Dynamic Decomposition of a Variety of Fungi

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Abstract: The carbon cycle describes the process of carbon exchange in the entire geochemical cycle and is an important part of life on Earth. Part of the carbon cycle includes the decomposition of compounds so that carbon can be updated and used in other forms. Based on the growth dynamics equation, this paper takes into account the growth rate of fungi and the humidity resistance of fungi, establishes a multi-regression model and a Lanchester model, analyzes the decomposition of various fungi on wood fibers, and expounds the role of fungi in the ecosystem.

1 INTRODUCTION

1.1 Problem Background

Ground litter, also known as organic debris, refers toall organic matter produced by biological components in an ecosystem and eventually returned to the surface of the land (LI 2016). It is the main carrier of energy flow and material circulation above and below ground (Wardle 2004). The carbon cycle refers to a process in which carbon elements are exchanged in four circles throughout the earth, as shown in Figure 1:

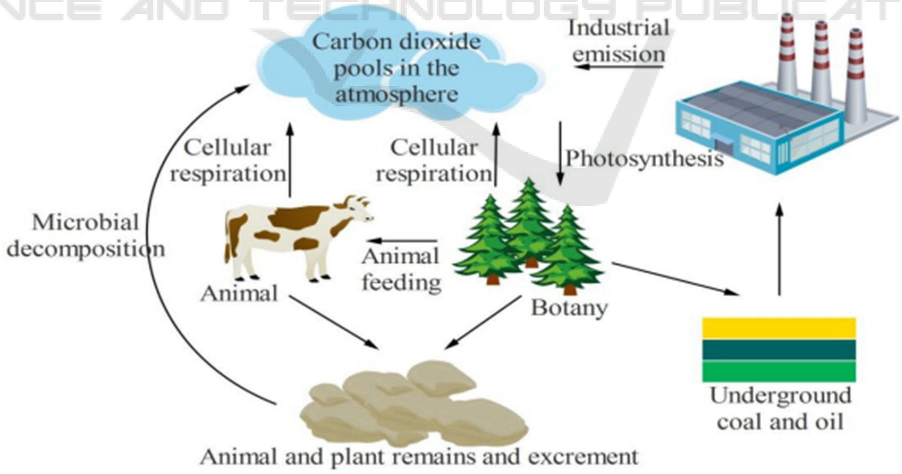

Figure 1: Carbon cycle.

As the decomposers of organic matter in the ecosystem, fungi play an essential and critical role in the decomposition of ground litter.

2 MATERIALS AND METHOD

The growth and decomposition of microorganisms such as fungi are also affected by temperature,

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inoculation amount, electric field intensity and other conditions (Kong 2001).

2.1 The Classification of Fungi

When studying the growth process on the interface of fungi, logical models are often used to describe the growth dynamic equation of fungi (Jin 1989).

$$\frac{dX}{dt} = \beta_X X \left[1 - \left(\frac{X}{X_m} \right)^n \right] \quad (1)$$

Where t is time, X is the biomass per unit area, and Xm is the maximum biomass per unit area is the growth rate constant.

2.1.1 Factors That Affect the Rate of Fungal Decomposition

In order to rapidly degrade ground litter with fungi that have different hyphae elongation and moisture tolerance, it is necessary to ensure that temperature, humidity, pH and other conditions are maintained under appropriate conditions (Xue 1999).

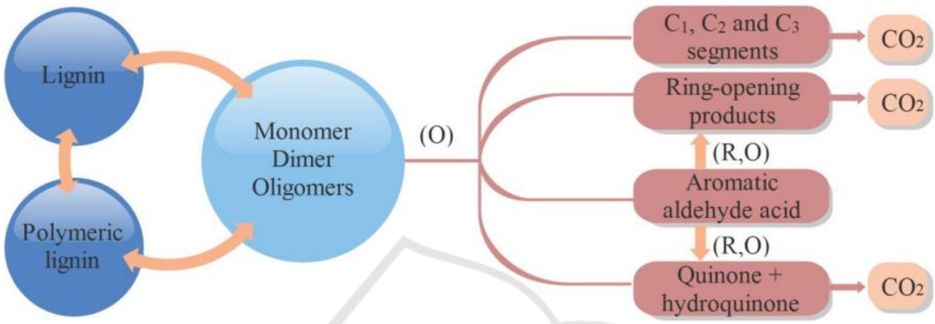

Figure 2: Lignin degradation diagram.

2.1.2 Establish Multivariate Nonlinear Regression Model

Based on the fungal decomposition rate and humidity, temperature and acidity as arguments, a nonlinear regression model is established:

$$\begin{cases} z = f\left(b_0, b_1, \ldots, b_m; y_1, y_2, y_3\right) \\ \varepsilon_i \sim N\left(0, \sigma^2\right) \end{cases} \quad (2)$$

Where, ε is the random error term. In order to minimize the square sum of the error between the sample data of fungi decomposition rate and the estimated fungi decomposition rate, the least square method was used in parameter calculation in this paper to minimize the error. That is:

$$\min R\left(b_0, b_1, \ldots, b_m\right) = \sqrt{\sum_{i=1}^{n} \left(z_i - \widehat{z_i}\right)^2} \quad (3)$$

Where, $\widehat{z_i} = f\left(b_0, b_1, \ldots, b_m; y_{1i}, y_{2i}, y_{3i}\right)$ is an estimate of the rate of fungal decomposition.

Through data observation, it can be found that the fungi decomposition rate has a non-linear relationship with each index. Therefore, this paper uses SPSS software to curve-fit each index and the fungi decomposition rate, and uses quadratic, logarithmic, and exponential functions for analysis. Take the fitting figure 3 of the decomposition rate of Armillaria as an example:

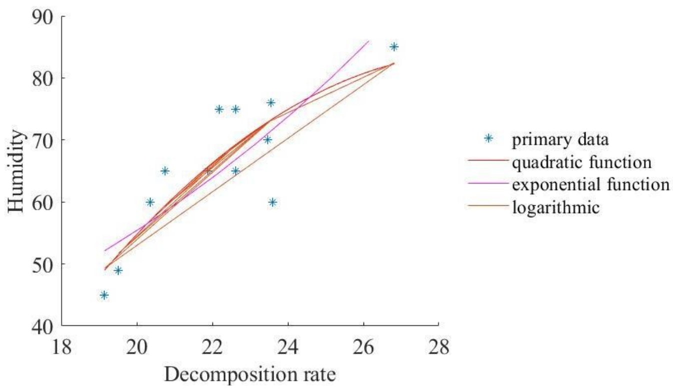

Figure 3: Relationship fitting grap.

Therefore, the multivariate nonlinear regression model of decomposition rate of Armillaria mellea and environmental influencing factors can be obtained by solving SPSS as follows:

$$y = 16.992 + 0.107x_1 - 0.593x_2 + 1.16x_3 + 0.003x_1^2 + 0.016x_2^2 - 0.105x_3^2$$

According to the above method analysis, it can be found that different species and even different fungi are affected by temperature, humidity, pH and other environmental factors. Relatively speaking, the higher the temperature, the faster the fungus breaks down wood.

2.2 The Interaction of Fungi

The rate at which withpositor and wood fibers break down depends not only on the type, characteristics and environment of the fungus, but also on the competition of the fungus's growth process (Tadashi 2010).

2.2.1 Internal Competition for Fungi

According to the symmetrical fork model, the total NA node for each active bud tube growing on the interface is and the total number of growth segments is determined by the number of active segments. According to biological research, the proportion of active organisms in total biomass is 33%. Available based on growth dynamics equations:

$$\frac{dX_T}{dt} = \beta_X X_A = \beta_X \frac{X_T}{3} \quad (4)$$

For X_T , according to the definition of growth rate and combined with the above equation, take the pair to get (Lu 2016):

$$\ln X_T = \ln X_0 + \frac{\beta_X}{3} t \quad (5)$$

Based on the growth model of microorganisms in the growth of several years, the growth state of the fungus can be obtained during this period, so that the performance of the fungus in the competitive process can be studied.

When fungi are full on the interface, myceliums collide with each other during growth, leading to competition of substances and rendering some mycelium inactive. The proportion of inventory will decrease in a pair after the competition of mycelium: $F_v = 0.33Le^{-k(t-t_\alpha)}$. When $t = t_\alpha$, $X_T = X_E$ stop growing, combined with the growth process of fungi, can get the fungus internal competitive model:

$$\ln \frac{X_T}{X_E} = \frac{\beta_X L}{3k}\left[1 - e^{-k(t-t_0)}\right] \quad (6)$$

According to the establishment of the internal competitive model of fungi, we can understand the growth and development of fungi. when environmental factors such as temperature and humidity are in the optimal growth environment of fungi.

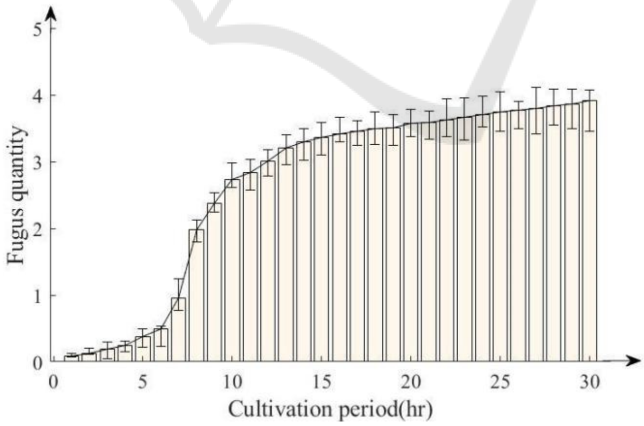

Figure 4: Growth curve fitting of Armillaria.

We can see that in the process of separate growth of Armillaria, the interaction of the fungi is in an internal competition relationship. But competition among fungi isn't just internal competition due to growth interface constraints.

2.2.2 External Competition of Fungi

The Lanchester equation is mainly used to predict the fighting situation of the two sides, this article compares the competition of multiple fungi to multi-army combat to obtain related models:

$$\begin{cases} \frac{dx}{dt} = -cy - \alpha x + u(t) \\ \frac{dy}{dt} = -dx - \delta y + v(t) \end{cases} \quad (7)$$

Among them, and represent the attack power of both sides of the competition, α and δ represent the non-competitive damage factor of both sides of the competition, $u(t)$ and $v(t)$ represent the number of fungi regenerated by fungi.

The development of each fungus is in an internalcompetition link because the interface has not been overgrown in the early stage.

3 RESULTS & DISCUSSION

3.1 Fungi Are Affected by the Environment

The fluctuation of the environment means that the temperature and humidity that were originally suitable for fungi growth will also change accordingly, causing the growth and competition of fungi to be affected to a certainextent, so this article mainly considers the influence of environmental fluctuations on the external competition of fungi.

$$\frac{dF}{t} = \frac{F_{k+1} - F_k}{T} \quad (8)$$

Obtain the effect of the introduction of environmental factors on the state equation: $F_{k+1} = A^* \cdot F_k + C$. By adding the state equation to the analysis of the fungus's external competition, the following new Lanchester equation can be obtained:

$$F' = E_{cA} AF + C \quad (9)$$

The growth and development of Armillaria gallica, Armillaria tabescens and other fungi in arid environments are much lower than the development of tropical rain forest environments.

3.2 The Importance of the Diversity of Fungal Communities

The rate at which fungi break down can be compared to the amount of wood the fungus eats, creating anOlsen model to break down fallen objects:

$$RP = \frac{P_t}{P_0} \times 100\% = e^{-zt} \times 100\% \quad (10)$$

Among them, z is the decomposition rate of garbage, P_t is the quality of falling material at the moment, and P_0 is the initial mass of falling material. Among them, RP is the residual rate of withering material.

A diagram of the amount of withering material left over from the individual and co-action of chicken honey ring bacteria, sequined honeycella and other bacterial species was solved:

Table 1: Mass residual rate after decomposition.

	Single strain	Two strains	Three strains	Four strains
0	1	1	1	1
1	0.95	0.94	0.94	0.93
2	0.89	0.87	0.83	0.85
3	0.83	0.81	0.79	0.69
4	0.77	0.74	0.73	0.53
5	0.71	0.67	0.68	0.47
6	0.65	0.61	0.55	0.32
7	0.59	0.54	0.47	0.27
8	0.53	0.47	0.39	0.19
9	0.47	0.41	0.23	0.13
10	0.41	0.34	0.13	0.08

Based on the above figure, it can be seen that when Armillaria gallica, Armillaria tabescens and other fungi act alone, the decomposition rate of ground drop and wood fiber is slower than that of the fungus group and the four fungi community. The quality of the litter More residual rate. For this reason, the diversity of fungi communities is beneficial to the decomposition of ground litter and wood fiber by fungi.

4 CONCLUSIONS

As a decomposer in the ecosystem, fungi are also a key component of the entire planet's carbon cycle. There are many types and different shapes, and the environments in which different fungi live are also diverse. The growth mode of fungi is similar to that of plants, and the way of nutrient intake is similar to that of animals. It takes in the nutrients necessary for life by decomposing organic matter into simple substances that plants can absorb and use.

In fact, not only do fungi maintain plant biodiversity in the soil, but plant diversity also acts on fungi diversity. Studies have shown that fungi diversity and plant diversity have a significant positive correlation, and fungi diversity increases, the fungi community can cooperate with each other to help plants obtain more resources and nutrients, and reduce nutrient competition(Wang 2020).

All in all, rich and diverse fungi are an indispensable part of the earth. Fungi promote the development of biodiversity in the ecosystem. Biodiversity is also conducive to the development of fungi diversity. The two develop in a balanced manner to form a mutually beneficial and win-win situation.

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