allium worldwide. In the Adjara registered three autoecious species of rust on Allium, namely *P. allii* with mostly two-celled teliospores, P. porri with equal numbers of one- and two-celled teliospores, and U. ambiguus with onecelled teliospores.

Among them the most harmful is the rust Puccinia allii. It affects leek, garlic, onion, and chives, and usually appears as bright orange spots on infected plants.

Puccinia alli is autoecious, meaning that all stages of its life cycle occur on the host plant.

On Alium spesies, manifests as bright orange or yellow pustules on the upper parts of the leaves, usually between veins (Figure 76). Sometimes, the pustules grow to network with each other and spread to the base of the leaf. The aeciospores are between 18, 8 and 28,2 micrometers in diameter, with yellow walls 1 to 2 micrometers in length. The urediniospores are more elliptical in shape, with a major axis diameter of 21,5–32,5 micrometers and a minor axis diameter of 20–26 micrometers. The teliospores are also elliptical, with a major axis diameter of 27–46 micrometers and a minor axis diameter of 19–27 micrometers.

In Georgia, onion is produced in many parts of the country by small farmers, private growers and state enterprise. National production of onion is estimated to be over 19.2 thousand tons of dry bulb per annum and yield per hectare is 7.6 t ha-1.

Despite onion is rapidly becoming fungicides alone against onion rust is a common practice, the use of integrated management to subdue the disease through combination of various onion varieties along with compatible systemic fungicides is a more effective means than sole fungicide application. Therefore, integrated management of onion rust is the most efficient, environmentally sound and socially acceptable management strategy for sustainable onion crop production and productivity.

Therefore, the study was carried out with the objectives to evaluate the effects of host resistance, alone and alternate application of the different fungicides on onion rust epidemic and bulb yield; and determine the economics of fungicide application in the management of onion.

Fig, 76. Pustules of Allium rust (from left to right) on *Allium cepa, A. sativum* and *A. porum*

15.1.1. Onion rust - *Puccinia alli*

Among the genus of Allium in Adjara onion is most on the 5 maior species of Fungi (Onion rust - *Puccinia alli*, downy mildew - *Peronospora destructor*, onion twister - *Colletotrichum cingulata*, purple blotch - *Alternaria porri*, neck and bulb rot - *Botrytis alli* and pink rot - *Pyrenochaeta terrestris*) were identified as a result of phytopathological and mycological studies conducted in different places of agrocenosis in Georgia.

Sometimes, during storage, the infected onion can be covered with a multi-colored mycelium which includes 6 species of fungi (*Mucor sp., Aspergillus Niger, Botrytis allii, Fusarium oxysporium, Alternaria spp, Sclerotinia sclerotiorum*).

Among the pathogens registered by us, onion rust *Puccinia allii*, are the most widespread and destructive pathogens of cultivated onion. Some disease, noresistant varieties onion, have been observed to dry (42 -100%) out within a 3-4 day (Figure 77).

The initial symptom was small flecks, which expanded into slightly larger, oval- to diamond-shaped, reddish-to dull-orange pustules on the leaves. Reddish airborne spores (urediniospores) are produced copiously within the lesions. Later in the growing season, the lesions may appear dark because black survival spores (teliospores) develop within the pustules.

When the two cropping seasons were compared, the higher disease severity was recorded in 2020 than in 2019 cropping season. This variation in varietal responses to Onion rust might be due to genetic differences and epidemic differences between cropping seasons could be attributed to variability in weather variables during the experimental period since there was higher rainfall and relative humidity and lower aerial temperature in the growing period of 2020 than in 2019 cropping season.

Fig. 77. Affected organs (42 -100%) of onion in an untreated area

The average result for 2019-2020, obtained from the different onion varieties/fungicide application alone and in alternation had significant impacts on onion rust development. The treated with all treatments, that reflect on the increase in plant height, bulb diameter, bulb weight and total bulb yield compared with untreated after 90 days from sowing.

As shown in Table 12, show that in the experimental plot of Khelvachauri, treatment with the fungicide Mancozeb led to an increase in plant height (65.2 cm), bulb diameter (19.5 cm), bulb weight (123.0 g) on Pinoy F1. In the case of the use of other fungicides and other varieties of onions, these indicators change slightly. Plant height (51.0 cm), bulb diameter (13.5 cm), bulb weight (94.2 g) are significantly reduced in untreated areas. A similar result was obtained at the research site in Keda.

Tab. 12. Some plant growth parameters of onion of different control approaches after 90 days

Variety	Fungicide	Khelvachauri						Keda					
		Plant Height		Bulb diameter		Bulb weight		Plant Height		Bulb diameter		Bulb weight	
		sm	Increase %)	sm	Increase (%	sm	Increase (%)	sm	Increase (%)	sm	Increase (%	sm	Increase (%)
Creole	Mancozeb	63.5	23.8	19.0	26.6	119.0	27.3	62.1	22.8	17.3	25.6	120.0	27.3
	Mancozeb+Nativo	61.2	20.2	18.6	23.0	118.0	25.3	61.3	21.2	16.6	22.0	118.0	25.3
	Nativo	55.4	18.0	17.2	22.8	115.2	22.3	55.5	18.0	16.2	21.8	115.2	22.3
	Nativo+Mancozeb	52.5	17.7	16.0	19.5	110.3	16.8	52.6	17.7	16.0	21.5	110.3	16.8
Pinoy F1	Mancozeb	65.2	25.6	19.5	26.7	123.0	28.6	63.2	23.9	18.1	26.7	122.0	26.4
	Mancozeb+Nativo	56.5	24.2	17.6	23.6	118.0	26.3	61.3	20.2	16.6	23.0	117.0	23.3
	Nativo	53.6	22.0	18.2	22.8	115.2	23.3	55.5	8.0	18.2	22.7	115.2	22.3
	Nativo+Mancoze	53.0	21.7	16.0	18.5	110.3	21.8	62.6	22.7	16.0	**21**.9	110.3	17.8
local (Enza)	Mancozeb	62.2	23.9	17.1	24.7	119.0	23.4	63.2	23.9	17.1	26.7	120.0	27.4
	Mancozeb+Nativo	61.3	20.2	16.6	22.0	118.0	23.3	61.3	20.2	16.6	23.0	116.0	25.3
	Nativo	55.5	18.0	16.2	19.8	115.2	22.3	55.5	8.0	18.2	34.8	115.2	22.3
	Nativo+Mancozeb	52.6	17.7	15.0	18.5	110.3	21.8	62.6	22.7	16.0	18.5	110.3	16.8
Untreated (control)		51.0	-	13.5	-	94.2	-	51	-	13.5	-	94.2	-

Table 13 shows that onion rust was highly influenced by the application of Mancozeb and Nativo fungicides alone, in combination and in alternation. Interaction effects of onion variety x fungicide indicated that PSI at final assessment date, AUDPC and disease progress rate revealed a significant difference in both Khelvachauri and Kobuleti districts.

Analysis of variance revealed that there was an interaction effect of variety x fungicide for mean severity of onion rust at final date of assessment and they showed significant difference at both locations. The maximum (95.4%) mean severity was obtained on the untreated plots of the local cultivar, and followed by untreated plots of Pinoy F1 and Creole varieties, which exhibited similar results with mean severity of 89.9% at 102 DAP at Khelvachauri. But, lower and insignificant mean severity was observed on the other treatments on the last assessment date in the same location at Khelvachauri.

Regarding Keda, the highest (83.4%) mean onion rust severity was recorded on the unsprayed plot of the Ensa cultivar, followed by Creole (76%) and Pinoy F1 (55%) at the last assessment date (92 DAP). With the same date of assessment, the lowest mean severity was recorded due to treatment with Mancozeb on plots of Pinoy F1 (5.7%) and Mancozeb + Nativo (5.4%).

The interaction effects of onion variety x fungicide application on AUDPC revealed significant difference among the evaluated treatments. The highest (2657.1 %-days) AUDPC value was recorded from untreated plots of all treatments at Khelvachauri. Untreated plots of Pinoy F1 and Creole varieties a non-significant difference; but, the treated Creole variety with Nativo differed significantly from Nativo and Mancozeb + Nativo treated Pinoy F1 variety.

The treated local cultivar with Mancozeb, Nativo and their alternate applications showed a significant difference from the treated Pinoy F1 and Creole varieties and this had high AUDPC value. However, the fungicides Mancozeb, Nativo and their alternate applications on the Enza cultivar revealed nonsignificant difference among themselves. *A similar* phenomenon was depicted in Keda on tested onion varieties as well as the fungicides applied.

Tab.13. Interaction effect of variety x fungicide on onion rust on final PSI and AUDPC at Khelvachauri and Keda districts of Adjara, during the 2019/2022 cropping season

Variety	Fungicide	Khelvachauri		Keda	
		PSI (f)	AUDPC	PSI (f)	AUDPC
Creole	Unsprayed	89.9^{a}	2281.8^{b}	76.00^{a}	1719.0^{a}
	Mancozeb Mancozeb+Nativo	19.9^{c}	698.4^{e}	5.82^{c}	543.5^{bc}
	Nativo	16.8^{c}	728.9^{e}	8.93^{c}	648.4^{bc}
	Nativo+Mancozeb	18.7^{c}	773.0^{e}	12.15^{c}	681.8^{bc}
		16.8^{c}	833.9^{e}	20.03^{c}	768.7^{bc}
Pinoy F1	Unsprayed	90.2^{a}	2202.2^{b}	55.70^{a}	1393.1^{a}
	Mancozeb Mancozeb+Nativo	18.58^{e}	636^{e}	5.70^{e}	584.5^{bc}
	Nativo	19.41^{e}	835^{e}	5.43^{e}	505.2^{bc}
	Nativo+Mancozeb	19.12^{e}	1038.8^{e}	17.62^{e}	778.9^{bc}
		18.23^{e}	743.3^{e}	7.33^{e}	609.0^{bc}
local (Enza)	Unsprayed	95.4^{a}	2657.1^{a}	83.4^{a}	1752.8^{a}
	Mancozeb Mancozeb+Nativo	32.41^{b}	1719.2^{c}	7.21^{c}	548.3^{bc}
	Nativo	33.85^{b}	1837^{c}	13.28^{c}	803.1^{b}
	Nativo+Mancozeb	36.69^{b}	1858^{c}	17.35^{c}	801.2^{b}
		32.88^{b}	1921^{c}	8.56^{c}	574.2b^{c}
Means		36.9	1383	22.88	802.33
CV (%)		13.5	10.76	53.57	35.13
LSD (0.05)		8.3	246.21	20.46	467.17

Note: [a] PSI (f) = final percentage severity index at 102 DAP and 92 DAP in Lalibella and Gidan, respectively, AUDPC = Area under disease progress curve. CV = Coefficient of variation, LSD = Least significant difference at 0.05 level of probability.

Table 14 shows that among the sprayed treatments, Mancozeb alone fungicide applicati gave nil/minimum bulb yield losses. Relatively, the lower bulb yield losses were also obtained from plots sprayed with Nativo alone on Enza and Pinoy F1 onion varieties in both locations. However, total bulb yield losses were reduced by the application of alternate and alone fungicide application compared to the unsprayed check plots.

The highest (49.98%) relative bulb yield loss was obtained from unsprayed local cultivar that was higher by 4.55 and 11.54% from unsprayed Pinoy F1 and Creole, respectively, in Khelvachauri district. Similarly, maximum relative yield losses were calculated for the untreated Pinoy F1 (64.46%), Enza (63.92%) and Creole (63.32%) onion varieties in Keda district.

Tab. 14. Relative yield loss of onion due toonion rust (P. allii) as influenced by onion variety and fungicide application in Khelvachauri and Keda districts of Adjara, during the 2019 cropping season

Variety	Fungicide	Khelvachauri			Keda		
		Bulb yield (t ha-1)	Relative yield loss in percentage	Relative yield advantage in ercentag	Bulb yield (t ha-1)	Relative yield loss in percentage	Relative yield advantage in percentage
Creole	Mancozeb	19.66	6.02	53.23	14.22	0.00	175.56
	Nativo +Mancozeb	18.28	11.77	43.64	8.88	37.55	72.09
	Nativo	17.66	0.00	63.01	10.88	23.49	110.85
	Nativo+Mancozeb	13.12	21.26	28.38	9.56	32.77	85.27
	Unsprayed	11.22	38.44	0.00	5.16	63.32	0.00
Pinoy F1	Mancozeb	21.12	0.00	82.70	14.44	0.00	183.12
	Mancozeb+Nativo	19.56	7.39	69.20	8,66	40.03	69.80
	Nativo	18.88	10.66	63.32	13.56	6.09	165.88
	Nativo+Mancozeb	18.88	10.66	63.32	12.96	10.66	152.92
	Unsprayed	11.56	45.43	0.00	5.10	64.46	0.00
Enza (local cultivar)	Mancozeb	15.12	0.00	102.30	16.66	0.00	177.67
	Mancozeb+Nativo	13.34	46.30	8.62	8.88	46.70	48.00
	Nativo	12.88	39.01	23.37	10.22	38.66	70.33
	Nativo+Mancozeb	11.34	27.36	46.93	9.78	41.30	63.00
	Unsprayed	10.0	49.98	0.00	6.00	63.92	0.00

As can be seen from Table 15, the maximum net profit was obtained on the onion varieties Pinoy F1 (16920 lari on 1 ha) and Creole (16000 lari on 1 ha) in combination with Mancozeb fungicide alone and on the variety Local only with Nativo (15620 lari on 1 ha). In case of alternate fungicide applications, higher marginal rate of return was noted than on unprotected plots. Especially treatment of Pinoy F1 and Local cultivar with Mancozeb+Nativo indicated higher marginal rate of return value than Nativo+Mancozeband and unsprayed plots.

Tab. 15. Partial budget analysis for the garlic rust management through host resistance, and alone and alternate applications of fungicides in Khelvachauri and Keda districts of Adjara, during the 2020 cropping season

Variety	Fungicide	Yeld (t/ha^{-1})	Sale price (Lari kg^{-1})	Sale revenue (Lari)	Total input cost (Lari)	Net profit (Lari)
Creole	Mancozeb	16.0	1,0	16000	80	15920
	Nativo +Mancozeb	13.6	1,0	13600	69	13531
	Nativo	14.5	1,0	14500	58	14442
	Mancozeb+ Nativo	14.3	1,0	14300	69	14231
	Unsprayed	7.4	1,0	7400	0	7400
Pinoy F1	Mancozeb	17.0	1,0	17000	80	16920
	Nativo +Mancozeb	13.8	1,0	13800	69	13731
	Nativo	15.2	1,0	15200	58	15142
	Mancozeb+ Nativo	15.0	1,0	15000	69	14931
	Unsprayed	7.5	1,0	7500	0	7500
Enza (local cultivar)	Mancozeb	14.2	1,0	14200	58	14142
	Nativo +Mancozeb	13.5	1,0	13500	69	13431
	Nativo	15.7	1,0	15700	80	15620
	Mancozeb+ Nativo	13.9	1,0	13900	69	13831
	Unsprayed	7.2	1,0	7200	0	7200

Note: Mean unit of mean price of bulb per kilogram was $ 0.33 (at the current exchange rate of 1$ = 3.0 Lari) at the time of produce selling in 2019/20 cropping season.

15.1.2. Mildew - *Peronospora destructor*

The most common disease for all three cultures (*Allium cepa, Allium porum* and *Allium sativum*) is Perenospora destructor. The pathogen develops in two ways: in the first case, separate spots were observed on either the leaves and stalk, or the bulb alone, in the second case, the disease was of a total nature. All organs of the plant are covered with mycelium. Under conditions conducive to disease, crop yields are reduced by 40-50%. Infections typically develop from late May into summer. Usually first notices in foci which if untreated spread out to affect wider areas of the crop. Can survive to infect subsequent spring crops via infected plants or bulbs or as resting spores in the soil which can survive for several years.

Symptoms

Irregular lesions are initially found on the older leaves. The leaf area under these early infections are at first a pale green colour which later become visibly more yellow. These lesions later develop a typical downy mildew grey/purple mycelium (Figures 78) containing fruiting bodies (sporangia) which can spread spores by rain splash or over longer distances on the wind. In severe attacks whole leaves can be lost. Infections can further spread systematically to the bulbs of onions and shallots which become soft and shrivelled adversely affecting bulb quality and size. Affected areas of plant tissue can be further colonised by other bacterial or fungal pathogens

Favourable Factors Cool wet seasons especially in areas of high rainfall.

Fig. 78. Downy mildew of *Allium cepa* on leaves

Control

Control is by crop rotation (at least 3 years between successive onion crops), use of healthy bulbs for planting (heat treatment has been used to eliminate the pathogen from bulbs), fungicide treatment of the bulbs for planting, and fungicide sprays of the foliage if downy mildew infection is nevertheless observed

15.1.3. Botrytis Neck Rot - *Botrytis allii*

Botrytis neck rot of alliums, caused by the fungus Botrytis allii, affects onions, garlic, leeks and shallots. ts teleomorph is unknown, but other species of Botrytis are anamorphs of Botryotinia species. Botrytis conidia may arise from these sclerotia and be carried out by wind to spread the disease. Infected plants exhibit leaf distortion, stunted growth, and splitting of leaves around the neck area. A grayish sporulation of the fungus may be observed between leaf scales near the neck area. In storage, infection is mostly observed in the neck region but can also originate from anywhere tissue comes into contact with the fungus inoculum. Infected tissue is sunken, water soaked, and spongy with a reddish-brown color (Figure 79).

Life Cycle

Botrytis allii overwinters in the soil on bulb residue or as sclerotia, dense masses of mycelia surrounded by a weather-resistant black rind that can survive long-term in soil. In the spring, sclerotia germinate and directly infect bulbs or produce asexual spores, which are dispersed in the air. Spores and sclerotia that come in contact with tissue of susceptible hosts may initiate new infections, especially if the tissue is wounded. Under prolonged moist conditions, the pathogen can also produce spores on infected dead or dying leaves. After harvest, topped onions and garlic can become infected if the cut edge comes in contact with spores or soil containing sclerotia.

Fig.79. Botrytis infection of scales and inner scales

Management

Late season applications of labeled fungicides such as Mancozeb,Cabrio, or Rovral; A three - to four-year crop rotation plays an important part in reducing the incidence; Onion fields should be separated from each other because the spores of Botrytis allii are able to travel far distances

15.1.4. Onion purple blotch - *Alternaria porri*

Symptoms & Life Cycle

Spots on the leaves are at first small with white centres, but expand rapidly into oval, brown to purple blotches, several centimetres long (Figure 80). Light and dark rings appear on the blotches. If the blotches grow around the leaves, or merge, the parts above the blotch wilt, collapse and die. The leaf tips are commonly infected. The bulbs can also be infected at harvest; infection is usually at the neck where a watery yellow to red rot develops.

Spores of the fungus are produced in the brown to purple blotches and are spread by wind, rain splash and, possibly, by insects. Heavy dews or rains favour the disease, as the leaves need to stay wet for 7-8 hours for the spores to infect.

Chemical control

Application of Ridomil (MZ 58), Ridomil once and Dithane M-45 (Mancozeb, 80% WP) subsequently, and Dithane M-45 for management of purple blotch fungus, Alternaria porri.. The highest marginal benefit was achieved by applying Ridomil once and Dithane M-45 subsequently at intervals of 14 and 21 days. The lowest marginal benefit was with sole Ridomil application at 21 day spray interval. With weekly sprays it was more economical to apply Dithane M-45 than Ridomil first followed by Dithane M-45 subsequently.

Fig. 80. Syptoms of *Alternaria alli* on Allium

15.1.5. Pink Root - *Pyrenochaeta terrestris*

Pink Root - Pyrenochaeta terrestris, this plant pathogen causes a disease in onion and garlic. In Adjara his fungus is to infect garlic, leek and chive, carrot, corn, cumber, eggplant, bean, peas, peppers, potato and tomato. This fungus produces dark brown to black pycnidia that have setae with one to five septa.

Symptoms

Roots will become infected and at first be light pink, sometimes they can be yellow or a yellow-brownish color. As the disease progresses the roots will become a darker pink then red and lastly turn to purple the advanced stages of this disease. Also in the later stages of this disease roots can become transparent, water soaked, and eventually disintegrate. New roots that form will also become infected, turn pink, and then die (Figure 81). Leaf size and number will be reduced, and bulbing will start early in infected plants compared to non-infected. Seedlings that become infected can be killed. Plants that survive from this disease become stunted and undersized which makes them not marketable. Plants that survive the infection will produce seed with a lowered biomass and germination rate.

Fig. 81. Pink root rot on the onion and garlic

Control

One of the best ways to control this disease is to use a crop rotation. It is suggested to rotate planting onion every 3–6 years with crops that are not susceptible to Pyrenochaeta terrestris. This will reduce but not completely eliminate the primary inoculum source. Planting cultivars of onion that are resistant to the Pyrenochaeta terrestris pathogen is a very effective management strategy that should be used in all commercial operations.

Fumigation with metam sodium or chloropicrin can be effective against some strains of the fungus, but its effects can vary.

Chapter XVI. Major Diseases of lettuce - *Lactuca sativa* L.

Introduction

The leafy green vegetable lettuce, member of the family Asteraceae, is popular around the world for food and feed purposes. Unfortunately, lettuce is sensitive to a wide range of fungal pathogens.

Isolation and identification of the microbionts

On the lettuce, 16 species of microbionts (Alternaria leaf spot - *Alternaria sonchi* Davis; Anthracnose - *Microdochium panattonianum* Sut.; Black root rot - *Thielaviopsis basicola* Ferraris; Bottom rot - Rhizoctonia solani J. G. Kühn; Cercospora leaf spot - *Cercospora lactucae-sativae* Sawada; Damping - *Pythium dissotocum* Drechsler; Damping - *Rhizoctonia solani* J. G. Kühn; Downy mildew - *Bremia lactucae* Regel; Drop - *Sclerotinia minor* Jaggar - *S. sclerotiorum* (Lib.) de Bary; Fusarium wilt - *Fusarium oxysporumf. sp. lactucae* Matuo & Motohashi; Gray mold - *Botrytis cinerea* Pers.; Phytophthora stem and root rot - *Phytophthora lactucae* Bertier, H. Brouwer; Pythium wilt and leaf blight - *Pythium aphanidermatum* Fitzp.; Rust - *Puccinia dioicae* Magnus; Septoria leaf spot - *Septoria lactucae* Pass. and Verticillium wilt - *Verticillium dahliae* Kleb.) were identified as a result of phytopathological and mycological studies conducted in different places of agrocenosis in Adjara.

Among the diseases found in Adjara, the most dangerous and widespread is Black root rot - *Thielaviopsis basicola,* Drop - *Sclerotinia minor, S. sclerotiorum* and Septoria leaf spot - Septoria lactucae.

16.1. Fungal diseases

16.1.1. Black root rot - *Thielaviopsis basicola*

Thielaviopsis basicola is the plant-pathogen fungus responsible for black root rot disease. This particular disease has a large host range. In Adjara of susceptible hosts: lettuce, carrot, tomato, and others.

Symptoms

Symptoms of this disease resemble nutrient deficiency but are truly a result of the decaying root systems of plants. Common symptoms include chlorotic lower foliage, yellowing of plant, stunting or wilting, and black lesions along the roots. The lesions along the roots may appear red at first, getting darker and turning black as the disease progresses (Figure 82). Black root lesions that begin in the middle of a root can also spread further along the roots in either direction. Due to the nature of the pathogen, the disease can easily be identified by the black lesions along the roots, especially when compared to healthy roots.

Fig. 82. Syptoms of *Thielaviopsis basicola* on of lettuce

Management

The biological method used against *Thielaviopsis basicola* proved to be the most effective among the agro-technical, sanitary – hygienic, chemical, biological and other types of controls. In particular, the antagonist fungus Trichoderma lignorum was used against pathogens. Soil was tilled with 4% of the suspension (400 gm of T. lignorum per 10 L in 5 m2 area) prior to planting the lettuce. In this case, the percentage of infection of plant was 6.8% in a nursery garden and 5.7% in a field. The biological efficiency was equal to 80.5 and 72.6. In the control variant, the percentage of infection of plant (without introducing the antagonist into it) was 63.0% in a nursery and 58.0% in a field. The experimental results have shown that the harvest and economic efficiency respectively are increasing, which were equal to 27.8% in a nursery garden and 19.8

16.1.2. Sclerotinia rot - *Sclerotinia sclerotiorum* and *S. minor*

Cause Two fungi, *Sclerotinia sclerotiorum* and *S. minor*, that overwinter on lettuce refuse on the ground and as sclerotia in soil. There are two phases: the damping-off phase, which attacks seedlings; and the important field phase called "drop", which causes a watery soft rot. It is severe whenever lettuce is grown under cool, moist conditions. Sclerotia of *S. minor* are small (2 to 3 mm) compared to *S. sclerotiorum* (20 to 30 mm). These fungi survive as sclerotia, which may be associated with infected plant residues, contained in seed lots, or persist in the soil. Sclerotia can survive three to five years in the soil, depending on environmental conditions and cropping practice.

Typically, sclerotia germinate and then produce a small, stalked, cup-shaped fruiting structure known as an apothecium, which forcibly ejects millions of ascospores into the air. Sporulating apothecia may persist five to ten days while released ascospores can survive up to two weeks, depending on environmental conditions.

Symptoms Under moist conditions, outer leaves wilt, and there is a slimy rot of the plant. A cottony fungus growth appears on the stem near the soil level. Then the drop phase appears in midsummer or later after leaves wilt; it begins with the oldest leaves and continues until the plant collapses. Hard sclerotia develop throughout the diseased portion of the plant.

Cultural control

S. minor can be controlled economically by removing infected plants from the field promptly before leaves start to drop off. However, that is not feasible for S. sclerotiorum.

Chemical control

Cannonball WG (Group 12) at 7 oz/A on 7- to 10-day intervals. May be applied the day of harvest. 12-hr reentry.

16.1.3. Septoria leaf spot - Septoria *lactucae*

Symptoms

Small, irregularly shaped chlorotic spots on oldest plant leaves which enlarge and turn brown and dry out; lesiuons may fall out of leaves creating holes; leaf spots may have chlorotic halos; if plant is severely infected, lesions may coalesce forming large necrotic patches, wilting leaves and plant death.

Fungus survives in infected seed and in crop debris; disease spreads in humid or wet conditions; can be spread by splashing water.

Management

Plant pathogen free seed; plant in areas where Septoria is uncommon; ideal planting sites are in regions with low rainfall; hot water treatment of seeds prior to planting may help reduce levels of disease.

Recommendations and suggestions

In order to combat the dominant vegetable crops diseases, we recommend the following system of measures for based on our experiment:

First of all, it is necessary to establish strict control over quarantine diseases of plants (Exotic diseases or pests pose a significant threat to wildlife in a new region).

Using resistant varieties (Using resistant varieties is the most efficient way of controlling vegetable diseases).

Using crop rotation (Grow the same plants or closely related plants in the same soil only once every 3 to 5 years). This practice starves out most pathogens that cause stem and leaf diseases.

Using Diseases Free Seed and Transplants (Many plant diseases can be seed-borne, including common blight, anthracnose of snap beans, and bacterial spot of tomatoes).

Follow the recommended planting dates for the particular vegetable grown. For example, warm-season crops should be planted when soil temperatures are warm for good germination and growth. Planting these crops when soil temperatures are cool can cause increased incidence of soil-borne diseases

Use a Mulch Layer (Mulching prevents soil from splashing onto plants and also fruit from touching the bare ground). This will help prevent rots on mature fruit. Mulches also are a sound cultural practice to help conserve soil moisture and reduce weed infestations.

Proper Fertilization (Proper fertilization helps prevent vegetable diseases).

Weed control (good weed control will increase air movement and decrease conditions – such as excessive moisture – that favor disease development).

Implementation of necessary sanitary measures (after harvest, remove and destroy plant material; plow the soil to help break down debris that may harbor fungi, and bacteria; remove diseased plants, plant residue, and weeds in and around the vegetable garden to reduce the occurrence of some diseases).

Fungicide and Bacteriocide use (Pesticides should be the last defense used by home gardeners once all other diseasecontrol options have been exhausted). Chlorothalonil (Bravo ® or Daconil ®), Maneb, Mancozeb, Ridomil Gold, Nativo, Terraclor ® (PCNB), sulfur, and copper products can be used on certain crops.

These products provide disease suppression across a range of foliar diseases and are more effective if they are applied in a preventive manner at the very onset or before a disease outbreak occur. Terraclor is used as a transplant soil drench to suppress Southern blight and Rhizoctonia damping-off. Copper products suppress fungi but primarily reduce losses to bacterial pathogens. Sulfur is suppressive to fungi and is especially effective against powdery mildews.

From biological measures we recommend to use the biopreparation Gaupsin prior to the flowering period of vegetable crops, during the formation of the fruit and the start of ripening. The drug is used in open soil with leaf spray at 7-10 day intervals. For vegetable crops, the recommended dose is 250/300 ml per 100 liters of water.

Antagonistic fungus *Trichoderma lignorum* should be used against soil pathogenic fungi. Before planting vegetable crops, the soil should be treated with 4% suspension (400 gm of *T. lignorum* per 10 L in 5 m^2 area). The experimental results have shown that the harvest and economic efficiency respectively are increasing, which were equal to 27.8% in a nursery garden and 19.8%.

Also, of *Allium cepa, Stevia rebaudiana, Inula racemosa, Buxus colchica, Rubia coradifolia, Panax ginseng* and *Corylopsis sinensis* extracts can be used against the dominant diseases of many vegetable crops.

Seed treatment with antagonist fungal culture of *Trichoderma viride* (3-4 g/kg of seed) or Thiram (2-3 g/kg of seed). Soil around the affected seedling should be drenched with Dithane M 45 (0.2%) or Bavistin (0.1%) to control the spread of the disease.

REFERENCES

Agrios, G. N. (2005). Plant pathology. University of Florida, 922 pp.

Alexandrov, V. (2011). Efficacy of Some Fungicides Against Late Blight of Tomato. Bulg. J. Agric. Sci., 17, 465-469.

Andrivon, D. (1996). The origin of Phytophthora infestans populations present in Europe in the 1840s: a critical review of the historical and scientific evidence. Plant Pathol. 45, 1027–1035.

Arif, T., Bhosale, J.D., Kumar, N., Mandal, T.K., Bendre, R.S., Lavekar, G.S., Dabur, R. (2009). Natural products- antifungalagents derived from plants. J Asian Natural Products Res, 11(7): 621-63820.

Aroma, K., Imanaka, H. & Konsaka, M. (1964). Pyrrolnitrin, a New Antibiotic Substance, Produced by Pseudomonas. Agricultural and Biological Chemistry, 28, 575–582.

Aylor, D.E., Fry, W.E., Mayton, H. and Andrade-Piedra, J. (2001). Quantifying the rate of release and escape of

Phytophthora infestans sporangia from a potato canopy. Phytopathology, 91, 1189–1196.

Bahcevandziev, K., Silva, M.C., Monteiro, A.A. (2015). Histological characterization of downy mildew (Hyaloperonospora brassicae) resistance in Portuguese cabbage (Brassica oleracea var. tronchuda). European Journal of Plant Pathology 141: 199-207.

Bahariev, D., Velev, B. & Harizanov, A. (1988). Plant protection of vegetables. Zemizdat, Sofia, 391.

Behera, S.K. and Misra, M.K. (2005). Indigenous phytotherapy for genito-urinary diseasesused by the Kandha tribeof Orissa, India. J. Ethnopharmacol, 102:319-325.

Bérénice, A., Stéphane, B., Claudie, M., Anne, Q., Yves, H. & Silué, D. (2003). Evidence that a Leaf-DiskTest Allows Assessment of Isolate-Specific Resistance in Brassica oleracea Crops Against DownyMildew (Peronospora parasitica. European Journal of Plant Pathology, 109, pp: 471–478

Bernd, H. & Rehm, A. Pseudomonas (2008). Model Organism, Pathogen, Cell Factory. Wiley-Blackwell, 395.

Bilay, V., Elanskaya, I. (1982). Methods Experimental Mycology [Journal]. - Kiev: Naukova Dumka, p. 418-430.

Birch, P.J., Bryan, G., Fenton, B., Gilroy, E., Hein, I., Jones, J., Prashar, A., Taylor, M., Torrance, L., Toth, I. (2012). Crops that feed the world 8: potato: are the trends of increased global production sustainable. Food Sec, 4:477.

Bonnet, A., Blanchard, D. (1987). Resistance of radish (Raphanus sativus L.) to downy mildew, Peronospora parasitica. Cruciferae Newsletter, 12:98–99.

Bourke, A. (1991). Potato late blight in Europe in 1845: the scientific controversy. In: Phytophthora (Lucas, J.A.,

Shattock, R.D., Shaw, D.S. and Cooke, L.R., eds), New York: Cambridge University Press. pp. 12–24.

Carlier, E., Rovera, M., Rossi Jaume, A. & Rosas, S. B. (2008). Improvement of growth, under field conditions, of wheat inoculated with Pseudomonas chlororaphis subsp. aurantiaca SR1. World Journal of Microbiology and Biotechnology, 24, 2653-2658

Chand, Sudeep (2009). Killer genes cause potato famine, BBC News, Retrieved, 09-26.

Chincholkar, S. & Tomashow, L. (2013). Microbial Phenazines Biosynthesis, Agriculture and Health. Springer, Berlin, Heidelberg, 248.

CIP (1996). Enhancing the Global Late Blight Network. Global Initiative on Late Blight. Lima, Peru: Centro Internacional de la Papa.

CIMMYT (1988). From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely Revised Edition, Mexico, 79 pp.

Coffey, M.D., Wilson, U.E. (1983). Histology and cytology of infection and disease caused by Phytophthora. In Phytophthora, Erwin D.C., Bartnicki-Garcia S., Tsao P.H., eds (St. Paul, MN: American Phytopatholological

Society), pp. 289–301.

Coelho, P.S, Monteiro, A.A. (2018). Genetic and histological characterization of downy mildew resistance at the cotyledon stage in Raphanus sativus L. Euphytica, 214 (11):208.

Cvitanich, C. and Judelson, H.S. (2003a): A gene expressed during sexual and asexual sporulation in Phytophthora infestans is a member of the puf family of translational regulators. Eukaryot. Cell, 2:465–473.

Cvitanich, C. and Judelson, H.S. (2003b). Stable ransfomation of the oomycete, Phytophthora infestans, using microprojectile bombardment. Curr. Genet. 42:228–235.

Davitadze, R. (2006). Parasitic mycobiota Kintrishskaya valley and its environs. Thesis on agriculture degree of Doctor of Sciences, Batumi, pp. 296.

Dickinson, C. H. & Greenhalgh, J. R. (1977). Host range and taxonomy of Peronospora on crucifers.Transactions of the British Mycological Society, 69: 111–116.

Dickson, M. H. & Petzoldt, R. (1993). Plant age and isolate source affect expression of downy mildew resistance in broccoli. Hort Science, 28: 730–731.

Dilbo, C., Alemu, M., Lencho, A. and Hunduma, T. (2015). Integrated Management of Garlic White Rot (Sclerotium cepivorum Berk.) Using Some Fungicides and Antifungal Trichoderma Species. Journal of Plant Pathology and Microbiology, 6(4): 1-9.

Dowley, L. J., Bannon, E., Cooke, L.R., Keane, T. and O'Sullivan, E. (1995). Phytophthora infestans, Vol. 150. Dublin: Boole Press Ltd. 7.

Dudka, I., Wasser S., Ellanskaya, I. (1982). Methods of Experimental Mycology. [Book].- [BM] K. Dumka, pp. 4 - 550.

Duffy, B. K. & Défago, G. (1999). Environmental Factors Modulating Antibiotic and Siderophore Biosynthesis by Pseudomonas fluorescens Biocontrol Strains. Applied and Environmental Microbiology, 65, 2429-2438.

Ellis, M.B. (1971). Dematiaceus Hyphomycetes Common wealth Mycologycal Institute Rev. Surrey, England, pp. 608.

Ellis, M.B. (1976). More Dematiaceus Hyphomycetes Commonwealth Mycological Institute Kew. Surrey, England, pp. 567.

Etebarian H. (1992). Studies of Fusarium wilt of tomato and its chemical control in Varamin area. Iranian J. Agric. Sci., 23: 89-114.

Fabritius, A.L., Cvitanich, C. and Judelson, H.S. (2002) Stage-specific gene expression during sexual development in Phytophthora infestans. Mol. Microbiol. 45, 1057–0661.

Fay, J.C. and Fry, W.E. (1997). Effects of hot and cold temperatures on the survival of oospores produced by United

States strains of Phytophthora infestans. Am. Potato J. 74, 315–323.

Fernandez-Pavia, S.P., Grunwald, N.J., Diaz-Valasis, M., Cadena-Hinojosa, M.A. and Fry, W.E. (2004). Soil-borne oospores of Phytophthora infestans in central Mexico survive winter fall and infect potato plants in the field. Plant Dis. 88, 29–33.

Flier, W.G., Kroon, L.P.N.M., Hermansen, A., van Raaij, H.M.G., Speiser, B., Tamm, L., Fuchs, J.G., Lambion, J.,

Razzaghian, J., Andrivon, D., Wilcockson, S. and Leifert, C. (2007). Genetic structure and pathogenicity of populations of Phytophthora infestans from organic potato crops in France, Norway, Switzerland and the United Kingdom. Plant Pathol., 56: 562–572.

Forbes, G.A., Escobar, X.C., Ayala, C.C., Revelo, J., Ordonez, M.E., Fry, B.A., Doucett, K. and Fry, W.E. (1997): Population genetic structure of Phytophthora infestans in Ecuador. Phytopathology, 87, 375–380.

Gabrilovich, I. M. (1989). On the inhibitory effect of Bacillus subtilis and B. Brevis on putrefactive microorganisms during storage of vegetables and fruits. In: Abstracts of the conference “Microorganisms-stimulants and inhibitors of growth of plants and animals.”, Tashkent, 8.

Garrett, K.A., Nelson, R.J., Mundt, C.C., Chacon, G., Jaramillo, R.E. and Forbes, G.A. (2001). The effects of host diversity and other management components on epidemics of potato late blight in the humid highland tropics. Phytopathology, 91, 993–1000.

Glits, M. (1977). Downy mildew on the roots of radish produced in glasshouses. Acta Horticulturae, 58:411–415.

Göker, M., Voglmayr, H., Blázquez, G. G. & F. Oberwinkler, 2009. Species delimitation in downy mildews: the case of Hyaloperonospora in the light of nuclear ribosomal ITS and LSU sequences. Mycological Research, 113, pp: 308–325.

Gomez, K.A. and Gomez, A. (1984). Statistical procedure for agricultural research, 2nd edition. A Wiley Interscience Publications, New York, 691 pp.

Gondal, A. S., Ijaz, M., Riaz, K. & Khan, A. R. (2012). Effect of Different Doses of Fungicide (Mancozeb) against Alternaria Leaf Blight of Tomato in Tunnel. Journal of Plant Pathology & Microbiology, 3 :3.

Goral, V. M., Lappa, N. V., Goral, S. V., Garagulia, A. D., Kiprianova, E. A., Omelianets, T. & Smirnov, V. V. (1999). The insect – fungicidal preparation, gaupsin, isolated from Pseudomonas aureofaciens strains. Prikl Biokhim Mikrobiol, 35(5), 596-8.

Govindarajan, R. M., Vijayakumar, M., Singh, C.H.V. Rao, A. Shirwaikar, A.K.S. Rawat and Pushpangadan, P. (2006). Antiulcer and antimicrobial activity of Anogeissuslatifolia. J. Ethnopharmacol.,106: 57-61.

Grouffaud, S., van West, P., Chapman, S., Hein, I., Toth, I.K., Pritchard, L. and Birch, P.R.J. (2007). A translocation signal for delivery of oomycete effector proteins into host plant cells. Nature, 450, 115–118.

Grunwald, N.J. and Flier, W.G. (2005). The biology of Phytophthora infestans at its center of origin. Annu. Rev. Phytopathol. 43, 171–190.

Grunwald, N.J., Romero-Montes, G., Lozoya-Saldana, H., Rubio-Covarrubias, O.A. and Fry, W.E. (2002b). Potato late blight management in the Toluca Valley: field validation of SimCast modified for cultivars with high field resistance. Plant Dis. 86, 1163–1168.

Harris, C.A., Renfrew, M.J. and Woolridge, M.W, (2001). Assessing the risk of pesticide residues to consumers: Recentandfuture developments. Food Additives and Contaminat. 18:1124-1129.

Hibbett, David, S., Binder Manfred, Bischoff, Joseph F., Blackwell Meredith, Cannon Paul, F., Eriksson Ove, E., Huhndorf Sabine, James Timothy, Kirk Paul, M. (2007). "A higher-level phylogenetic classification of the Fungi". Mycological Research. 111 (5): 509–547.

Horneburg, B. & Becker, H. C. (2011). Selection for Phytophthora field resistance in the F2 generation of organic outdoor tomatoes. Euphytica, 180, 357 – 367.

Jensen, B. D., Hockenhull, J. & Munk, L.(1999). Seedling and adult plant resistance to downy mildew (Peronosporaparasitica) in cauliflower (Brassica oleraceaconvar. botrytis var. botrytis). Plant Pathology, 48: 604–612.

Judelson, H.S. and Roberts, S. (2002). Novel protein kinasae induced during sporangial cleavage in the oomycete Phytophthora infestans. Eukaryot. Cell, 1, 687–695.

Kanchaveli, L. (1987). Agricultural Phytopathology [Book]. - Tbilisi [s.n.], pp.3 – 600.

Khokhryakov, M. (1984). Key crop diseases [Book]. - [S.l.]: L. Kolos, P. 30-124.

Kiprianova, E. A., Klochko, V. V., Zelena, L. B., Churkina, L. N. & Avdeeva, L. V. (2011). Pseudomonas batumici sp. nov., the antibiotic-producing bacteria isolated from soil of the Caucasus Black Sea coast. Mikrobiology, 73 (5), 3-8.

Kiprianova, E. A. & Safronova, A. O. (2017). Antimicrobial, entomopathogenic and antiviral activity of gaupsin bioprepara tion created on the basis of Pseudomonas chlororaphis strains Prosyanov. Biotechnologia Acta, 10, 7-16.

Kriek, N. P., Kellerman, J. T. S. and Marasas, W. F. 0. (1981). A comparative study of the toxicity of Fusarium verticillioides (= F. moniliforme) to horses, primates, pigs, sheep, and rats. Onderstepoort J. Vet. Res. 48:129-131.

Kriek, N. P. J., W. F. 0. Marasas, and P. G. Thiel. (1981). Hepato- and cardiotoxicity of Fusarium verticillioides (F. moniliforme) isolates from southern African maize. Food Cosmet. Toxicol. 19:447-456.

Kuprashvili, T. D. (2006). Fungal diseases of the seeds of vegetable crops in Georgia and the fight against them. Thesis on biology degree of Doctor of Sciences, Tbilisi, pp. 308.

Kuznetsov, A. E. & Gradova, N. B. (2006). Scientific basis of environmental biotechnology. Moscow, Mir, 504.

Latijnhouwers, M., Ligterink, W., Vleeshouwers, V.G.A.A., van West, P. and Govers, F. (2004). A Gα subunit controls zoospore motility and virulence in the potato late blight pathogen Phytophthora infestans. Mol. Microbiol., 51, 925–936.Lee, J. S., Lee, H. B., Shin, H. D., Choi, Y. J. (2017). Diversity, phylogeny, and hostspecialization of Hyalopero-nospora species in Korea. Mycobiology 45(3):139–149.

Lindau, J. (1907). Fungi imperfecti, VIII: 602, Leipzig.

Lindau, J. (1910). Fungi imperfecti, IX:580, Leipzig.

Madden, L.V. and Wheelis, M. (2003). The threat of plant pathogens as weapons against u.s. crops. Annu. Rev. Phytopathol., 41, 155–176.

Mahesh, B. and Satish, S. (2008). Antimicrobial activity of some important medicinal plant against plant and human pathogens.World Journal of Agricultural Scien. 4, pp:839-843.

Mandryk, M. N., Kolomiets, E. I. & Dey, E. S. (2007). Characterization of antimicrobial compounds produced by Pseudomonas aurantiaca S-1. Polish Journal of Microbiology, 56, 245-250.

Mateeva, A., Braikova, B. & Avdjiiski, G. (1985). Diseases and pest on potato. Zemizdat, Sofia, 101.

Mehnaz, S. (2013). Secondary metabolites of Pseudomonas aurantiaca and their role in plant growth promotion. In: Plant Microbe Symbiosis: Fundamentals and Advances. Berlin-Heidelberg. Germany, Springer, 373-393.

Mercado-Blanco, J. & Bakker, P. (2007). Interactions between plants and beneficial Pseudomonas spp.: exploiting bacterial traits for crop protection. Antonie van Leeuwenhoek, 92 (4), 367–89.

Mikeladze, Z., Kutaladze, N. & Lominadze, Sh. (2021). Influence of the biopreparation "Gaupsin" on storability of mandarin fruits. International Journal of Scientific Research and Management (IJSR), 09, 304-312

Mishustin, E., Emtsev, V. (1987). Microbiology [Book].- [BM] M. Agropromizdat, p. 4 -368.

Mizubuti, E.S.G. and Fry, W.E. (2006): Potato late blight. In: The Epidemiology of Plant Diseases (Cooke, B.M., Jones, D.G. and Kaye, B., eds), pp. 445–471.

Nagornaya, L. V. (2015). Main diseases of apricot and biological control of their distribution in conditions of the southern steppe of Ukraine. Journal "Scientific works of the North Caucasian Zonal Scientific Research Institute of Horticulture and Viticulture", 8, 183-188.

Nakov, B., Nakova, M., Angelova, R. & Andreev, R. (2007). Forecasted and signalization of diseases and pest on crop plants. Publisher IMN-Plovdiv, 434.

Nowicki, Marcin (2013). Late blight of tomato. In: Translational Genomics for Crop Breeding: Volume 1, Biotic
Stress, pp. 241-265.

Olaniyi, J. O., Akanbi, W. B., Adejumo, T. A. & Akande, O. G. (2010). Growth, fruit yield and nutritional quality of tomato varieties. African Journal of Food Science, 4:398-402.

Palombo, E.A. and Semple, S.J. (2001). Antibacterial activity of traditional medicinal plants. Ethnopharm,77: 151- 157.

Pristou, R., Gallegly, M.E. (1954). Leaf penetration by Phytophthora infestans. Phytopathology 44, 81–86.

Robert, G.D. & James, H.T. (1991). A Biomerical approach. Principles of statistics 2nd ed. New York. USA. SAS Institute Inc. (2009).

Rosas, S. B., Altamirano, F., Schroder, E. & Correa, N. (2001). In vitro biocontrol activity of Pseudomonas aurantiaca. Phyton-International Journal of Experimental Botany, 67, 203- 209

Rosas, S., Rovera, M., Andrés, J. A., Pastor, N. A., Guiñazú, L. B. & Carlier, E. (2005). Characterization of *Pseudomonas aurantiaca* as biocontrol and PGPR agent. In: Endophytic properties. Proceeding prospects and applications for plant associated microbes, 1st International conference on plant– microbe interactions: endophytes and biocontrol agents. Lapland, Finland: Sorvari, 91-99.

Rosas, S. B., Andrés, J. A., Rovera, M. & Correa, N. S. (2006). Phosphate solubilizing Pseudomonas putida can influence the rhizobia–legume symbiosis. Soil Biology & Biochemistry, 38, 3502-3505.

Rosas, S. B. (2008). Improvement of growth, under field conditions, of wheat inoculated with Pseudomonas chlororaphis subsp. aurantiaca SR1. World Journal of Microbiology and Biotechnology, *24,* 2653-2658

Rosas, S. B., Avanzini, G., Carlier, E., Pasluosta, C., Pastor, N. & Rovera, M. (2009). Root colonization and growth promotion of wheat and maize by *Pseudomonas* aurantiaca SR1. Soil Biology and Biochemistry, 41, 1802–1806.

Rosas, S. B., Carlier, J.A., Andrés, J., Bergesse, L.B., Guiñazú, V., Vogt, V., Bergesse, J. & Rovera, M. (2012). Efficacy of Pseudomonas chlororaphis subsp. aurantiaca SR1 for improving productivity of several crops. Crop Production Technologies, 178-270.

Rovera, M., Andres, J., Carlier, E., Pasluosta, C., Avanzini, G. & Rosas, S. (2008). Pseudomonas aurantiaca: plant growth promoting traits, secondary metabolites and inoculation response. Plant–bacteria interactions. In: Strategies and Techniques to Promote Plant Growth, Germany: Wiley– VCH; 155-164.

Rovera, M., Pastor, N., Niederhauser, M. & Rosas, S. B. (2014). Evaluation of Pseudomonas chlororaphis subsp. aurantiaca SR1 for growth promotion of soybean and for control of Macrophomina phaseolina. Biocontrol Science and Technology, 24 (9), 1012- 1025.

Saccardo, P.A. (1886). Sylloge Fungoral, Vol IV: 870, Berlin.

Saccardo, P.A. (1888). Sylloge Fungoral, Vol XIII: 660-743, Berlin.

Saccardo, P.A. (1896). Sylloge Fungoral, Vol XI:236-291, Berlin.

Saccardo, P.A. (1902). Sylloge Fungoral, Vol XVI: 570-580, Berlin.

Saccardo, P.A. (1913). Sylloge Fungoral, Vol XXV: 970-980, Berlin.

Samy, R.P. and Ignacimuthu, S. (2000). Antibacterial activity of some folklore medicinal plants used by tribals in Western Ghats in India. J. Ethnopharm, 69: 63-71.

SAS/ Stat Guide for Personal Computers, Version 9.1 edition. SAS Institute Inc., Cary, North Carolina, USA.

Shainidze, O.T. (1999). Mycobiota of Adjara, Batumi, pp. 5- 355.

Shainidze, O. (2013). The Results of Phytopathological Research in Adjara [Book]. - Tbilisi : [s.n.], 3-304.

Shainidze, O. and Ghoghoberidze, S. (2015). Dominant pathogenic of Lycopersicum esculentum Mill.

International Journal of Agricultural Science Research Vol. 4(5), pp. 092-097.

Shainidze. O., Murvanidze, A., Lamparadze, Sh., Diasamidze, J. (2016). Destroyer pathogen of potato (Solanum tuberosum) in Georgia. International journal of advanced research. (IJAR), N 4(9), United Kingdom, pp. 235-247.

Shainidze, O.T. (2017). Fusarium sp. nev (Hypocreales) and the fight against it in Georgia. American Scientific Journal. NY, United States, vol.17, pp. 32-42

Shainidze, O.T. (2019). Analysis of the Diversity of Microskopic Fungi In the Soils of Adjara, Georgia. Journal IOP, Conference Series: Earth and Environmental Science, United Kingdom, pp. 1755-1765

Shainidze, O., Aleksidze, G., Sh, Kanchaveli (2020). New Species of Mycobiota from Adjara, Georgia. Bull. Georg. Natl. Acad. Sci., vol. 14, no. 1:64-72.

Shainidze, O. (2021). Control of *Hyaloperonospora brassica* by Certain Aqueous Plant Extracts in Adjara, Georgia. International Journal of Agriculture and Biological Sciences, 64:13

Shainidze, O., Kanchaveli, Sh., Chkubadze, G., Beridze, N., and Sh. Lamparadze (2021). Control of Hyaloperonospora brassica by Certain Aqueous Plant Extracts in Adjara, Georgia. International Journal of Agriculture and Biological Sciences, Publisher: PMAS-Arid Agriculture University Rawalpindi-Pakistan, 64:63-72.

Shainidze, O., Sh. Lamparadze, N. Beridze, G. Chkubadze, and G. Macharadze (2022). Efficiency of different doses of insectofungicidal biopreparation (Gaupsin) against phytophthora of tomato in Adjara, Georgia. Bulgarian Journal of Agricultural Science, 28 (No 3) 2022, 437–442.

Shahid, I., R.ivan, M., Baig, D. N., Saleem, R. S., Malik, K. A., & Mehnaz, S. (2017). Secondary Metabolites Production and Plant Growth Promotion by *Pseudomonas chlororaphis* and *P. aurantiaca* Strains Isolated from Cactus, Cotton, and Para Grass. *J. Microbiol Biotechnol., 27(3),* 480– 491.

Shanahan, P., Sullivan, D. J. O., Simpson, P., Glennon, J. D. & Gara F. O. (1992). Isolation of 2,4-diacetylphloroglucinol from a fluorescents *Pseudomonas* and investigation of physiological parameters influencing its production. *Applied and Environmental Microbiology, 58,* 353-358.

Sgherri, C., Kadlecova, Z., Pardossi, A., Navari-Izzo, F. & Izzo, R. (2008). Irrigation with diluted seawater improves the nutritional value of cherry tomatoes. Journal of Agricultural and Food Chemistry, *56,* 3391-3397.

Smart, C.D., Mayton, H., Mizubuti, E.S.G., Willmann, M.R. and Fry, W.E. (2000). Environmental and genetic factors influencing self-fertility in Phytophthora infestans. Phytopathology, 90, 987–994.

Stepanovic, S.N., Antic, I., Dakic and M, Svabic-vlahovic (2003). In vitro antimicrobial activity of propilis andantimicrobial drugs. Microbiol. Res., 158: 353-357.

Stewart, H.E., Bradshaw, J.E. and Pande, B. (2003). The effect of the presence of R-genes for resistance to late blight (Phytophthora infestans) of potato (Solanum tuberosum) on the underlying level of field resistance. Plant Pathol. 52, 193–198.

Tani, S. and Judelson, H. (2006). Activation of Zoosporogenesis-Specific Genes in Phytophthora infestans Involves a 7-Nucleotide Promoter Motif and Cold-Induced Membrane Rigidity. Eukaryotic Cell, 5 (4), 745– 752.

Tombolini, R., Gaag, D. J., Gerhardson, B. & Jansson, J. K. (1999). Colonization Pattern of the Biocontrol Strain *Pseudomonas chlororaphis* MA 342 on Barley Seeds Visualized by Using Green Fluorescent Protein. *Applied and Environmental Microbiology, 65 (8),* 3674–3680.

Turner, R.S. (2005). After the famine: plant pathology, Phytophthora infestans and the late blight of potatoes, 1845–1960. Hist. Stud. Phys. Biol. Sci. 34.2, 341–370.

Turkensteen, L.J., Flier, W.G., Wanningen, R. and Mulder, A. (2000). Production, survival and infectivity of oospores of Phytophthora infestans. Plant Pathol. 49, 688–696.

Vleeshouwers, V.G.A.A., van Dooijeweert, W., Govers, F., Kamoun, S. and Colon, L.T. (2000). The hypersensitive response is associated with host and nonhost resistance to Phytophthora infestans. Planta, 210, 853–864.

Van der Plank, J.E. (1963). Plant diseases: Epidemics and control. London: Acadamic press. 346 pp.

Velikanov, L., Sidorova, I., Uspenskaya, G. (1980). Field Practice on Ecology of Fungi and Lychen, Pp. 5-72.

Wang, X., Xu, L., Song, Z., Wang, Y., Wang, R., Gong, Y., Limera, C., Liu, L. (2014). Resistance gene analogue isolation and RGA-based marker development for identifying downy mildew resistance in radish (*Raphanus sativus* L.). Euphytica, 198:289–303. Scholarly articles for Euphytica, 198:289–303.

Wang, Y., Song, Z., Zhang, W., Xu, L., Su, X., Muleke, E.M., Liu, L. (2017). Identification and characterization of expressed TIR- andnon-TIR-NBS-LRR resistance gene analogous sequences from radish (Raphanus sativus L.) de novo Transcripttome. Scholarly articles for Sci Hortic, 216:284–292.

Watanabe Maiko, Yonezawa Takahiro, Lee Ken-ichi, Kumagai Susumu, Sugita-Konishi Yoshiko, Goto Keiichi, Hara-Kudo Yukiko (2011). "Molecular phylogeny of the higher and lower taxonomy of the Fusarium genus and differences in the evolutionary histories of multiple genes" BMC Evolutionary Biology, 11 (1): 322.

Weller, D. M. (2007). Pseudomonas Biocontrol Agents of Soilborn Pathogens: Looking Back over 30 years. Phytopathology, 97(2), 250-6.

Wheeler, B. J. (1969). An Introduction to Plant Diseases. John Wiley and Sons, Ltd., 374.

Widmark, A. K., Andersson, B., Cassel-Lundhagen, A., Sandstrom, M. and Yuen, J.E. (2007). Phytophthora infestans in a single field in southwest Sweden early in spring: symptoms, spatial distribution and genotypic variation. Plant Pathol. 56, 573–579.

Xu, L., Jiang, Q.W., Wu, J., Wang, Y., Gong, Y.Q., Wang, X. L., Limera, C., Liu, L. W. (2014). Identification and molecular mapping of the RsDmR locus conferring resistance to downy mildew at seedling stage in radish (*Raphanus sativus* L.). Journal of Integrative Agriculture, 13(11):2362–2369.

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