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RESEARCH ARTICLE

DESTROYER PATHOGEN OF POTATO (SOLANUM TUBEROSUM) IN GEORGIA.

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Abstract

Phytophthora infestans (Oomycota) remains a problem to production agriculture. Historically there have been many controversies concerning its biology and pathogenicity, some of which remain today. Composition pathogenic fungi potato (*Solanum tuberosum*) is discussed in this article. 50 species of microbiota fully identified. Also, 11 species of fungi involved in the formation of the consortium on tuber potato plants were identified. Long-term (1985-2015) monitoring showed that the destructive pathogen potato late blight is what causes the most damage and economic losses. favorable and unfavorable weather conditions and the development of its distribution was found. Experiments have shown that widespread rot of potato is significantly different from other types of fungi in the aggressiveness and severity. He can completely destroy all the varieties of potato plants in some localities within 5-6 days. The highest disease severity was on the Nevsky and Picaso variety, the highest resistance to diseases manifested in 3 years German variety – Kardena, Russian – Sante, Finland – Katu and Holland variety - Desire.

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Introduction:-

Potatoes (*Solanaceae*) are a staple food and occupy a prominent place in many national cuisines. He 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. Among the biotic factors of *Phytophthora infestans* (potato late blight) remains a challenge for production in agriculture.

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

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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; Fabritius et al., 2002; Grunwald et al., 2002b; Judelson and Roberts, 2002; Cvitanich and Judelson, 2003a, 2003b; Madden and Wheelis, 2003; 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, 2000, 2013; and et al.). Here we look at the current state of the pathogen.

Research objectives:-

The objectives of this study was to identify and determine the composition of pathogenic fungi that propagate in the *Solanum tuberosum* weight agroecosystems Georgia; among them to clarify and examine the most common potato destructor; to establish the scope of its development - the spread under favorable and enabling environment. In addition, the aim of this study was to evaluate the resistance of varieties of potatoes *Phytophthora infestans* in relation to the effectiveness and stable yields.

Materials and methods:-

The object of the study were different varieties of potato plants (*Solanum tuberosum*) and pathogenic fungi which inhabit agroecosystems weight Georgia. Materials were collected using well known methods (Bilal et al., 1982; Giants et al., 1980; Dudka et al., 1982; Foster et al., 2004). Routing and stationary methods were used to study the field of research. Symptoms such as rot, mummification, wilting, spotting, necrosis, mold, Gaults, ulcer, deformation, chlorosis, mosaic, etc., were recorded. The study upper and lower parts of infected plants were collected and labeled. The following procedures, such as off-site and laboratory treatment, collection of preserved plant specimens, assembly, storage, assessment of the infected plants have been carried out for processing the collected samples. We analyzed the distribution and development of disease. Identification of fungi was carried out using modern identification guides (Hawksworth, 1974; Khokhryakov et al., 1984; Watanabe, 2000).

Collections of the new species have been examined by standard light microscopy (Pereval, Carl Zeiss, Jena and Olympus, BX 50, Hamburg, Germany). The SEM micrographs have been prepared by means of a JSM-35 (Japan) SEM microscope. The specimens examined are deposited at HAL, KW and TGM (Holmgren et al., 1990). Collections were examined by standard light microscopy (Pass, Carl Zeiss, Jena, and Olympus, BX 50, Hamburg, Germany). SEM photomicrographs were prepared using DSM-35 (Japan) SEM microscope. Samples were deposited on Hal, KW and TGM (Holmgren et al., 1990).

Results and Discussion:-

A total of 50 species (including 13 species of virus and viroid, 5 - bacteria, 32 - the fungus) have been identified in *Solanum tuberosum* (Table 1), as a result of phytopathological and mycological studies carried out in different places (agroecosystems Georgia) in industrial regions. Among the total microbiota, late blight is one of the most devastating potato diseases. Sometimes, during storage, infected tubers may be covered with different colored mycelia (Figure 1), which includes 11 species of fungi (*Alternaria solani*, *Aspergillus Niger*, *Botrytis cinerea*,

Fusarium solani, *F. moniliforme*, *Mucor* sp., *Penicillium citrinum*, *Phytophthora infestans*, *Sclerotium rolfsii*, *Rhizoctonia solani*, *Rhizopus* spp.). Infected tubers are often invaded by soft rot bacteria which rapidly convert adjoining healthy potatoes into a smelly, rotten mass that must be discarded.

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 a consortium of home 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. 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 (Figure 2) on the leaves and stems, 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.

Tabel 1:- Systematical structure of microbiota Potato.

Microbiota (Exciter)	Division	Class	Order	Family	Genus	Species
Rhizaria	Cercozoa	Phycomycetes	Plasmodiophorales	Plasmodiophoraceae	Spongospora	Spongospora subterranea
Chromista	Oomycota	Oomycetes	Peronosporales	Pythiaceae	Pythium	Pythium deliense
				Phytophthoraceae	Phytophthora	Phytophthora cryptogea
						Phytophthora drechsleri
						Phytophthora infestans
Fungi	Chytridiomycota	Chytridiomycetes	Synchytriales	Synchytriaceae	Synchytrium	Synchytrium endobioticum
	Zygomycota	Mucormycotina	Mucorales	Mucoraceae	Mucor	Mucor sp.
					Rhizopus	Rhizopus nigricans
	Ascomycota	Sordariomycetes	Hypocreales	Nectriaceae	Gibberella	Gibberella pulicaris (Fusarium solani)
						Gibberella acuminatum
		Leotiomyces	Helotiales	Sclerotiniaceae	Botryotinia	Botryotinia fuckeliana
		Dothideomycetes	Capnodiales	Mycosphaerellaceae	Mycovellosiella	Mycovellosiella

		cetes		eae		concors
					Cercospora	Cercospora solani- tuberosi
		Ascomycetes	Incertae sedis	Incertae sedis	Polyscytalum	Polyscytalum pustulans
		Leotiomyce-tes	Helotiales	Sclerotiniaceae	Sclerotinia	Sclerotinia sclerotiorum
		Eurotiomyce-tes	Eurotiales	Trichocomaceae	Aspergillus	Aspergillus niger
					Penicillium	Penicillium citrinum
		Leotiomyce-tes	Helotiales	Sclerotiniaceae	Botrytis	Botrytis cinerea
		Dothideomy- cetes	Pleosporales	Pleosporaceae	Alternaria	Alternaria alternata
						Alternaria solani
		Sordariomy- cetes	Hypocreales	Nectriaceae	Fusarium	Fusarium equiseti
						Fusarium crookwellense
		Sordariomyc- etes	Hypocreales	Incertae sedis	Verticillium	Verticillium albo-atrum
						Verticillium dahlia
		Dothideomy- cetes	Pleosporales	Pleosporaceae	Helminthospori- um	Helminthospori- um solan
		Sordariomy- cetes	Glomerellales	Glomerellaceae	Colletotrichum	Colletotrichum atramentarium
						Colletotrichum coccodes
		Dothideomy- cetes	Capnodiales	Mycosphaerella- ceae	Septoria	Septoria lycopersici var. malagutii
		Dothideomy- cetes	Botryosphaeri- ales	Botryosphaeria- ceae	Macrophomina	Macrophomina phaseolina
		Dothideomy- cetes	Pleosporales	Incertae sedis	Phoma	Phoma solani- cola f. foveata
Bacteria	Proteobacte- ria	Agaricomyc- etes	Cantharellales	Ceratobasidiace- ae	Rhizoctonia	Rhizoctonia solani
			Atheliales	Atheliaceae	Athelia	Athelia rolfsii anamorph (Sclerotium rolfsii)
		Beta Proteo- bacteria	Burkholderiales	Ralstoniaceae	Ralstonia	Ralstonia solanacearum
	Actinobacte- ria	Gamma proteobac- teria	Enterobacteria- les	Enterobacteria- ceae	Pectobacterium	Pectobacterium atrosepticum Pectobacterium carotovorum Syn.:Erwinia carotovora
		Actinobacte- ria	Actinomyceta- les	Microbacteria- ceae	Clavibacter	Clavibacter michiganensis

				Streptomycetaceae	Streptomyces	Streptomyces scabiei
Virus and viroid		—	Group IV ((+)ssRNA)	Potyviridae	Potyvirus	Potato virus A (PVA)
		Group IV ((+)ssRNA)	Tymovirales	Betaflexiviridae	Carlavirus	Potato virus M (PVM)
		Group IV ((+)ssRNA)	Tymovirales	Betaflexiviridae	Carlavirus	Potato virus S (PVS)
		Group IV((+)ssRNA)	Picornavirales	Secoviridae	Nepovirus	Potato virus U (PVU)
		—	Group: IV (+)sense RNA Viruses	Potyviridae	Potyvirus	Potato virus V (PVV)
		Group IV ((+)ssRNA)	Tymovirales	Alphaflexiviridae	Potexvirus	Potato virus X (PVX)
		—	Group:IV: (+)sense RNA Viruses	Potyviridae	Potyvirus	Potato virus Y (PVY)
		Group IV ((+)ssRNA)	Tymovirales	Tymoviridae	Tymovirus	Andean potato latent virus (APLV)
		—	—	Comoviridae	Comovirus	Andean potato mottle virus (APMV)
		—	Group IV: (+)sense RNA Viruses	Comoviridae	Nepovirus	Potato black ringspot virus (PBRSV)
		Group IV ((+)ssRNA)	Tymovirales	Betaflexiviridae	Carlavirus	Potato latent virus (PLV)
		—	Group IV ((+)ssRNA)	Luteoviridae	Polerovirus	Potato leafroll virus (PLRV)
		(unranked): Subviral agents	(unranked): Viroid	Pospiviroidae	Pospiviroid	Potato spindle tuber viroid (PSTVd)
Total	8	30	36	39	42	50



Figure 1:- Symptoms of consortium the Infected tubers.

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.



Figure 2:- Symptoms of late blight on the leaves, stems and tubers of potato.

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; Gees and Hohl, 1988; Coffey and Wilson, 1983).

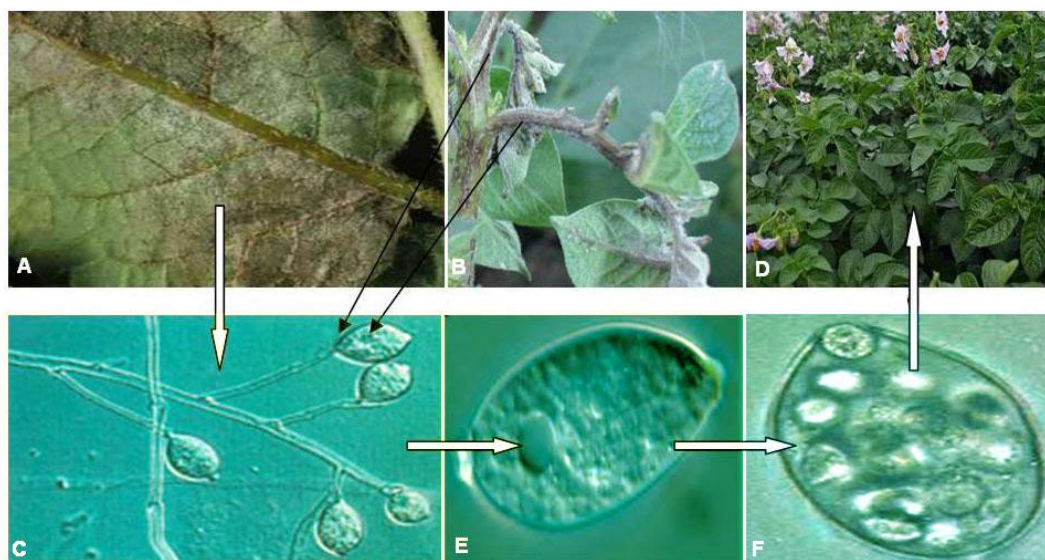


Figure 3:- Asexual life cycle of *P. infestans*: A,B,C - Sporangiophores grow out of diseased tissue; D - Sporangia are released into the atmosphere; E - Indirect germination zoospores, which produce lesions; F - visible after 2–4 days.

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.

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 (Diagram 1), 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 %.

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.

As spreading late blight of potato so intensity of disease development are comparatively high in Adjarian Lowland. Disease development intensity index in Adjara reaches 55% (Figure 2). Intensity of development potato late blight is comparatively low 32-35% in areas under potato crops of Samtskhe-Javakheti and Kvemo Kartli.

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 (Diagram 3).

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 4).

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.

Intensity of spreading potato late blight is the lowest in areas under potato crop of Bolnisi, Gardabani, Dmanisi, Marneuli and Tetritsqaro. 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.

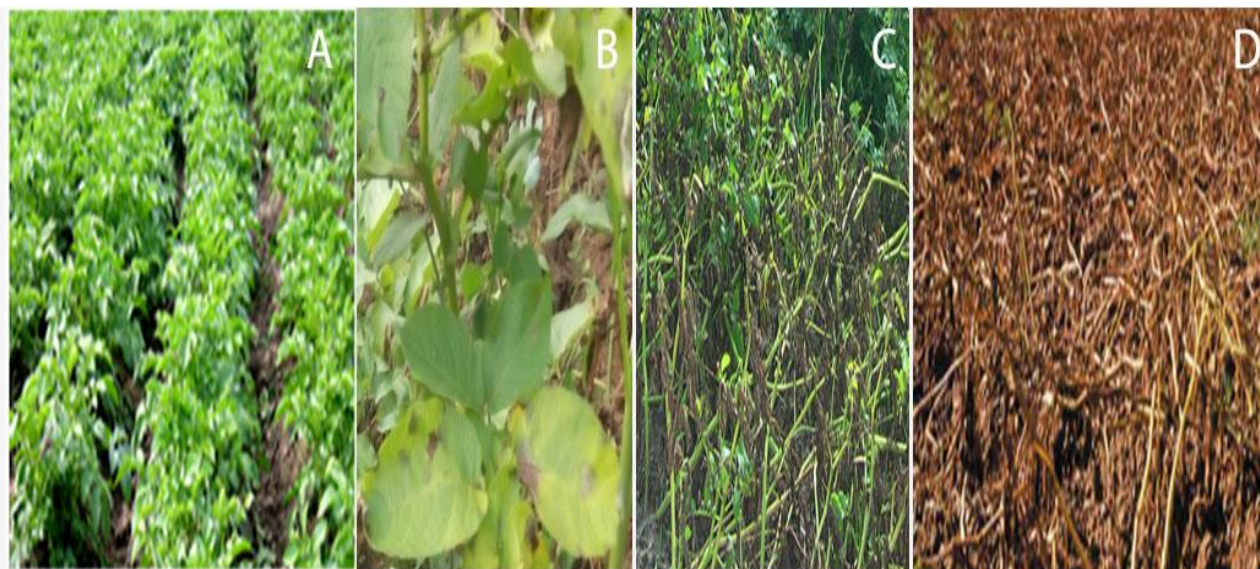


Figure 4:- The speed with which late blight can destroy a field of potatoes is impressive: A - healthy plant before flowering; B - symptoms affected leaves next week; C, D - and within another week can be totally destroyed

Diagram 1:- Spread of potato late blight according to zones in Georgia.

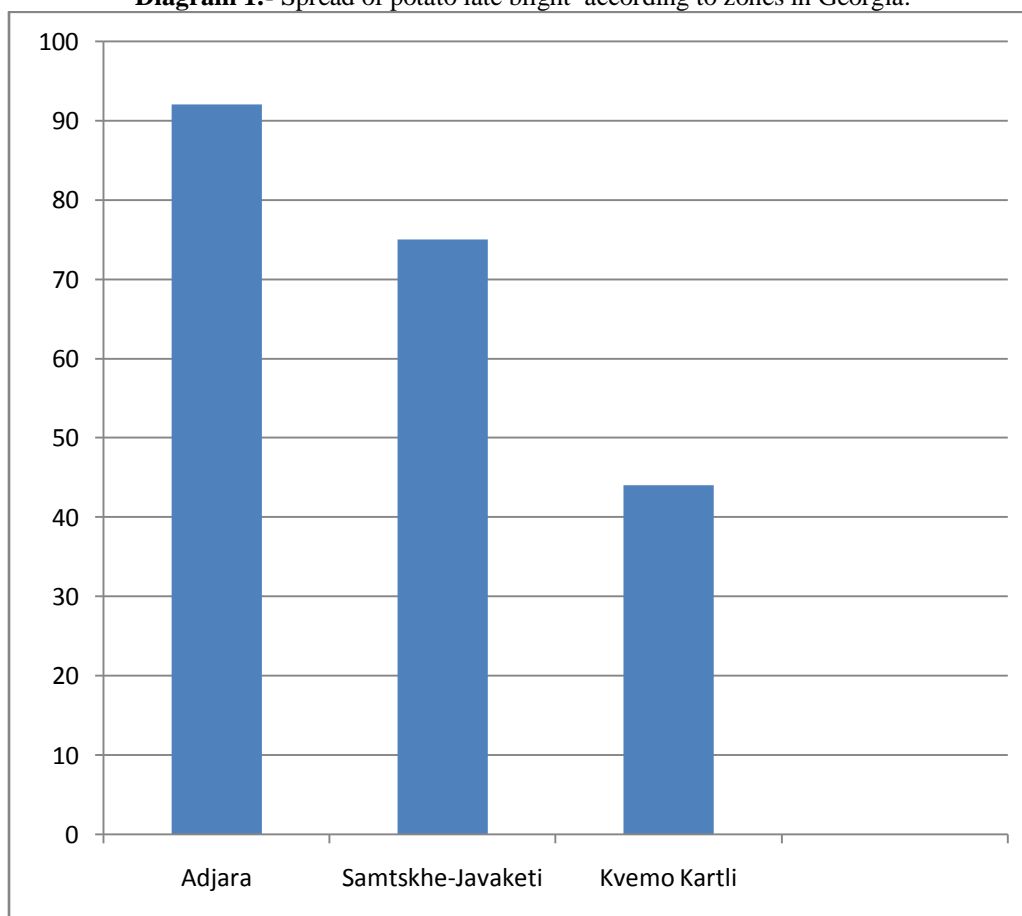


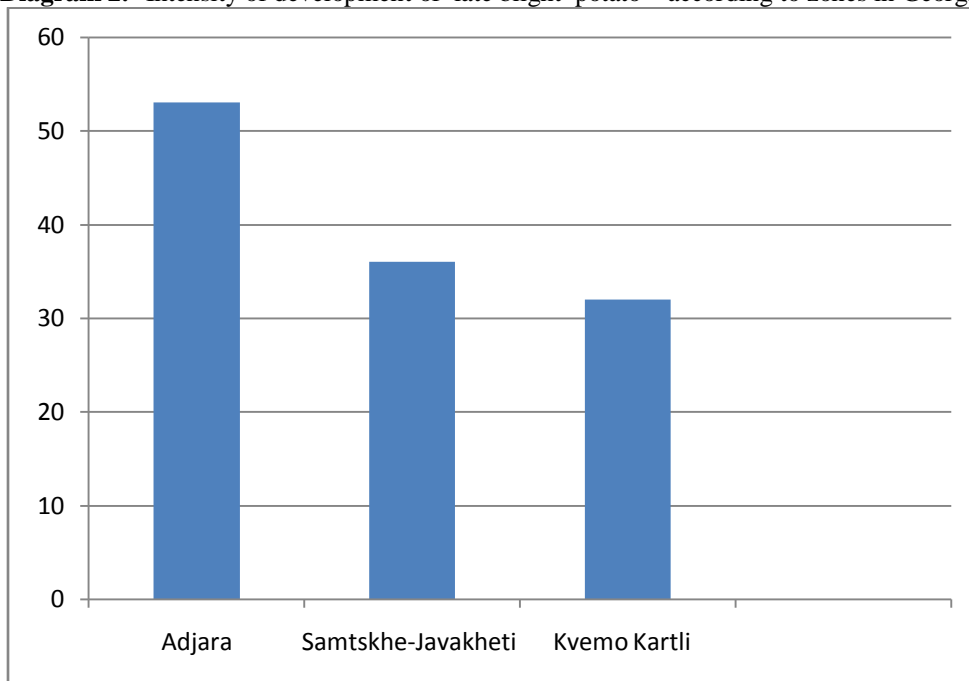
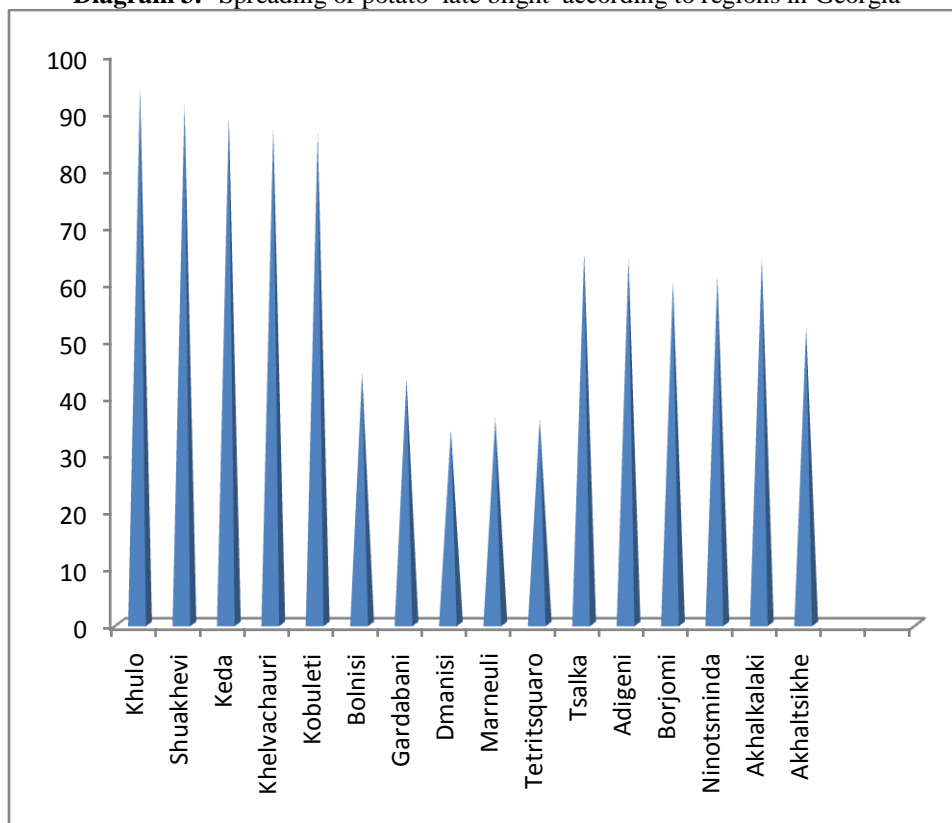
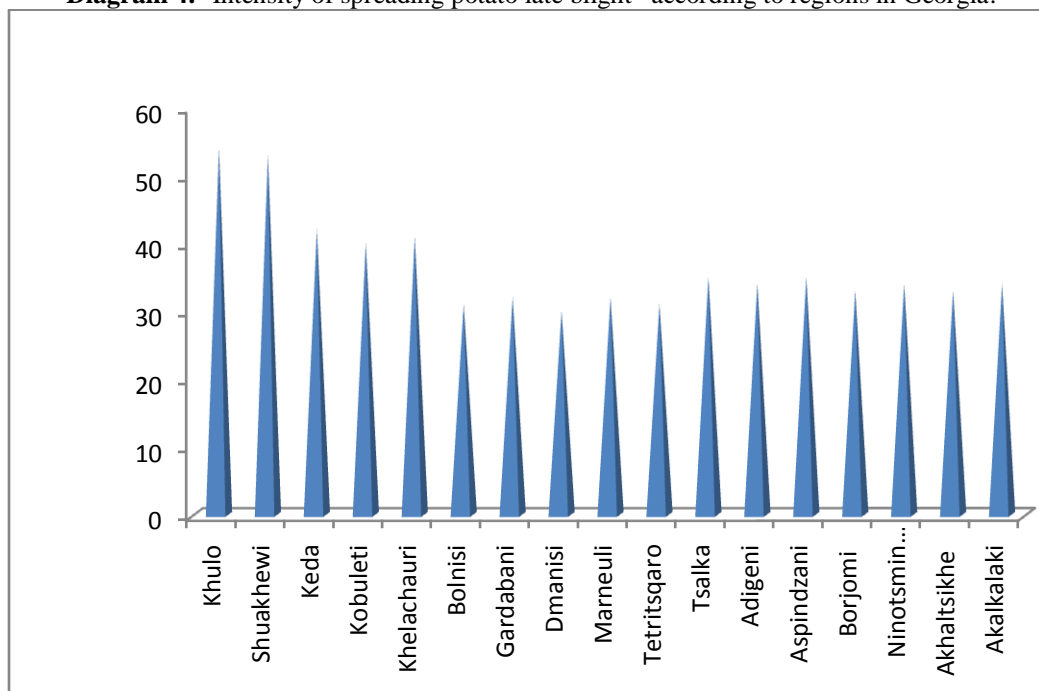
Diagram 2:- Intensity of development of late blight potato according to zones in Georgia**Diagram 3:-** Spreading of potato late blight according to regions in Georgia

Diagram 4:- Intensity of spreading potato late blight according to regions in Georgia.

The test of 12 varieties of potatoes (Table 1) shows significant differences in the resistance of varieties. In 2013-2015 years The highest disease severity was on the Nevsky and Picasso 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 Picasso.

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.

Table 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	32,4H	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

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 biological method used against *Phytophthora 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 m² 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.

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