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Phyto- and pedobiont yeasts of plants

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ABSTRACT

This paper contributes to the study of yeast communities in the rhizo- and phyllosphere of plants, as these communities have not been sufficiently investigated in terms of the influence of various ecological factors and root exudates. The surface of the underground and aboveground parts of plants significantly differs in the composition of dominant epiphytic yeast species. Eurybiontic and phytobiontic yeasts dominate in the phyllosphere, while pedobiontic yeasts prevail in the rhizosphere. Seasonal changes in the abundance and qualitative composition of yeast communities in the rhizosphere are considerably more stable (synchronized) than those in the phyllosphere.

Keywords: *plant, yeasts, root.*

INTRODUCTION

The rhizosphere, or rhizospheric soil, has long been a favored subject of research in soil microbiology. As early as the beginning of the 20th century, it was established that microorganisms are more abundant in the rhizosphere than in the soil outside the root zone. At that time, the term "rhizosphere effect" was introduced, referring to the influence of plant roots on the increased abundance of microorganisms in the rhizosphere compared to the surrounding soil. The rhizosphere effect increases with soil depth, where the number of microorganisms in bulk soil decreases sharply, while in the rhizosphere it remains at a high level. At the same time, some authors argue that the observed rhizosphere effect is nothing more than a laboratory artifact, associated with the use of micro-samples for analysis (Poljakova, 2002).

The rhizosphere effect on bacteria and filamentous fungi in the soil has been well studied. In contrast, yeasts of the rhizosphere and rhizoplane have been studied very little. There are few studies specifically focused on examining the species composition of yeasts on the roots of certain plants (Babjeva, 1963; Kasimova et al., 1975; Kvasnikov et al., 1975; Mestre et al., 2011). However, these studies are based on limited material, from which no definitive conclusions can be drawn about the characteristic features of yeast communities in the rhizosphere.

SEASONAL DYNAMICS OF YEAST ABUNDANCE IN THE RHIZOSPHERE AND RHIZOPLANE OF PLANTS

A more detailed study of the community of rhizospheric yeasts and the specifics of their seasonal dynamics was conducted by Golubova et al. (2007). Two plant species were selected as objects: dandelion (*Taraxacum officinale* L.) and ground ivy (*Ajuga reptans* L.). These plants have different types of root systems: dandelion – taproot, and ground ivy – fibrous. The authors found that, for yeasts as a whole, a significant increase in abundance on the root surface (rhizosphere effect), which has been repeatedly observed in studies of rhizospheric bacteria, is not characteristic.

However, this effect is manifested when it comes to certain yeast species. The average yeast abundance on the roots is significantly lower than on the aboveground parts of the plants, where it can reach 10^7 CFU/g, or 10^4 CFU/gram, on average annually.

Throughout the year, yeast abundance on all substrates changes significantly (Figure 1).

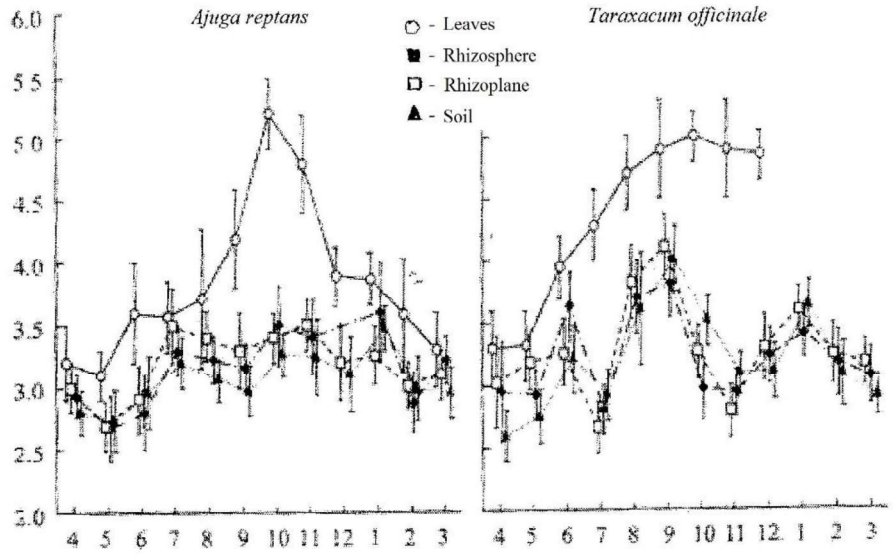

Figure 1. Annual dynamics of yeast abundance on the leaves and in the rhizosphere of two plant species (months on the abscissa and the number of yeast cells per gram on the ordinate)

In the aboveground parts of the plants, these changes are regular: on young leaves, the average yeast abundance does not exceed 10^3 CFU/gram, then it gradually increases during the summer and autumn, reaching 10^5 CFU/gram in october-november. Dandelion leaves die off with the onset of frost, while on the leaves of ground ivy, which remain green even under the snow cover, the abundance regularly decreases during the winter. As already established, such dynamic yeast abundance is characteristic of most summer and evergreen mesophytic plants (Glušakova and Černov, 2007). The variations in yeast abundance on the roots and rhizospheric soil are less significant. Throughout the year, fluctuations in abundance are observed in all three fractions: rhizoplane, rhizosphere, and non-rhizospheric soil. For the examined plants, the increase and decrease in abundance occur at different times. It is likely that these variations are related to the quantity and composition of root exudates, which change significantly during the ontogeny of the plants (Bais et al., 2006).

DYNAMICS OF THE ABUNDANCE OF PHYTO- AND PEDOBIONT YEASTS IN THE RHIZO- AND PHYLLOSPHERE OF PLANTS

The groups (fractions) of yeasts on the aboveground and underground parts of plants fundamentally differ in the composition of dominant species, while at the same time, the differences between plant species are less significant. On the leaves of the examined plants, *Rhodothorula mucilaginosa* and *Cryptococcus magnus* dominate – typical epiphytic yeasts of the temperate zone. On the root surfaces and in the rhizosphere, anamorphic basidiomycetous pedobiontic yeasts are most commonly found, which are typical for forest soil and litter: *Cryptococcus terricola, Cryptococcus podzolicus*, teleomorphic yeast-like fungi *Cystofilobasidium capitatum*, and ascomycetous *Candida oleophila*. Thus, on the surface of the underground parts of plants, as well as in the non-rhizospheric soil, pedobiontic and litter species of yeasts dominate, rather than phytobiontic, as on the aboveground parts. *C. terricola* and *C. podzolicus*, which dominate in the rhizosphere, are practically absent from the leaves. It is evident that the life of these species is confined to the soil due to their inability to withstand the limiting conditions to which epiphytic yeasts are well adapted, primarily periodic desiccation and high solar radiation. At the same time, epiphytic yeasts are constantly isolated from the soil and root surfaces. The average relevant abundance in the phyllosphere of dominant typical (epiphytic) species, such as *Rhodothorula glutionis*, *R. mucilaginosus, Sporobolomyces rasens*, is significantly higher on the root surfaces than in the soil. Seasonal changes in the abundance of epiphytes in the rhizoplane are also observed (Figure 2).

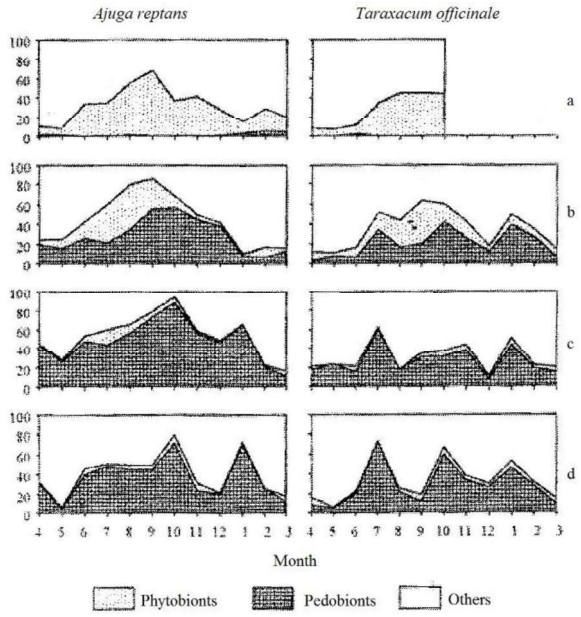

Figure 2. Dynamics of relative abundance (%) of phytobiontic (*Cryptococcus magnus*, *Rhodothorula mucilaginosa, Rhodothorula glutionis, Sporobolomyces rasens*) and pedobiontic (*Cryptococcus terricola, Cryptococcus podzolicus*) yeast species on the leaves and in the rhizosphere of the examined plants: a – leaves, b – rhizoplane, c – rhizosphere, d – soil

The total proportion of epiphytic yeasts in the soil and rhizosphere fractions practically does not change throughout the year. However, in the rhizoplane, a significant increase in

their relative abundance is observed during the summer and autumn, i.e., in the period of maximum yeast abundance in the phyllosphere. During this period, their participation on the root surface increases to 30-40 %. Thus, typical epiphytic yeasts develop across the entire surface of the plant during the active growing season, including the rhizoplane, while their significance on the underground parts is much lower compared to pedobiontic forms. During the summer and autumn periods, the overall diversity of yeasts in the rhizoplane also increases, including ascomycetes and eurybiontic basidiomycete species.

CLUSTER ANALYSIS OF SUBSTRATE SIMILARITY BASED ON YEAST SPECIES COMPOSITION

The results of the cluster analysis based on the average annual relative abundance of yeast species showed that the analyzed substrates are divided into two clusters based on the species composition of their yeast community (Figure 3).

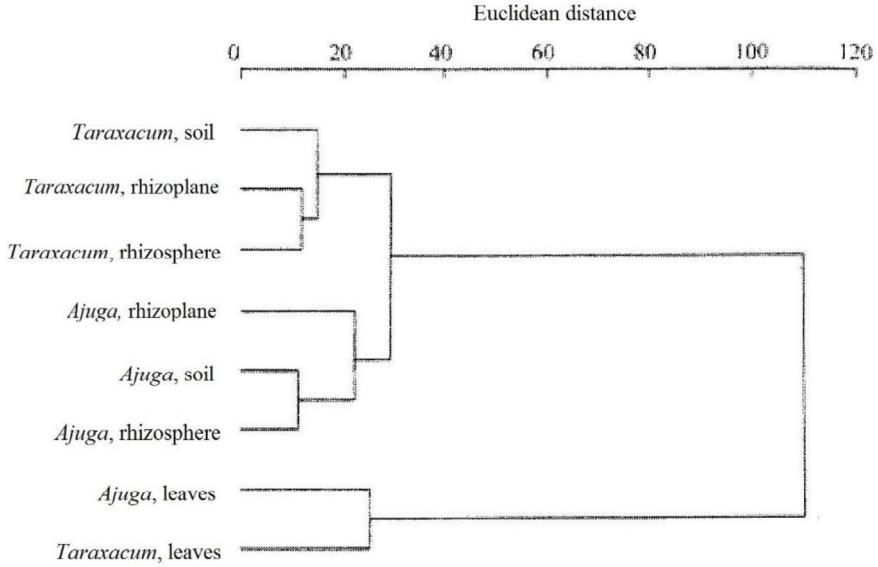

Figure 3. Dendrogram of similarity of the examined substrates based on the species composition of the yeast community (the average relative abundance of species and the unweighted average method were used as properties)

The first refers to the aboveground parts, while the second refers to the underground parts of plants and soil. Furthermore, underground substrates are classified based on their association with a particular plant species, and the rhizoplane, rhizosphere, and non-rhizospheric soil exhibit greater similarity in terms of the species structure of their yeast community for each plant species compared to the corresponding substrates for different plant species. As previously mentioned, epiphytic yeast communities on the leaves of different plant species growing under the same conditions are very similar, and on different plants, regardless of their taxonomic affiliation and ecological specificity, the same species of epiphytic yeasts generally dominate. It is not excluded that the underground parts of plants are more individual in terms of the species structure of epiphytes than the phyllosphere. This can be interpreted as the specificity of root exudates for each plant

species, as well as the more difficult colonization of the underground parts of different plants by yeast cells.

The surface of the aboveground and underground parts of plants significantly differs in the composition of dominant epiphytic yeast species. In the phyllosphere, eurybiontic and phytobiontic yeasts, such as phyllobasidic cryptococci and red-pigmented species, dominate, while in the rhizosphere, typical pedobiontic species include *Cryptococcus terricola* and *C. podzolicus*. The composition of subdominant and minor species can be quite specific to different plant species. Seasonal changes in yeast abundance and species composition in the rhizosphere are much more synchronized compared to the phyllosphere and are mostly manifested by an increased proportion of phytobiontic species on the root surface at the end of the growing season.

CONCLUSION

Based on the presented data, it can be concluded that the surface of the underground and aboveground parts of plants significantly differs in the composition of dominant epiphytic yeast species. In the phyllosphere, eurybiontic and phytobiontic yeasts, such as phyllobasidic cryptococci and red-pigmented species, dominate, while in the rhizosphere, typical pedobiontic species include *Cryptococcus terricola* and *C. podzolicus*. The composition of subdominant and minor species can be quite specific to different plant species. The average yeast abundance on the roots is significantly lower than on the aboveground parts of the plants, where it can reach 10^7 CFU/gram, or 10^4 CFU/gram, on average annually. Seasonal changes in yeast abundance and species composition in the rhizosphere are much more synchronized compared to the phyllosphere and are mostly manifested by an increased proportion of phytobiontic species on the root surface at the end of the growing season.

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REFERENCES

Babjeva, J.P (1963). Drožževaja flora počv nekotoryh rajonov Pamira. *Naučnye doklady vysshej školy. Biologičeskie nauki*, *2*, 194–198.

Bais, H.P., Weir, T.L., Perry, L.G., Gilroy, S., & Vivanco, J.M. (2006). The role of root exudates in rhizosphere interactions with plants and other organisms. *Annual Review of Plant Biology*, *57*, 233–266.

Golubova, Ju. V., Glušakova, A.M., & Černov, I.Ju. (2007). Sezonnaja dinamika drožževyh soobščestv rizosfery. *Počvovedenie*, *40*(8), 875–879.

Glušakova, A. M., & Černov, I. Ju. (2007). Sezonnaja dinamika čislennosti epifitnyh drožžej. *Mikrobiologija*, *76*(5), 668–674.

Kasimova, G.S., Abdulova, Z.A., & Babjeva, L.P. (1975). Vidovoj sostav drožžej, vyyavlennyh iz rizosfery plodovykh, tekhnicheskikh i zernovykh kul'tur *Azerbaydzhana i ikh osobennosti. Učenyje zapiski Azerbaydzhanskogo gosudarstvennogo universiteta, seriya biologicheskikh nauk*, 3-4, 25–29.

Kvasnikov, E.I., Nagornaja, S.S., & Sielokova, I.F. (1975). Drožževaja flora rizosferi i filosferi rastenij. *Mikrobiologija*, *44*(2), 339–346.

Mestre, M.C., Rosa, C.A., Safar, S.V., Libkind, D., & Fontenla, S.B. (2011). Yeast communities associated with the bulk-soil, rhizosphere, and ectomycorrhizosphere of a Nothofagus pumilio forest in northwestern Patagonia, Argentina. *FEMS Microbiology Ecology*, *78*(3), 531–541.

Poljakova, A.V. (2002). *Drožži v torfjano-bolotnyh počvah* [Yeasts in peat-bog soils] (PhD dissertation). Moscow: Moscow State University, 118 pp.