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Research on decomposition rate of fungi based on temperature and humidity model

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Abstract: *Fungus is one of the decomposers in biosphere. Through its unique decomposition effect, it decomposes, converts and absorbs the organic matters in animal and plant remains of the humus layer. Fugus plays an essential role in not merely maintaining the carbon cycle but ensuring the ecosystem on earth under the environment of geochemical cycle, which is beneficial to the stability of the Earth's environment and the sustainable development of biodiversity. Our team simulated the decomposition of fungi by establishing a mathematical model, aiming to study the following questions: How do fungi with different traits interact and decompose the litter layer in a given land environment; What effect will moisture and temperature have on the decomposition process of fungi in different environments; environmental change trends and kinetic significance; fungal competition in a specific environment; taking into account the growth rate, the decomposition rate of fungi is estimated by the model . A variety of methods are used in the process of model establishment and data analysis: 'single variable control' experiment, Python software data analysis, Matlab software data analysis, system dynamics analysis and error analyzing and processing. Strictly control the simulation experiment conditions, guarantee the scientificity and rationality of the experimental data, eliminate interference factors, reduce gross errors, and improve the accuracy of experimental data.*

Keywords: *Fungi, Decomposition rate, Decomposition process, Carbon cycle, System dynamics analysis*

1. Introduction

The carbon cycle, the process of carbon exchange in the entire geochemical cycle, plays a decisive role for life on earth. Specifically, part of the carbon cycle involves the decomposition of compounds [1], allowing carbon to be renewed and used in other forms. The key component of this process is the decomposition of plant material and woody fibers [2].

Fungi, the key medium for decomposing woody fibers, whose growth rate will be affected by changes in moisture and temperature in the environment. As the environment changes, the growth rate and water tolerance of fungi also change, which in turn affects the process of decomposing litter and woody fibers [3].

In the ecosystem, the remains and relics of animals and plants are decomposed by a large number of bacteria and fungi into inorganic substances such as carbon dioxide, water and inorganic salts, which are returned to the soil for re-absorption and use by green plants to produce organic matter. It can be seen that fungi are essential in the ecosystem in promoting the material circulation and helping maintain the ecological balance of the earth [4].

2. Overview of Problem Resolution Process

For the existence of a single species, we know that white rot fungi, brown rot fungi, and soft rot fungi are the dominant species that can decompose plant materials and wood fibers [5]. As thermophilic aerobic fungi, their growth rate will increase with temperature. Gradually increase and speed up. Here we refer to the respective fungi of the three fungi, and get the data of the growth rate of the three wood-rot fungi with temperature changes [6].

This problem is to analyze the decomposition of dead branches and leaves and lignocellulosic fibers in the presence of a variety of fungi. Although this analysis only focuses on the decomposition of dead branches and leaves and lignocellulosic fibers due to fungal activities, the fungus has both moisture resistance and growth rate. An important feature, the model we built is not only the growth rate variable. Wood fiber contains three components: lignin, cellulose and hemicellulose.

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Table 1: Three wood-rot fungi with temperature changes

Isolate	Extension rate(mm day-1) ±SD		
	10℃	16℃	22℃
Phellinus gilvus HHB11977 C4H	1.40±0.05	1.53±0.18	3.70±0
Hyphodontia crustose HHB13392 B7H	1.20±0.03	0.90±0.07	1.77±0.20
Armillaria gallica HHB12551C6C(north)	0.14±0.06	0.32±0.05	0.48±0.15

3. Problem analysis

Regarding the relationship between the mycelial elongation rate and the decomposition rate of various fungi at various temperatures, the main research is the decomposition rate under the conditions of 10℃, 16℃ and 22℃, and the error of the graph is always Exist, and under the 95% confidence condition, if we need to get the decomposition rate of the corresponding situation, we need to use the method of fitting interpolation to estimate and solve the measured value. From the relationship diagram, we get 10 sets of data:

Table 2: Numerical relationship between growth rate and decomposition rate at 10 ℃

Er	0	0.1	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.5
Dr	0.1	1.12	2.19	2.58	2.96	3.32	4.03	4.35	4.75	5.29

Table 3: Numerical relationship between growth rate and decomposition rate at 16 ℃

Er	0.1	0.5	0.9	2.1	2.5	3.7	5.0	6.0	6.5	7.5
Dr	5.14	6.17	6.83	9.26	10.48	12.98	13.96	14.86	15.69	16.32

Table 4: Numerical relationship between growth rate and decomposition rate at 22 ℃

Er	1.0	2.0	2.5	4.0	5.0	6.5	7.5	8.5	9.0	10.0
Dr	10.23	14.33	16.72	19.21	21.36	23.16	24.34	25.12	26.03	27.85

The paper make a feasible fitting curve in the corresponding data table. We are discussing the decomposition rate at 10°C, 16°C, and 22°C. Obviously we don't need to use the edge data of the chart, so each of the three fitting curves The values of the points have certain accuracy, and we have got the fitting curves corresponding to the three sets of data.

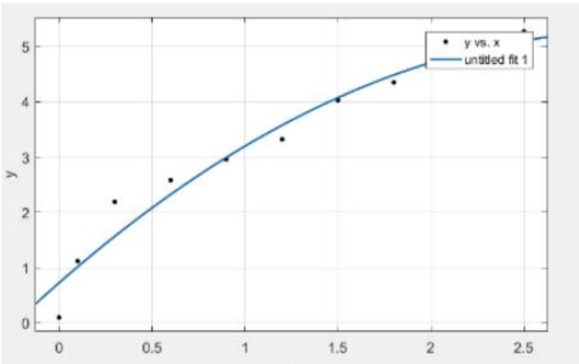

Figure 1: Dr1=-0.48Er^2+3Er+0.725

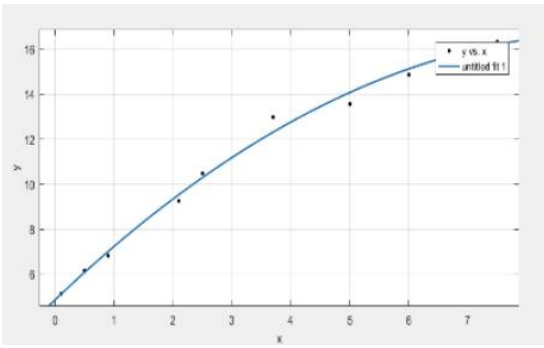

Figure 2: Dr2=-0.13Er^2+2.5Er+5

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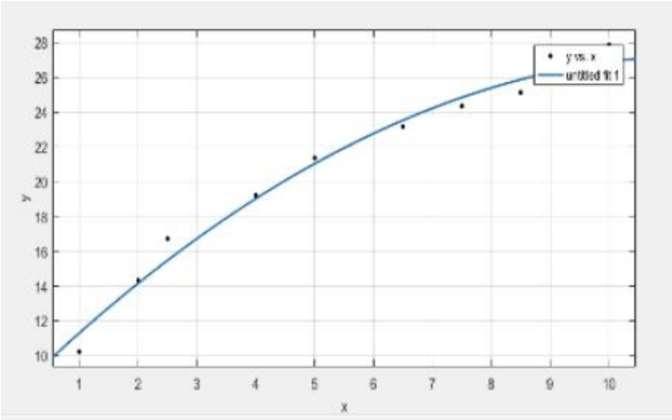

Figure 3: Dr3=-0.14Er^2+3.3Er+8.16

For the relationship between moisture resistance and decomposition rate, refer to the data set in the chart here, and the explanation of moisture resistance is the difference in the competitive ranking of each isolate and the width of the wet niche.

Table 5: Numerical relationship between the logarithm of moisture resistance and decomposition rate of various fungi

Wr	-1.0	-0.5	0	0.5	1.0
Log(Dr)	1.1	1.6	2.0	2.4	2.7

To obtain the numerical relationship between moisture resistance and log (decomposition rate), it is still necessary to establish a fitting curve to solve, and the relationship equation of the linear function of the fitting curve is obtained:

$$Dr4=0.8Td+2.0 \quad (1)$$

A major measure of moisture tolerance is the niche width, and for a single ecological factor axis, the niche width is in the interval [0,1]. The decomposition of wood fibers by the three fungi is not a real competition. More is synergy. Here it is assumed that the fungus will feed on three food resources (lignin, cellulose, hemicellulose), and the number of fungi that feed on lignin is n1, and the number of fungi that feed on cellulose is n2+n3, take The number of fungi that feed on hemicellulose is n2+n3. Here, we define Pi=Ni/(N1+N2+N3) as the proportion of the number of individuals that feed on the i-th species in the population, calculated by R. Levins Niche width.

$$B=1/[(P1)^2+(P2)^2+(P3)^2] \quad (2)$$

In the decomposition of wood fiber, the niche width B can be defined as a complete measure of moisture resistance, because the difference in the competitive ranking of each isolate can be ignored under this condition, and finally:

$$Dr5=0.8/[(P1)^2+(P2)^2+(P3)^2]+2.0 \quad (3)$$

The last input condition is temperature. Similarly, we need to use the accurate value of the data to find the relationship expression between temperature and decomposition rate. However, due to the influence of other factors, the original data becomes not so accurate. We need to fit the original data to get the measured value we need instead of the real value. In the chart, we extract certain data:

Table 6: Data relationship between single temperature condition and decomposition rate

T(℃)	0	5	10	15	20	25	30	35	39	40	45	50
Dr	0	0.3	1.2	3.3	5.2	8.2	12.2	13.8	16.2	7.4	0.8	0

Fit the data in the table to get the final cubic function relationship equation between temperature and decomposition rate as:

$$Dr6=-0.001T^3+0.05T^2-0.4T+0.364 \quad (4)$$

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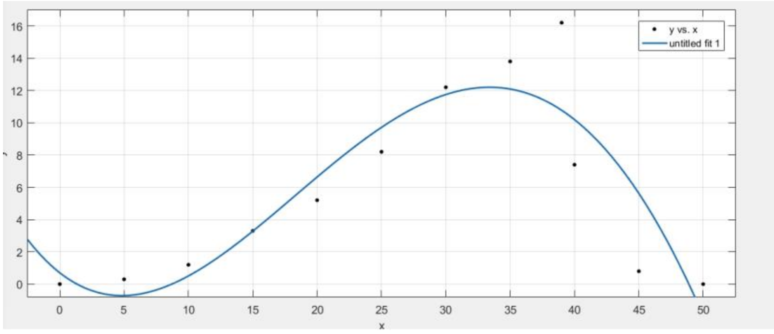

Figure 4

For the interaction between the three fungi, we can introduce a parameter Y as a promoting factor for the three types of fungi, because the growth rate of different fungi is roughly linear with the wood decomposition rate, and the moisture resistance of different fungi is also related to wood decomposition. The rate is roughly linear, so we can use the white rot fungus decomposition rate (X1) and the brown rot fungus decomposition rate (X1) to linearly express, namely:

$$Y=aX1+bX2 \tag{5}$$

Therefore, after the last three types of values are entered in the first question, the final unique output value-the total decomposition rate:

$$W=Dr[1,2,3]+Dr4+Dr5+Dr6+Y \tag{6}$$

4. Conclusions

The three major carbon reservoirs on the earth, including the atmosphere, ocean, and terrestrial systems, have been in a dynamic balance of interaction and continuous carbon exchange. Soil respiration is a major process of the global carbon cycle, which plays a vital role in the adjustment of atmospheric carbon dioxide and concentration. The respiration of soil fungi accounts for 81%-95% of the total soil respiration. Fungi are the primary agents of terrestrial decomposition, yet our understanding of fungal biogeography lags far behind that of plants, animals and bacteria.

Fungi are prominent components of terrestrial ecosystems in terms of biomass and diversity, and they influence almost every aspect of terrestrial ecosystem functioning. They are the dominant decomposers of organic plant material, with direct consequences for global carbon and nutrient dynamics. Given that different fungi process organic matter at vastly different rates, the composition of fungi in an area can provide a tangible link between biological communities and the functioning of ecosystems.

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