Soil enzyme activity in the dry valley phytocenoses under the influence of *Acer negundo* L.

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Abstract. The activity of hydrolytic enzymes in the soil of dry valley phytocenoses under the influence of ash-leaved maple was investigated. The research objects were selected taking into account the ranking of plantations by crown density. Soil samples were collected depending on the horizontal differentiation of communities in the undercrown and outer zones of phytogenic fields. An increase in the enzyme activity during the period of active tree growth among experimental and control samples was established. Among the enzymes, invertase demonstrated the highest activity, while protease and phosphatase were characterised by medium activity. An increased invertase activity was found in the trees with a high crown density as compared to the trees of other groups. The obtained data can be used as diagnostic indicators of soil condition for monitoring natural ecosystems.

1 Introduction

The formation of the soil enzymatic potential is a complex process caused by the interaction of environmental factors of soil formation. By implementing functional connections between soil and living organisms inhabiting it, enzymes contribute to maintaining the integrity of the biogeocenosis [1 – 3]. Hydrolytic enzymes – invertases, proteases and phosphatases characterised by strict specificity and the highest sensitivity of many biochemical processes in soils, are important criteria for soil diagnostics and identification of the soil formation specificity. During the period of active plant growth, as well as the decay of root and plant residues, the activity of soil enzymes increases [4 – 6]. At present, insufficient attention has been paid to the peculiarities of changes in enzyme activity under the influence of vegetation, in particular, of ash-leaved maple.

In this regard, it is relevant to search for an optimal solution to the problem of the soil condition and its biochemical activity under specific soil and climatic conditions in order to clarify the role of enzymes with different stability and localization in soil metabolism and, in general, in the environmental stability of biogeocenoses.

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This work is aimed at assessing the enzyme activity of the soil of dry valley phytocenoses under the influence of ash-leaved maple.

2 Materials and Methods

Soil samples of dry valley phytocenoses collected under the plantations of ash-leaved maple within the city of Kemerovo were investigated. The experiment was carried out in the summer period during May–September, 2020. The soil samples were taken in the undercrown space of ash-leaved maple at the following test plots: 1 – single trees in unclosed stands; 2 – trees with average (50 – 60 %) crown density; 3 – trees with high (100 %) crown density. The outer zone of single trees was selected as a control group. The soil enzyme activity was studied using freshly collected material in triplicates taken from a mixed sample. The determination of invertase activity was carried out according to the method by V.F. Kuprevich and T.A. Shcherbakova; protease activity – according to the method by A. Sh. Galstyan and E.A. Arutyunyan [7]; phosphatase activity – according to the method by A. Sh. Galstyan [8]. The agrochemical soil analysis from the investigated plots was performed at the accredited test centre of the "Kemerovsky" agrochemical service. Statistical processing of the obtained data and plotting of graphs were performed using the conventional StatSoft STATISTICA 8.0. software package for Windows and Microsoft Office Excel 2007.

3 Results and Discussion

The dynamics of enzyme activity depends on environmental conditions, including the agrochemical composition of soils. The closest relationship of enzyme activity is found with the content of mobile forms of phosphorus, nitrogen and potassium. However, high phosphorus content suppresses phosphatase activity. The results of the agrochemical analyses showed that the soil of the studied areas was characterised by a neutral and slightly alkaline reaction of salt extract (pH 7.0 – 7.9). The supply of mobile forms of phosphorus at all test plots varied within 75 – 80 mg/kg, and potassium - more than 80 mg/kg, which corresponded to the average supply of nutrients. According to the scale by G.P. Gamzikov [9], the content of nitrate nitrogen at the experimental plots fluctuated at the level of very low and low values - from 3.0 to 13.5 mg kg, which was 50 % lower on average relative to the control group. The mass fraction of exchangeable ammonium exceeded the mass fraction of nitrates by 1.3 – 1.7 times. The amount of absorbed bases was very high, varying within 48.4 – 64.3 mmol/100 g. A comparative analysis of the agrochemical parameters of the soil under the ash-leaved maple plantations showed that higher indicators of the studied parameters (mobile compounds of phosphorus and potassium, nitrate nitrogen, exchangeable ammonium, and the amount of absorbed bases) were characteristic of test plots under the trees of the third group (with high crown density), in comparison with control group and other sites.

Soil enzyme activity is subject to seasonal dynamics during the growing season, with a maximum in summer. Our studies showed that the highest indicators of enzyme activity in the studied samples were observed during the period of active plant growth (July), and the lowest – by the end of the growing season (September). Invertase activity in all soil samples was higher than that of protease and phosphatase.

In experimental samples, the level of invertase content in all observation periods varied from 51.73 to 71.35 mg glucose/g/24 h, which corresponded to high soil activity. At the beginning of the growing season, the values exceeded the control group by 26 – 34%. In the middle of the growing season, an increase of invertase to 71.35 mg glucose/g/24 h was

observed, while by the end of the growing season it decreased to 52.19 mg glucose/g/24 h. The conducted comparative analysis of the test plots indicated higher levels of soil invertase activity near the trees with high crown density (test plot 4 – 65.02 ... 71.35 mg/g/24 h), in comparison with other groups of trees and the control group.

According to the study of phosphatase and proteolytic activity, the soil in the studied areas belonged to the average degree of activity. During vegetation, the level of phosphatase in the studied samples at the test plots ranged from 3.71 to 5.24 mg P_2O_5/10g/h, which corresponded to the average degree of soil activity. Such a trend for phosphatase to increase by the middle of the growing season (up to 5.24 mg P_2O_5/10g/h) remained among all the tested plots. The greatest differences during the growing season relative to the control group were found in the samples from sites with an average crown density (on average by 16 %). The protease activity in the control and experimental samples at the test plots varied from 4.1 to 5.59 mg glycine/g/24 h. Comparative characteristics of the studied sites revealed some differences in this indicator during the growing season relative to the control group. Experimental samples of the second group (with average crown density) were characterised by higher indicators (5.1 – 5.59 mg glycine/g/24 h) of proteolytic activity, exceeding those of the control group by an average of 11 %.

4 Conclusion

The conducted studies have shown that, under the conditions of dry valley phytocenoses and influence of ash-leaved maple, hydrolytic enzymes are characterised by high (invertase) and medium (protease, phosphatase) levels of activity. The level of invertase in all samples was higher than that of protease and phosphatase. During the period of active plant growth, an increase in enzyme activity in the studied samples was observed, while by the end of the growing season it decreased. Trees with a high crown density, due to the increased content of nutrients and the amount of absorbed bases, showed the highest invertase activity in comparison with those of other studied groups. The obtained data can be used as diagnostic indicators of soil condition for monitoring natural ecosystems.

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