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Study on the model of fungi degradation

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Abstract: As the crucial participant in the organic matter cycle of evolution, the characteristics of the fungi are always at the top of the researchers' attention. Many biologists have fully studied their growing habits, including the sensitivity of external environmental factors and the use of nutrients, etc. There are, at the same time, a few variations between different fungi. We study the classification about the most acceptable types of fungi, the features of various fungi and the simple method of their decomposition from a number of articles and publications. Then, on behalf of all the species, we select ten fungi, using data analysis and fitting, we have originally developed the model of fungi growth rate and decomposition rate. On the basis of this, we add the influence of external conditions on the growth rate of fungi, and finally we get a model of the rate of fungal decomposition and external variables.

1. Introduction

Carbon cycle is an important component of life, in which compounds are decomposed and converted into carbon dioxide, and then enter the atmosphere. This key process is the decomposition of plant materials and wood fibers. Fungi are the main factor of decomposing lignocellulose. A recent study showed that the growth of fungi is closely related to temperature and humidity.

Under the assumption that there are many fungi degrading lignocellulose in a fixed land and in the same area, the following problems need to be solved in this paper. Establish mathematical model and describe the degradation of lignocellulose and litter by fungi. Under the condition that various fungi have different growth rates and moisture resistance, establish mathematical model analyses the interaction of various fungi.

2. Fungal degradation model

Virtually, fungal degradation is an interactive process between enzymes and litter. Take lignin as an example, the laccase and lignin peroxidase secreted by lignin are particularly important for the degradation process.

Under the assumption that fungi do not affect each other, when fungi grow, the secreted enzymes increase at the same time, and when the temperature is about 20℃, the enzyme activity is the highest and most active. Therefore, enzyme solution is related to the growth rate of fungi, and fungal degradation is essentially a process in which enzymes oxidize litter on the ground, so there is also a correlation between available enzymes and degradation rate, thus establishing a fungal degradation model and seeking the relationship between fungal growth rate and degradation rate.

By consulting the data, we found the relevant data about the growth and degradation of fungi, and fitted it with MATLAB [1]. As shown in the figure, the relationship between the growth rate and degradation rate of fungi is as follows:

$$y = -0.42x^2 + 9.87x + 2.295$$

In the figure above, y represents decomposition rate, and x represents growth rate.

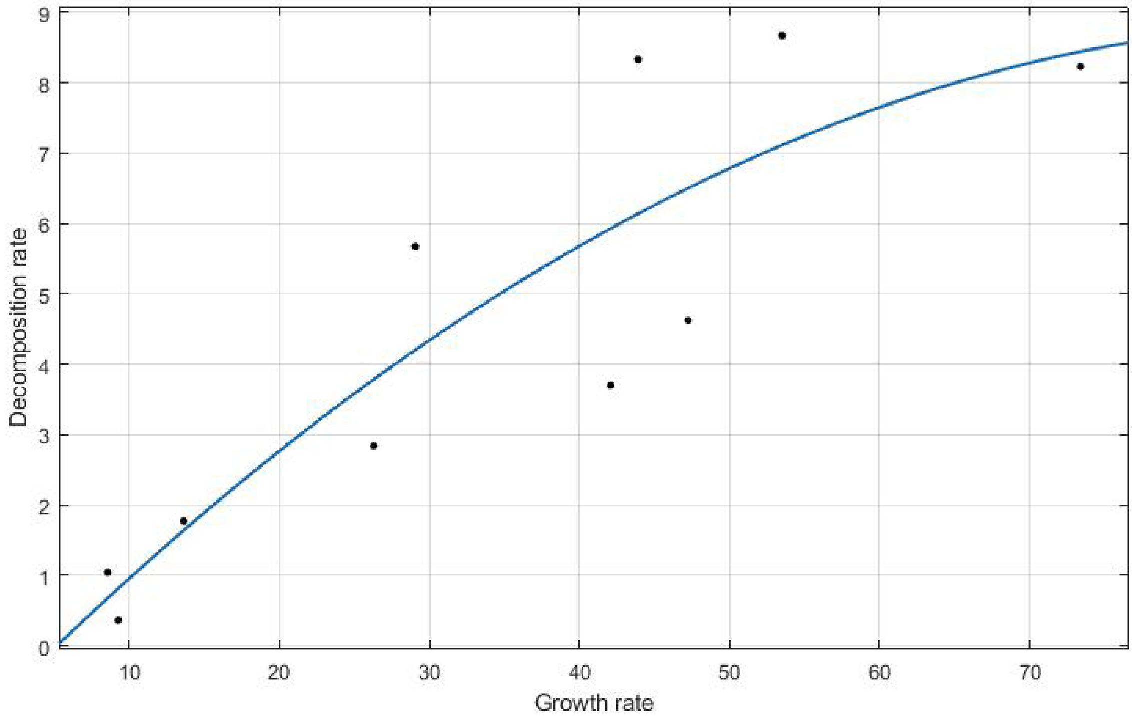


Figure 1: Decomposition rate and growth rate

2.1 Decomposition rate of single fungus

According to their different growth rate and humidity tolerance, five kinds of fungi were selected as representatives. The relationship between growth rate and temperature, growth rate and osmotic pressure was analyzed. The relationship between decomposition rate and temperature, decomposition rate and humidity was obtained. The optimization model was established, and the maximum decomposition rate under the optimal temperature and osmotic pressure was obtained.

Through reading a large number of literatures, we found about the fungal growth rate and temperature, fungal growth rate and osmotic pressure data, and then use MATLAB fitting [2] (A case study of the Xylobolus subpileatus fungi.):

$$\begin{cases} y = 22.43e^{-\left(\frac{x-19.45}{16.98}\right)} - 13.33 \\ y = 16.95e^{-\left(\frac{x+2.16}{3.192}\right)} - 13.33 \end{cases}$$

2.2 Optimal model of decomposition rate for five fungi interacting

When the five fungi interact together, the optimal fungal decomposition model is established, and the relationship between the fungal decomposition rate and temperature, fungal decomposition rate and humidity is as follows:

$$y = -0.42\left[4.8e^{-\left(\frac{x-24.97}{10.37}\right)^2}\right]^2 - 47.38e^{-\left(\frac{x-24.97}{10.37}\right)^2} + 2.3$$

$$y = -0.42\left[3.9e^{-\left(\frac{x+0.7134}{1.03}\right)^2}\right]^2 + 9.87e^{-\left(\frac{x-0.7134}{1.03}\right)^2} + 2.3$$

Under the condition that various fungi have different growth rates and moisture resistance, we need to establish mathematical model and analyses the interaction of various fungi, three fungi, $\mathrm{h.crust}$, $\mathrm{m.trem.n}$, and $\mathrm{p.gilv.n}$, were selected as examples. The fungus growth model was established based on the literature by referring to the references [3]:

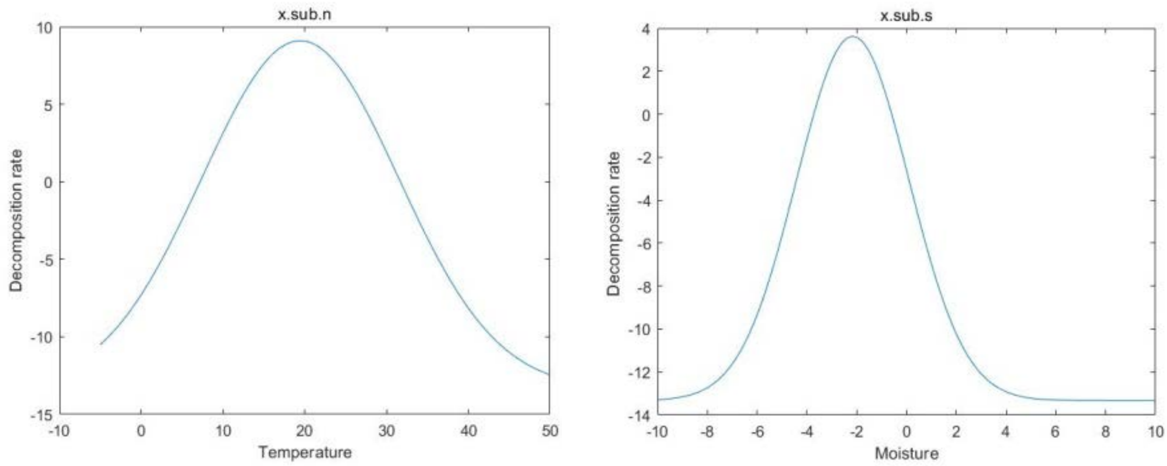
$$\begin{cases} x'(t) = D(x^0 - x) - \dfrac{g_1 x}{k_1 y_1} \cdot \dfrac{y_1}{\rho_1} - \dfrac{g_1 x}{k_1 y_1} \cdot \dfrac{y_2}{\rho_2} - \dfrac{g_1 x}{k_1 y_1} \cdot \dfrac{y_3}{\rho_3} \\ y_1'(t) = y_1\left(\dfrac{g_1 x}{k_1 y_1 + x} - O\right) \\ y_2'(t) = y_2\left(\dfrac{g_2 x}{k_2 y_2 + x} - O\right) \\ y_3'(t) = y_3\left(\dfrac{g_3 x}{k_3 y_3 + x} - O\right) \end{cases}$$

In the formula above, $x(t)$ and $y_i(t)$ represent the contents of nutrients, interacting fungi and competing fungi contained in the soil at time t, x^0 represents the initial content of nutrients in the soil, O represents the hourly output rate, g_i, k_i and ρ_i respectively represent the maximum growth rate, the semi-inclusion sum constant and the growth constant of fungi.

3. Solution Method for Model

3.1 Single fungus

The relationship between the decomposition rate of the fungi and the humidity are as follow (A case study of the Xylobolus subpileatus fungi.):



(a) Decom-temp relationship of fungus x (b) Decom-humi relationship of fungus x

Figure 2: The relationship of fungus x

3.2 Decomposition rates of five fungal interactions

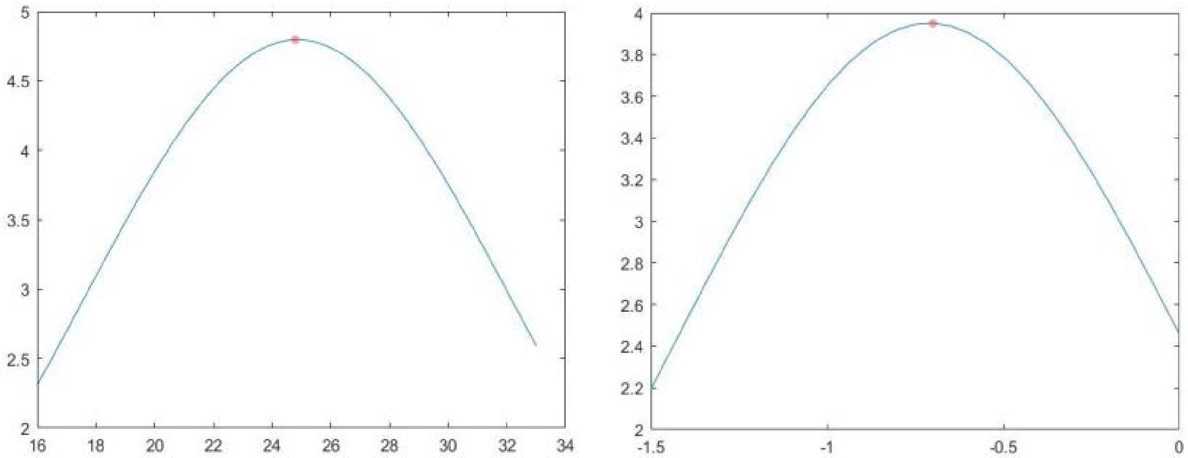
Considering the interaction between the three fungi, and based on the relationship between the decomposition rate of fungi and temperature and humidity, the maximum growth rates of fungi between 1 and 2, 1 and 3, 2 and 3 were analyzed, where fungi 1 was $h.crust$, 2 was $m.trem.n$, and 3 was $p.gilv.n$.

Table 1: Various fungi and maximum growth rate

Various fungi	Fungus 1	Fungus 2	Fungus 3
Maximum growth of fungi	0.5	0.55	0.6

Various fungi	Fungus 1 and 2	Fungus 1 and 3	Fungus 2 and 3
Maximum growth of fungi	0.48	0.53	0.58

Under the premise of interaction, the decomposition rate of fungi under different temperature and humidity content:



(a) Decomposition rate and temperature of five fungi. (b) Decomposition rate and moisture of five fungi

Figure 3: The relationship of fungus

Through graphic analysis, it can be conclude that when that five fungi are mixed, the growth rate is 4.8 when the temperature is 24.87℃, and the growth rate is 3.88 when the humidity is -0.685; Then the growth rate was related to the decomposition rate. The decomposition rate corresponding to the optimum temperature was 39.94℃, and that corresponding to the optimum humidity was 39.62%.

4. Summary

We searched a lot of research data, selected representative fungi, and established a fungal decomposition model. Based on the analysis of the interaction between fungi, we established a model of multiple fungi co-growth. By referring to official studies, the model has been improved, and our own interpretation of environmental effects has been applied, which is very creative. However, the simulated laboratory environment is only an ideal state that cannot be achieved in nature and could have a certain effect on the model's accuracy, but after overcoming the issue of initial nutrient conditions, it can be adopted in different situations.

References

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