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GRAY ROT PATHOGENS AND THEIR DEVELOPMENT PECULIARITIES DURING THE PROLONGED STORAGE OF SUGAR BEET ROOTS

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The results of the studies about the species composition determination of the main gray rot pathogens under insufficient humidifying conditions in a Central Forest-Steppe of Ukraine are presented.

The sugar beet roots usage in the industry for the purposes of sugar receiving related to their storage for a certain period during which they are affected by pathogenic microorganisms. This in turn leads to the losses of sugar beet [12].

The disease of sugar beet roots during the storage – gray rot – caused by a complex of fungi and bacteria and a number of factors that reduce their natural resilience. It is characterized by the appearance of different colors of tarnish and tissues softening on the roots [13].

The roots colonization by rot pathogens without showing symptoms of molding proceeds during the whole vegetative period and these pathogenic organisms are moving into an active state under proper storage conditions, causing gray rot [10].

It is commonly known that gray rot of sugar beet roots is caused by more than 150 fungi species and 20 bacterial species, which development is corrected by various unfavorable factors, first of all – ecological factors. Despite the considerable amount of microorganisms that are involved in the disease development, only a small part of them belongs to the active pathogens of disease [6].

Taking into consideration that this disease is caused by a number of pathogenic microorganisms, and the composition of rot pathogens changes in terms of the meteorological conditions and the roots storage conditions in the clamps, the purpose of research was to determine the species composition of gray rot pathogens and the sources of infection of the clamps.

Research methodology. Field and laboratory researches were conducted on the experimental fields and in the laboratories of Uman Research and Breeding Station during the years of 2010–2012 by the generally accepted methods [5].

To conduct researches, the sowing was held by sugar beet hybrids seeds of the domestic (Vesto, Ukrainian ChS 72, Uman ChS 97) and foreign selection (Akhat, Humber, Portland) in the stationary crop rotation in Uman Research and Breeding Station of the Institute of Bioenergy Crops and Sugar Beet of NAAS of Ukraine.

The roots samples selection from the field, grid formation of samples for initial analyzes and for research and industrial storage, appropriate phytopathological analysis according to the research methods were carried out [1, 2].

A method of counting fungi colonies on agar plates to determine the level of soil infection by main gray rot pathogens was used [3].

Quantitative and qualitative composition of rot pathogens on infected roots of Portland hybrid was determined. For this purpose mesh samples (sample weight is 8 kg) were laid in the clamps for storage (exposure time 28 days), after that, they were removed from the clamps and was conducted a visual overview of roots. Roots affected by pathogens were selected. Affected parts of tissues were cut out from them, and then grouped by morphological availability of rot (qualitative composition of disease pathogens). Each separate type of rot was weighed and then was determined the percentage of rotten mass to the sample mass and to the total rotten part of root tissue.

Pathogens identification of rot from each separate rotten part of roots tissue carried out by standard method of mycelium selection of gray rot pathogens to the nutrient environment (under the conditions invitro) and by the method of preparing ordinary microscopic preparations [11].

Preparing of laboratory instruments and equipments was carried according to the laboratory techniques of Kryshchenko V.P. and Ageeva V.S. [4].

Determination of species composition of gray rot pathogens was carried out using the determinants [7–9].

Research results. Sources of mycological flora of gray rot are quite various. Their basic mass gets into clamps from the field with the soil from the surface of the root (*Botrytis cinerea* and species *Penicillium*), with plant remains (*Phoma betae*) and with affected roots during the vegetation (fungal genus *Fusarium*). But the main source of root infection during their storaging in the clamps is soil.

Therefore, the aim of our research was to determine the level of soil infection by main pathogens of gray rot.

The analysis of obtained results shows (Table 1) that in the soil composition were dominated species of *Fusarium* and *Penicillium* – 65% of the total amount of allocated fungi. Fungi of the genus *Botrytis* were allocated 30%, and the proportion of pathogens of the genus *Phoma* was 5%.

Considerable soil contamination by fungi of the genus *Fusarium* shows the biological flexibility of the species of this genus. From literary sources is known that this type of pathogen can exist and saprophyte reproduces in the soil quite long under suitable conditions and with proper host plant a fungus changes its parasitic way of life [3].

Should be also noted that we had marked a define relationship between meteorological conditions and inoculum adjustments of *F.oxysporum* and *F.culmorum* species, while the *F.solani* species is more flexible to temperature fluctuations and humidity.

Thus, the number of spores of *F.solani* in 1 g of absolutely dry soil in 2010 and 2011 amounted 11,6% of the total number of spores, and in 2012 a slight increase of their proportion – up to 11,9% was observed.

The number of spores of *F.oxysporum* and *F.culmorum* in 1 g of absolutely dry soil in 2010 amounted 37,5% (HTC (hydrothermal coefficient) of this year according to the Salyaninov method amounted 1,2 for the long-term quantity 1,2). In 2011 it was observed the reducing of number of spores by 0,5% to 37,0% of the total rate (HTC of this year amounted 1,48). And during the dry year 2012 (HTC =0,85) the number of spores in 1 g of absolutely dry soil was 38,6% of the total amount of spores, that is respectively on 1,1% and 1,6% more than in 2010 and 2011.

1. Species composition of gray rot pathogens and their numbers in soil during vegetation of sugar beet, %

Fungi species	Number of fungal spores in 1 g of absolutely dry soil					
	2010		2011		2012	
	ths. pcs.	%	ths. pcs.	%	ths. pcs.	%
Fusarium oxysporum	3879	22,3	3724	21,7	3927	22,2
Fusarium culmorum	2640	15,2	2619	15,3	2894	16,4
Fusarium gibbosum	2346	13,5	2201	12,8	2290	13,0
Fusarium solani	2010	11,6	1980	11,6	2103	11,9
Penicillium commune	2819	16,2	2726	15,9	2659	15,0
Penicillium expansum	2605	15,0	2783	16,2	2731	15,5
Botrytis cinerea	873	5,0	972	5,7	905	5,1
Phoma betae	196	1,1	135	0,8	167	0,9
total amount	17368	100,0	17140	100,0	17676	100,0

So, it was noted a definite relationship between the availability of soil infection and subsequent development of the sugar beet root diseases during the growing season and during the storage in the clamps.

From rotten root tissues due to the seeding, we have identified gray rot pathogens and determined their species composition. In particular it is established that root tissues decay is caused by fungi of genus *Botrytis* (*Botrytis cinerea*), genus *Fusarium* (*F.oxysporum, F.culmorum, F.solani, F.gibbosum),* genus *Penicillium* (*P.commune*, *P.expansum*) and genus *Phoma* (*Ph.betae*).

It is found that the species composition of gray rot pathogens have been varied over the years of researches depending on the meteorological conditions during the growing season and during storage of sugar beet roots (Table 2).

Among rot pathogens that were allocated from rotten roots, the highest proportion is found in the *Botrytis cinerea* fungus, that is a hygrophilous fungus-cosmopolite.

Thus, depending on the meteorological conditions formed during the storage, the proportion of this pathogen by years have ranged from 55,6% to 59,5%. The largest proportion (59,5%) was allocated in 2011 due to the favorable for development conditions of this pathogen (double amount of precipitation and temperature close to the perennial indicators during the roots storage in the clamps).

Large proportion among allocated gray rot pathogens occurred in fungi of the genus *Fusarium (F.oxysporum, F.culmorum, F.solani, F.gibbosum*) – 17,1% in 2010, 19,8% in 2011 and 20,6% in 2012.

2. Composition of gray rot pathogens allocated from infected sugar beet, %

Rot pathogens	Years of research		
	2010	2011	2012
genus *Botrytis* (*B.cinerea*)	55,6	59,5	56,7
genus *Fusarium* (*F.oxysporum, F.culmorum, F.solani, F.gibbosum*)	17,1	19,8	20,6
genus *Penicillium* (*P.commune, P.expansum*)	15,3	13,9	13,4
genus *Phoma* (*Ph.betae*)	7,7	3,9	5,2
other genus	4,3	2,9	4,1

In particular, the increase of the proportion of these allocated pathogens in 2012 was caused by the appropriate meteorological conditions of plants vegetation (considerable temperature excess compared with the long-term indicators that led to the plants depression and an increase of development of fusarium rot) and the number of pathogens increasing in the soil.

Also it is found that fungus *F.culmorum* dominated (in our opinion because of its biological peculiarity – the optimum temperature for the development of pathogen +22°C) in 2011, and in 2010 and 2012 – fungus *F.oxysporum.*

Particle of fungi of the genus *Penicillium (P.commune, P.expansum)* amounted 13,4 – 15,3% depending on the year of research. We think that their increase in 2010 was instigated by low temperature during the storage of roots in the clamps (this kind of pathogens affects them even at +2...+5°C when other pathogens of gray rot require for their development higher temperature). Significant dominance between species *P.commune* and *P.expansum* wasn’t noted.

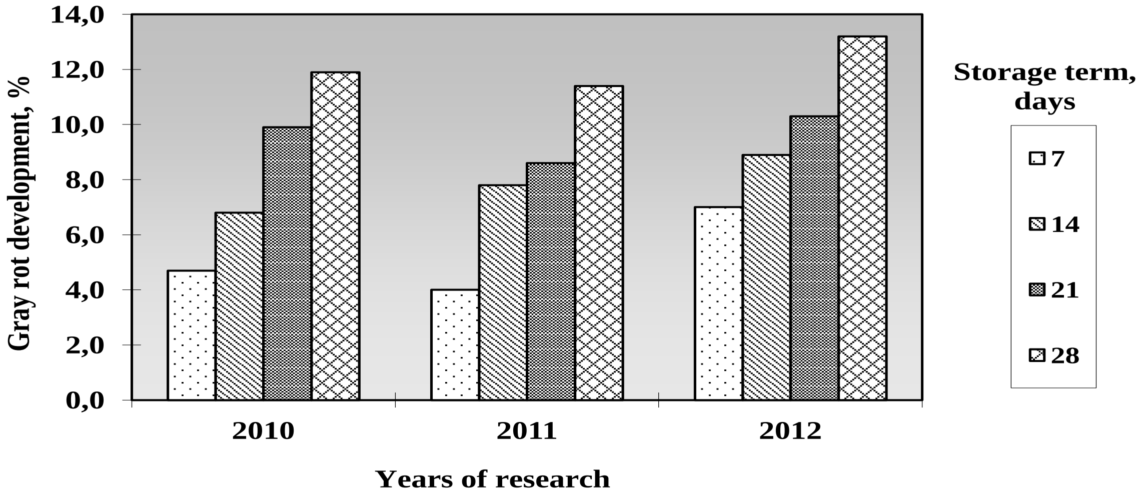
Among gray rot pathogens on fungus *Phoma betae (genus Phoma)* accounted 3,9–7,7% of the total share of pathogens that cause this disease. According to the results of our study it was found that this indicator depended on the soil infection presence and the level of zonal sugar beet maculation development (with the increase of maculation development, proportion of allocated pathogen among the pathogens of gray rot increased).

The number of other allocated pathogens of gray rot ranged from 2,9% to 4,3% depending on the research year.

Consequently, as results of the research show, the largest proportion among the allocated pathogens of gray rot in low moisture belongs to fungus *Botrytis cinerea Pers*. — 55,6–59,5%. This fungus is one of the most active pathogen that causes primary clamp decay. A significant number belongs to fungi of the genus *Fusarium* (17,1–20,6%) and the genus *Penicillium* (13,4–15,3%). The number of allocated fungi of the genus *Phoma* amounted 3,9–7,7%. Fungi of other species in experiments were observed rarely and more in combination with other pathogens, causing the secondary decay.

Also, concerning the main gray rot pathogens, was confirmed a certain dependence between the presence of soil infection and disease progression of sugar beet roots during their storage in the clamps.

According to the research results it was also determined that infestation of sugar beet roots by gray rot varied by years of the researches, depending on the meteorological conditions formed during the storage of root crops in the clamps (Pic.).



Pic. Gray rot development dynamics depending on the storage term of root crops in the clamps

Thus, the most favorable for sugar beet roots storage in the clamps was 2011, according to the weather conditions the rot development of which at the end of accountings amounted 11,4%, or respectively on 0,5% and 1,8% less than in 2010 and 2012. Obtaining such results, in our opinion, contributed the combination of air temperature approaches to perennial and increasing the amount of precipitation during the growing season and during the storage in the clamps of root crops (HTC=1,48).

Weather conditions in 2010 characterized by a combination of high temperature and insufficient amount of rainfall that were suspended in time during the growing season and during the roots storage (HTC=1,2), which negatively influenced on the stability of root crops to gray rot.

According to the weather conditions that were formed during 2012 the gray rot development at the end of accounting was the highest and amounted 13,2%. This increase of the disease progression can be explained by high temperature and insufficient and irregular rainfall during the growing season, which led to their depression and natural immunity reduction and high temperature during harvesting, transportation, clamping and storage that led to excessive loss of moisture from roots.

Consequently**,** as a result of conducted researches was found that the development of gray rot depends on the weather conditions during the growing season and during the storage of sugar beet roots in the clamps**.** Thus**,** the increase of average daily temperature and lack of moisture during the growing season negatively affect the storage of root crops in the clamps because under the influence of high temperatures they lose turgor and couldn't counteract the phytopathogenic microorganisms – gray rot pathogens**.**

Conclusions.

1. It was established that the main source of mycological flora of gray rot is soil. In the soil composition during the years of researches the fungi of the genus *Fusarium* and *Penicillium* – 65% were dominated. Fungi of the genus *Botrytis* were allocated 30%, and the proportion of pathogens of the genus *Phoma* was 5% of the total amount of selected fungi. Also it was found the certain dependence between the presence of main gray rot pathogens in the soil and further development of this disease during the storage of sugar beet roots in the clamps.
2. The main gray rot pathogens of sugar beet roots are fungi of the genus *Botrytis, Fusarium, Penicillium* and *Phoma* during the long-term storage. In particular, the most harmful types of fungi of the genus *Botrytis* is *B.cinerea Pers.*, the proportion among allocated gray rot pathogens of this fungus is 55,6–59,5%.
3. Gray rot development depends on the meteorological conditions formed during the growing season and during the storage of sugar beet root crops in the clamps. Thus, the most favorable for root crops storage was 2011 (HTC = 1,48) – gray rot development at the end of storage period was 11,4%, and the highest – 13,2% noted in 2012 (HTC = 0,85).

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Возбудители кагатной гнили и особенности их развития длительного хранения корнеплодов свеклы сахарной

Использование корнеплодов сахарной свеклы в промышленности для получения сахара, связано с хранением корнеплодов в течение определенного периода, во время которого они поражаются патогенными микроорганизмами. А это в свою очередь приводит к потерям сахарного сырья. Кагатная гниль — болезнь корней сахарной свеклы при хранении вызывается комплексом грибов и бактерий и рядом факторов, снижающих естественную устойчивость корнеплодов. Она характеризуется появлением на корнях налетов различного цвета и размягчением тканей. Инфицирование корнеплодов возбудителями гнилей без проявления симптомов загнивания проходит в течение всего вегетационного периода и при соответствующих условиях хранения эти патогенные микроорганизмы переходят в активное состояние, вызывая кагатную гниль. Как известно, эту болезнь корнеплодов сахарной свеклы вызывают более 150 видов грибов и 20 видов бактерий, развитие которых корректируется различными неблагоприятными факторами, прежде всего — экологическими. Несмотря на большое количество микроорганизмов, принимающих участие в развитии болезни, лишь небольшая их часть относится к активным возбудителей болезни.

Установлено, что развитие кагатной гнили зависит от погодных условий во время вегетации растений и при хранении корнеплодов сахарной свеклы в кагатах. Так, превышение среднесуточной температуры воздуха и дефицит влаги в период вегетации растений негативно влияет на хранение корнеплодов сахарной свеклы в кагатах, ведь под действием высоких температур корнеплоды теряют тургор и не могут противодействовать фитопатогенных микроорганизмам — возбудителям кагатной гнили.

***Ключевые слова**: возбудители кагатной гнили, видовой состав, сахарная свекла.*

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Causative agents of gray rot and peculiar properties of their development of the long-term storage of roots of sugar beet

The sugar beet roots usage in the industry for sugar receiving related to their storage for a certain period during which they are affected by pathogenic microorganisms. This in turn leads to the losses of sugar beet. Gray rot — caused by a complex of fungi and bacteria and a number of factors that reduce the natural resilience of roots during their storage.It is characterized by the appearance of different colors of tarnish and tissues softening on the roots. The roots colonization by rot pathogens without showing the symptoms of molding proceeds during the whole vegetative period and these pathogenic organisms are moving into an active state in proper storage conditions, causing gray rot. It is commonly known that gray rot of sugar beet roots is caused by more than 150 fungi species and 20 bacterial species, which development is corrected by various unfavorable factors, first of all — ecological factors. Despite the considerable amount of microorganisms that are involved in the disease development, only a small part of them belongs to the active pathogens of disease.

Found that the development of gray rot depends on the weather conditions during the growing season and in storage of sugar beet in clamps. Thus, the excess of the average daily air temperature and moisture deficit during the growing season affects the storage of sugar beet in clamps, because under high temperatures roots lose turgor and phytopathogenic microorganisms can not resist causative agents of rotting roots.

***Key words**: causative agents of gray rot, species composition, sugar beet.*