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### SILVICULTURAL AND FOREST-PROTECTION MEASURES IN PINE STANDS AFFECTED BY ANNOSUM ROOT ROT

The paper presents an evaluation of the effectiveness of silvicultural and forest protection activities in pine plantations affected by *Heterobasidion annosum* (Fr.) Bref. Revealed that forest practices in Belarus uses a very small set of measures to limit the damage of the disease. It was revealed that all types of cuttings have clearly low efficiency in the improvement of sanitary state of the pine stands due to lack of their effect on the pathogen.

**Introduction.** During the long co-evaluation of all living components of the forest ecosystems, at the relative steadiness of the environmental conditions, distinct balance between producers, consumers and decomposers are formed. Human intervention into the natural dynamics of the forest, sharp climatic changes and increased anomalous weather conditions disturb existing balance, there is a tendency of accumulation of woody plants with broken resistance which is favorable to the mass spreading of the noxious organisms. That is why for the modern stage of development of the forest estate land of Belarus, as for the majority of other European countries, recurring or continuous epiphytotic of woody plants are typical as well as frequent outbreak of mass reproduction of injurious insects.

In forests with intensive business activity root rot provoking by *Heterobasidion* fungus has wide spreading and considerable injuriousness. Pathogenesis of annosum root rot is the most studied issue in forest phytopathology – from the beginning of the last century a considerable number of research works which made it possible to get detailed data about biology of causative agents, spreading and injuriousness of the disease were dedicated to this problem. It was revealed that epiphytotic is the consequence of wide-ranging cultivation of coniferous monocultures in dwelling places not conforming to the ecological demands for woody plants and transferring of traditionally formed regime of forest cultivation to these places without taking into account underlying risk for root rot disease. New conditions of artificially cultivated planting stimulate development of new and rather dangerous strategy of pathogen – local lesion.

In the nineties of the XX<sup>th</sup> century research support of the issues of forest protection at post-Soviet area started to slow down, this resulted in the reduction, misrepresentation or abolishment of many regulations of recommendations on planting protection from root fungus in redrafted

technical regulations (RTR). Infringement of the entire system of recommended measures, alteration of the rules, methods and technology of forest estate land works against the background of more frequently occurred abiotic stress resulted in appearance of the new wave of epiphytotic of root rot in managed forests.

Intensive development of the forest estate land makes us to reconsider attitude to the role of pathogen organisms in forest ecosystem and search for the effective means of influence on pathocomplexes and ways of forests resistance improvement. Our task was to make assessment of the effectiveness of silvicultural and forest-protection measures in pine stands affected by root rot fungus.

**Main part.** According to SI "Bellesozashchita" as for the year 2011 only in the pine stands of Belarus there are one hundred and twenty one thousands of root fungus loci [1]. During the recent 7 years the number of affected stands almost stays invariable and in certain years increase. The similar situation is observed in the European part of the Russian Federation. FSI "Russian center of forest protection" informs that from 1999 to 2008 the area of root fungus loci increased by 41%, and great bulk of affected planting is situated in Central and Privolozhsky federal districts [2]. Only in the Republic of Marij El spreading of root fungus from 1989 increased by 6 times. Information about the spreading of *Heterobasidion annosum* area to the east till Krasnoyarsk Territory and growth of injuriousness pathogen in forest species and planting of natural origin appeared [3, 4].

The problem of root rot is not solved in pinery of some countries of West Europe and America. Damage from *Heterobasidion* fungus is observed. So, in the USA yearly losses is more than quarter million cubic meters of conifer. In Belgium about 100,000 ha or 17% out of the total area of conifer forest affected by root fungus. In Norway yearly loss of only white deal wood as a result of the development of mottled rot of trunks and roots is 200,000 m<sup>3</sup> [5].

Increase of spreading and as a consequence harmfulness of a disease is a result of low effectiveness of the using strategy of forest protection, its apartness from other forest estate land measures. Unfortunately, in the practice of forest estate land of Belarus and in modern normative documents there is rather limited number of methods and means of control of root rot (Table 1). It is evidently that in forest estate land of the country for limitation of the harmfulness of heterobasidi-osis by different reasons there are only some out of several possible forest protective measures. There is no a complex approach which is very important in solving this problem. In outstanding research works of N. I. Fedorov, Y. M. Poleshchuk, A. Vasilyauskas, S. F. Nekhrutski, I. A. Alekseev forest site is described in which threat of affection of pine forest plantation by root fungus is especially high. However, this experiment is ignored in forest estate land of the country as in the basic normative document specifying cultivation of for-

est plantation (TKP 047-2007), even under such conditions, cultivation of pine monoculture or plantations with a little number of mixed planting of deciduous species at strip mixture.

While making a project of forest plantations historical peculiarities of the forest block are not taken into consideration, a question about the necessity of rotation of main species after another cutting period are not touched upon by researchers and experts. It is known that pine cultures on lands gone out of agricultural use are most susceptible to disease. [6]. Such soils are characterized by the damaged structure and lean structure of microflora, and demand certain expenses for rehabilitation. One of the effective ways of development of forest environment on previously cultivated lands – this is cultivation of advance planting from the most disease resistant deciduous species [7]. Within the Republic this measure is not used, in spite of considerable number of lands giving under forest cultivation.

Table 1

**Usage of some measures on limitation of spreading and harmfulness of annosum root rot in the forest estate land of Belarus**

| Name of the measure  | Technical regulatory act     | Data about application in practice  |
|--|------------------------------|---|
| Division of planting areas on the threat of affection by root fungus   | –                            | Is not applicable   |
| Recording of traditional peculiarities of the forest block at projecting of forest plantations                             | –                            | Is not applicable   |
| Deep subsurface loosening  | TRA 224-2009                 | Is applicable in small without threat of affection of future plantation by root rot |
| Stump barking  | –                            | Is not applicable   |
| Stump coaling  | –                            | Is not applicable   |
| Stump chemical treatment   | –                            | Is not applicable   |
| Stump biological treatment   | TRA 224-2009                 | Is not applicable (absence of approved biological preparations)                     |
| Stump extraction   | –                            | Is not applicable   |
| Cultivation of advance planting of little affected species   | –                            | Is not applicable   |
| Cultivation of stable cultures with complicated schemes of mixture with allelopathic and stable brushwood and woody plants | TRA 224-2009<br>TRA 047-2007 | Is applicable in small  |
| Creation of deciduous barriers   | –                            | Is not applicable   |
| Inventory of sites of damage   | TRA 252-2010                 | Is not applicable   |
| Gathering of litter  | TRA 026-2006                 | Is not applicable   |
| Improvement thinning   | TRA 143-2008                 | Is not applicable   |
| Selective salvage cutting  | TRA 026-2006<br>TRA 224-2009 | Is not applicable   |
| Separating strip cutting   | –                            | Is not applicable   |
| Separating strip cutting with stumps treatment   | –                            | Is not applicable   |
| Full salvage cutting   | TRA 026-2006<br>TRA 224-2009 | Is applicable   |

In the process of cultivation of cultures with complicated mixer circuit especially during impurity introduction of allelopathic and substantial plants high effectiveness in limitation of harmfulness of root rot is proved [6, 7]. There are data on successful usage of such circuits in silvicultural practice of some forest estate lands. So, in SEFA (State Experimental Forestry Agency) “Osipovichy experimental forestry” on previously cultivated lands under the type of condition of site A<sub>2</sub> strip composition is used – 4 rows of pine and 2 compacted rows of Japanese quince (*Chaenomeles japonica*) which will become a technological corridor after closing of principal species. Block birch planting separated by briar (*Rosa canina*) were created by forest officers of SEFA “Smorgon experimental forestry” in the locations of root rot after full sanitation cuttings by maximal, preservation of natural regeneration. However, it should be mentioned that in our forests this are only singular examples of such an innovative approach of forest officers to the solution of the problem.

Thus, the weakest point in the system of measures on protection of pine forests from root rot is prophylactic actions which should be preferred in any forest protective strategy.

Analyzing of full baseline of planting affected by root rot including information about 22,194 forest disease centers it was revealed that with the aim of pine forests hygienic in practice of Belarus forest estate land there are only thinning, thinning in older stands removal of debris, selective sanitation cuttings. However, protective measures in arsenal of domestic forest officers cover only small part of affected planting. For example, in 2011 53.5 thousand ha out of 121 thousand ha of the sites of root rot demanded fulfillment of control measures but

in practice, only 1.25 thousand ha of damage sites was eliminated with the help of these measures. In this context 6.9 thousand ha of the damaged sites of root rot appeared again in a year [1].

Study of effectiveness of measures in pine plantings affected by root rot was carried out by comparison of periods of repetition, that is, the average number of years when condition of forest requires undertaking next cutting.

Analysis of history of silvicultural and sanitary measures on more than 190 lands of affected pine forest in different sites made it possible to reveal highly frequent repetition of felling that in average varies from 1 to 3 years (Table 2). Considerable difference in repetition of abovementioned measures depend on intensity of sampling of living part of forest (diagram). Removal of debris denoting removal of only dead forest that repeats every 1 year. Selective sanitary cuttings aiming to remove dead-standing trees together with drying out and very weakened-trees repeat in just a little bit more than 2 years. Necessity of carrying out sanitary measures after young growth tending is to be done on average in 3.2 years that is the result of sampling of unreliable unpromising trees with rather high probability of contamination by root rot.

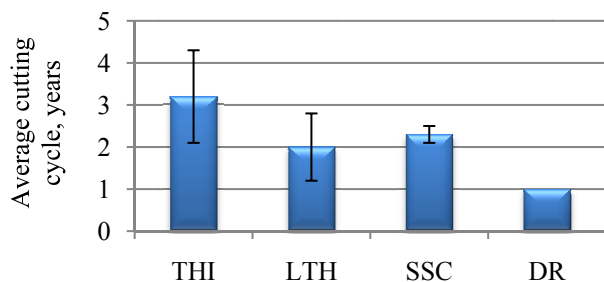
By sampling of trees with potentially high threat of affection by root rot and already contaminated trees we prevent pathological mortality for a short period of time. It is impossible to stop development of niduses by cuttings as these measures do not influence on pathogens concentrated in roots and soil. On the contrary, appearing of a large number of nutritious substrate in the form of stump and root wood of trees that have been cut down often brings negative effect contributing to accumulation of root rot infection.

Table 2

**Thinning cycle of pine stands affected by root rot**

| Succession of cuttings   | Volume of sampling, number of observations | Thinning cycle, years |   |
|--------------------------|--|-----------------------|---|
|                          |  | average               | confidence interval at 5% level of significance |
| SSC after completing THI | 10   | 3.2                   | 1.1   |
| SSC after completing LTH | 7  | 1.8                   | 1.2   |
| repeated LTH             | 7  | 2.3                   | 1.5   |
| THI after completing SSC | 6  | 1.7                   | 0.5   |
| LTH after completing SSC | 5  | 2.6                   | 0.7   |
| Repeated SSC             | 130  | 2.5                   | 0.2   |
| SSC after completing SSC | 21   | 1.4                   | 0.5   |
| Repeated DR              | 8  | 1.0                   | 0.0   |

Note. SSC– selective sanitary cutting, THI – thinning, LTH – late thinning, SSC – solid sanitation cutting, DR – debris removal.



Average cutting cycle in affected by root rot pine planting

**Conclusion.** Under conditions of Belarus the basic silvicultural and forest-protective measures carrying out in pine forests affected by root rot are different kinds of cuttings. We revealed the low effectiveness of these measures in solving the problem of improvement of sanitary conditions of pine forests. This is connected with absence of influence of these measures on pathogens. On the contrary, stump and root wood of newly cut trees is a good nutritious substrate for pathogen and stumps themselves becoming overgrowth with conk plays a role of a base for growing infection background. Thus, performing cuttings practically do not fulfill basic sanitation role. Only problems of minimizing loss from damages of trees shrinking centers by sampling of merchantable wood can be solved with the help of cuttings. Thus, in front of the modern generation of scientists and silviculturists there is a task on searching the effective measures and means of limitation of harmfulness from annosum root rot and their implementing into forest estate land of the Republic in the form of a complex strategy accompanying the entire process of forest cultivation – from planting cultivation to final felling operations.

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