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Original Article

The Potential of Using Mycorrhizal Fungi to Forecast Disturbances in Ecosystems Caused by Management Changes

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Abstract

Mature ecosystem balance is due to ability of fungi to create hyphal networks between roots of higher plant. The role of mycorrhizas as mediators in the nutrients circuit made them, in the course of evolution, more susceptible to changes in applied management of ecosystems. The ability to respond very quickly to disturbances, makes these symbiotic microorganisms to be a good indicator in shaping the ecological depreciations. The amplitude of mycorrhizal response to fertilization and treatment recipes, overlapped on climatic conditions, confers an increased stability to forecasting models. At high values frequency of colonization in the root system is a parameter with increased functionality in forecasting, whereas the intensity of the colonization provide stable patterns at low values. A complex model can be developed only on the basis of both parameters.

Keywords: mycorrhiza, disturbances, forecast, ecosystem, management changes.

1. Introduction

Grassland ecosystems are defined by a simultaneous evolution of plants and microorganisms in the rhizosphere, transformations determined under the effect of traditional management imposing a state of balance and nutrient resource use efficiency.

In the herbaceous plant rhizosphere role of maintaining balance, through proper allocation of resources from nutrient inputs, lies to mycorrhizal fungi which are able to create hyphal networks for interradicular transfer.

Higher plants are capable of association with mycorrhizal fungi, quality developed over evolution and that explains the dominance of certain species in the grass canopy [3, 4].

The mycelium developed by mycorrhizae has the ability to expand both in the roots plants, and outside them, increasing absorption capacity of the root and the nutrition surface of the plant [2].

The large surface of soil explored by mycorrhizal fungi networks and small diameter of hyphae, enhance the susceptibility of these microorganism to changes in management, especially the fertilization recipes [1, 6].

Uncontrolled growth of the level of nutrient in the ecosystem can cause destabilization of mycoflora, causing an increase in the transfer of nutrients to the dominant plants, and elimination of the species with lower degree of coverage.

Rapid response of mycorrhizal symbionts to disturbances may constitute an important element in preventing depreciation phenomena of grassland ecosystems, and may be a method of forecasting for biodiversity conservation actions [7, 5].

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2. Material and Method

Assessment the disturbance potential of management on mycorrhizal fungi was performed during the years 2010 and 2011 (A), in an experiment located on a meadow in Gârda de Sus village, Alba County, Romania [5]. The experimental design included six degrees of fertilization (F), in addition to the unfertilized control in the field were applied two recipes based of fertilization manure (V2 - 10 t/ha şi V3 – 10 t/ha + 50 kg N_2), respectively 3 recipes of chemical fertilizer (V4 – NPK 50:25:25 /ha, V5 – 120 kg/ha Eurofertil mezocalc + 50 kg N_2 and V6 – 120kg/ha Eurofertil mezocalc).

Over fertilization was overlapped a fungicide treatment Botran 75 WP – 0.07% (T) and area management was done by mowing once per year

The data presented in this paper evaluates the mycorrhizal colonization parameters (frequency - freq% and intensity - int%) at the end of the growing season in the roots of Festuca rubra plants, the dominant species in the cover.

The effect of experimental factors on mycorrhizal fungi progress in root systems was performed both individually and combined, statistical tests used for for analysis being specific to Statistica software [4].

3. Results and discussions

Analysis of the effect of experimental and ecological factors over the intraradicular colonization progress of mycorrhizas indicates a significant potential of perturbation of each factor taken individually (table 1). Although the influence was classified as very significant, climatic conditions and fertilization act more quickly on fungal development, fungicide treatment insertion in site management serving to temporarily block colonization and to provide a balanced nutrition space for all plants (table 1).

Under the effect of climate, the treatment has a much smaller influence, disturbing potential on colonization being reduced at the end of the growing season, combination of factors considered statistically not significant (table 1.).

At the opposite pole is situated fertilization, which in the ecological conditions from the area of experimentation had a much stronger effect, climate of 2010 and 2011 enhancing very significantly the action of this factor.

This phenomenon is based on a positive correlation between the colonization parameters and the level of fertilization (table 1).

Overall, colonization is very strongly influenced by the combined effect of the three factors, which support the hypothesis of the use of mycorrhizas reaction to management elements as an indicator in forecasting disturbances (table 1).

Climate of the two years of experimentation has acted negatively on colonization parameters, a significant correlation was observed for the frequency with which the roots were colonized (table 1). Fungicide treatment had a positive effect on the rate of colonization of the root system, influencing, however, in a slightly negative way the intensity of root penetration.

Table 1. Individual and combined effect of experimental factors on colonization

Factors	Value	F	Effect - df	Error - df	p
A	0.182	105.35	2	47	p < 0.001
F	0.004	146.05	10	94	p < 0.001
T	0.514	22.2	2	47	p < 0.001
A*F	0.442	4.73	10	94	p < 0.001
A*T	0.970	0.72	2	47	0.492
F*T	0.0156	65.93	10	94	p < 0.001
A*F*T	0.5762	2.98	10	94	0.003
	p < 0.05 * °	p < 0.01 ** °°	p < 0.001	*** °°°	

Corelation		
	Freq	Int
A	-0.150	-0.371
F	0.025	0.208
T	-0.003	0.175

Frequency values vary greatly under the influence of experimental factors, being noticeable the strong increase of this parameter in terms of fertilizing with Eurofertil mezocalc (V5) supplemented with N_2 and in the absence of treatment with a fungicide (fig. 1).

Integrating in the management of fungicide treatment gives good results in conditions of both experimental years in the absence of fertilization (V1) or if overlaped on manure fertilization (V3) is supplemented with N_2.

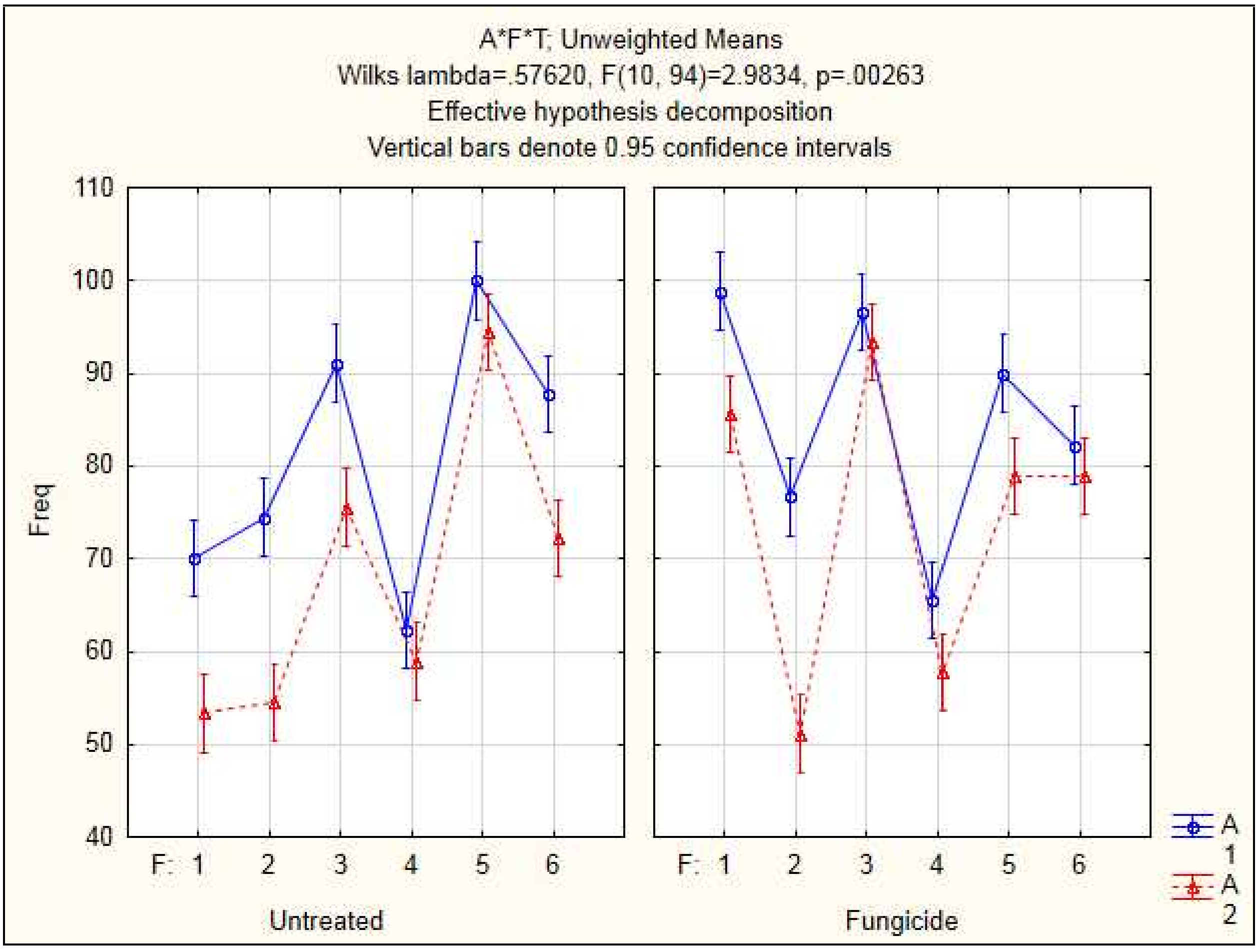

Figure 1. Fluctuation of colonization frequency

Low frequency variation in the two years of experimentation observed at the variant fertilized with NPK (V4) and variant fertilized with Eurofertil mezocalc (V5) supplemented with N2, indicate these recipes as the most stable fertilization variants in the absence of fungicide treatment (fig. 1). The application of a fungicide treatment stabilizes the frequency of colonization just in case of fertilization with manure (V3) supplemented with N_2, fertilization with NPK (V4) and fertilization with Eurofertil mezocalc, parameter variation in the two years of experimentation has been preserved low.

On the intensity of colonization, experimental factors act very strongly on the level observed in the root system of plants of Festuca rubra (fig. 2). The highest values were observed in the untreated variant and fertilized with Eurofertil mezocalc (V5) supplemented with N_2, respectively in the control variant (V1) treated with the fungicide.

From the perspective of the variation between the two years within each experimental variants, all management types and were found stable, without causing strong variations, which indicates the potential for forecasting of colonization intensity to be much higher than the frequency at which the the roots are colonized (fig. 1, fig. 2).

Analyzing the behavior of mycorrhizal fungi to the different types of management, highlights a potential parameter for perturbations forecast with an equal distribution in the case of colonization frequency (fig. 3) and unequal and for colonization intensity (fig. 4).

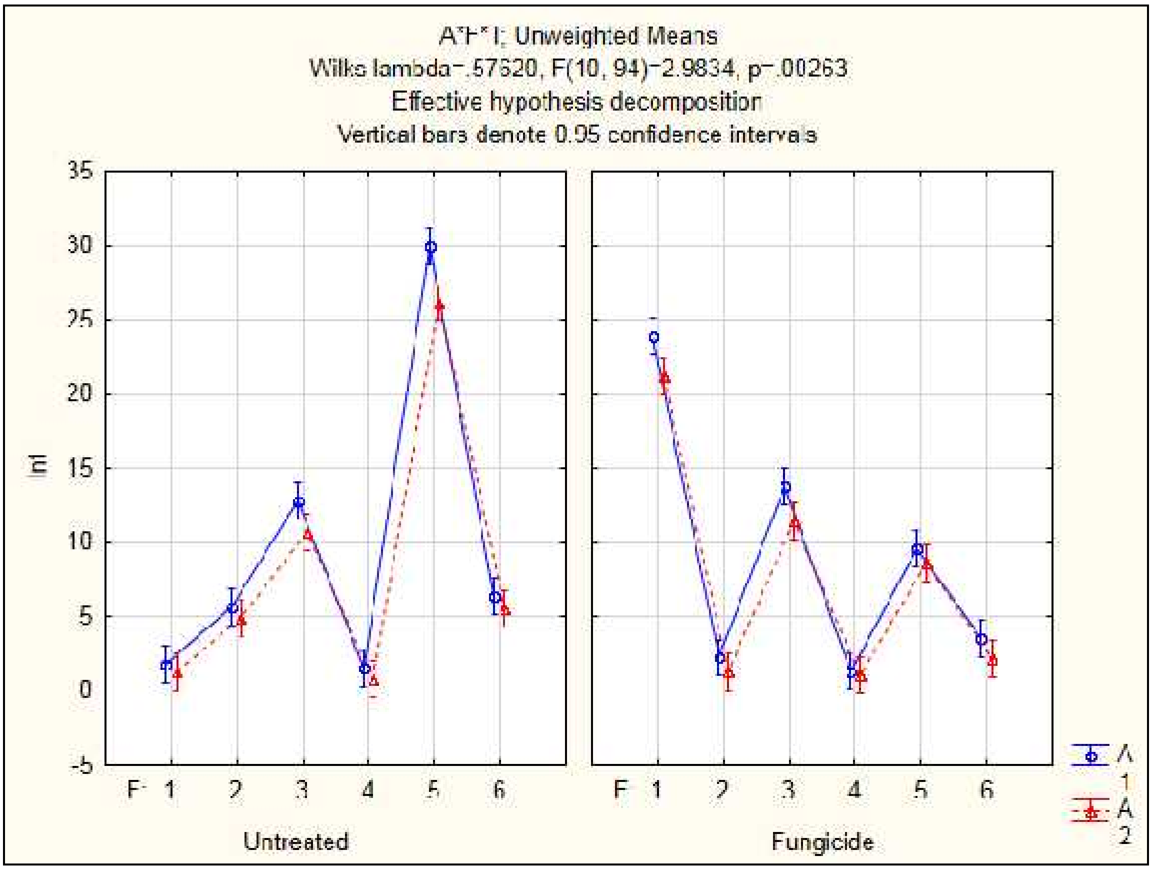

Figure 2. Fluctuation of colonization intensity

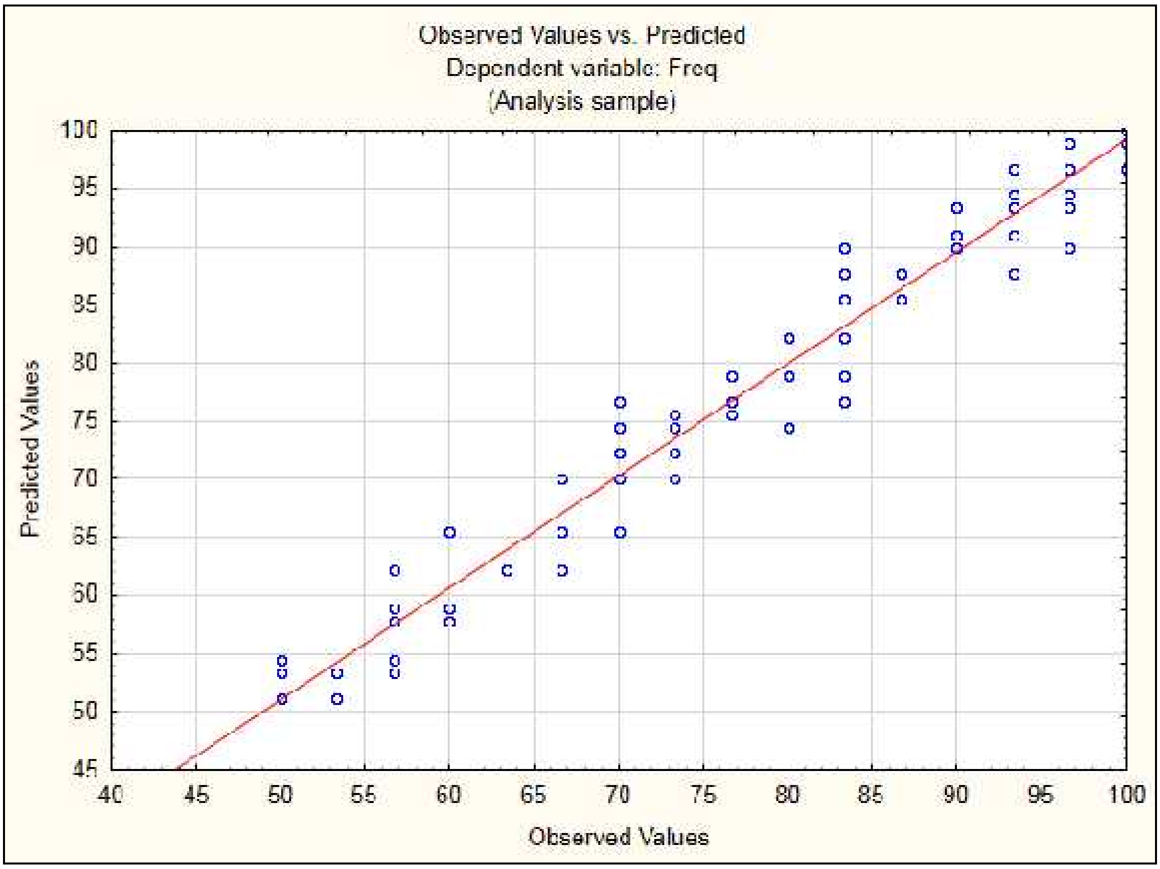

Figure 3. Distribution of the frequency values towards normal

The comparison between observed and predicted values show a relatively linear increase of frequency, distance of values to normal being uniformly distributed (fig. 3). This indicate a stability of forecasting models based on the frequency of colonization, at values over 50%, model gaining stability with increasing the number of samples analyzed. For grassland systems, whose characteristic is the development of complex root systems shallow depth, frequency of colonization can be used in extrapolating interradicular connections created through hyphal networks.

Regarding the intensity of colonization, distance toward normal of the observed values and those predicted indicates a strong stability of forecasting models at low values of colonization, 5% predict being equal to observed values (fig. 4). At intensity values in the range of 5-15%, the forecast model works reasonably well and the predicted values are close to the normal values, which permit to reduce the error by increasing the number of samples taken into consideration. At values above 20%, the prediction of the intensity values has a low efficiency predisposed for errors.

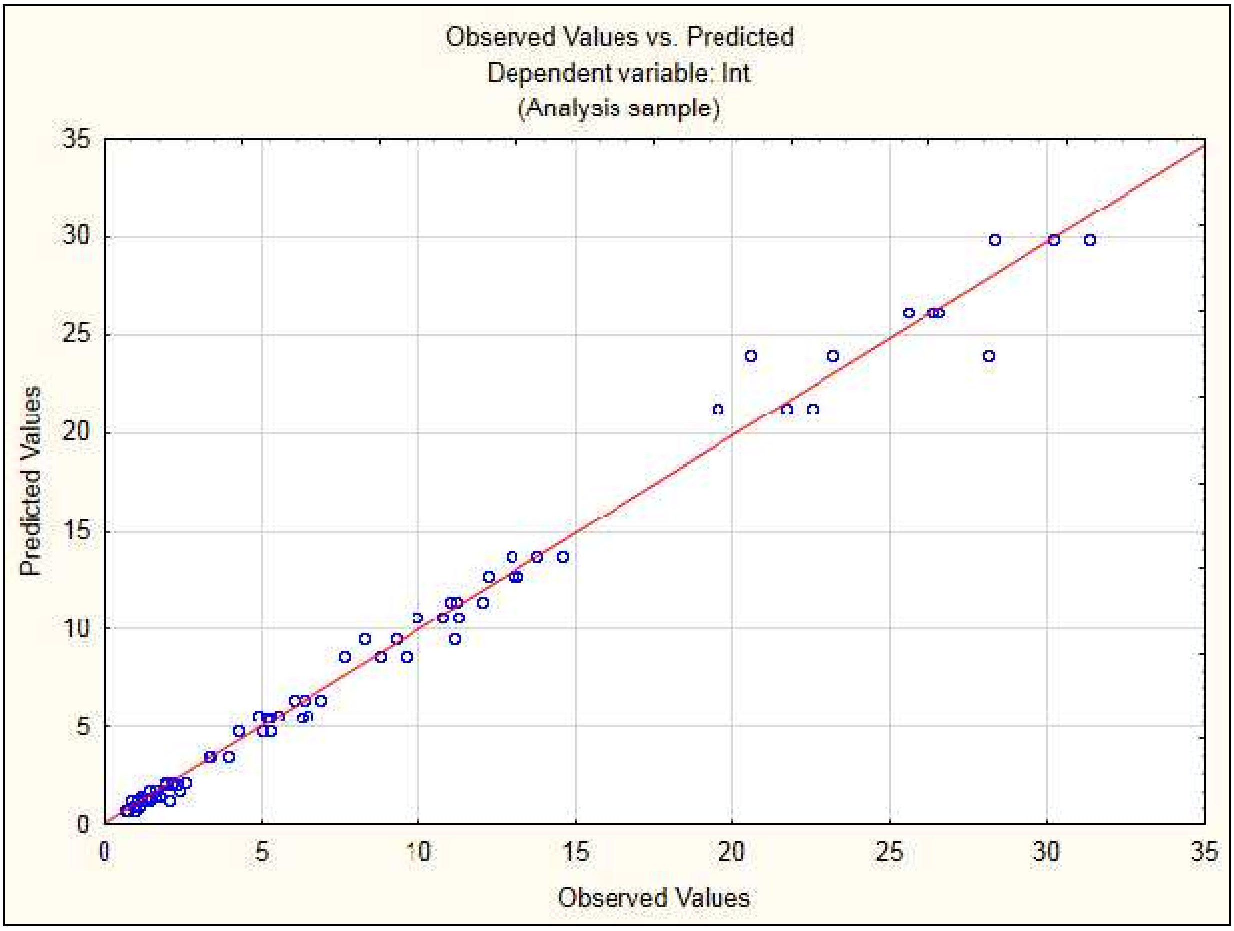

Figure 4. Distribution of the intensity values towards normal

Using colonization parameters to identify and evaluate perturbations due to changes in management, is effective at the level of whole populations if is used colonization frequency and at the individual level is more effective colonization intensity. To evaluate an entire ecosystem, it is preferable to integrate both parameters in forecasting models.

4. Conclusions

Fertilization recipe acts strongly on the frequency of mycorrhizal colonization, causing a significant variation of this parameter in the root system of Festuca rubra, the effect being enhanced by climatic conditions. Colonization intensity has a low variation in different climatic conditions, fertilization and treatment acting to stabilize parameter in time. Models based on the reaction of symbiotic fungi require both climatic and technological factors, their combination having a limiting potential on the intraradicular progress. Mycorrhizal fungi have a high potential to be used in forecasting potential disruptions that may arise from changes in ecosystem management. For forecast changes across an entire ecosystem is necessary to create complex models that use both the frequency and intensity of colonization.

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