ISSN 2616-5872 Vol.3, Issue 1: 38-42, DOI: 10.25236/AJEE.2021.030108

Fungal growth model based on logistic regression

Zhe Wang[1], Tengmei Wang[2], Hao Wu[3]

[1]*School of Mechanical Engineering, Hefei University of Technology, Xuancheng, Anhui 242000, China*
[2]*School of Computer Science and Information Engineering, Hefei University of Technology, Xuancheng, Anhui 242000, China*
[3]*School of Electrical Engineering and Automation, Hefei University of Technology, Xuancheng, Anhui 242000, China*

Abstract: *The decomposition of plant materials and wood fibers is an important part of the carbon cycle, and some of the key components of this decomposition are fungi. Our aim was to explore the relationship between the rate of decomposition and the growth rate and moisture tolerance of a variety of fungi. The logistic growth model of a single fungus was established to explore its growth mechanism, and the influencing factors of humidity and temperature were introduced to modify it.*

Keywords: *fungi multiple fungi interaction decomposition model*

1. Introduction

The carbon cycle is an important part of life on Earth, and the decomposition of c ompounds is part of the carbon cycle. A key component of this process is the decomp osition of plant materials and wood fibers. And the key factor in the decomposition of wood fiber is fungi. A recent research paper identified the fungal characteristics that d etermine the rate of fungal decomposition and the relationships between the different characteristics. However, fungi with different characteristics have different decomposi tion effects on lignin fiber.

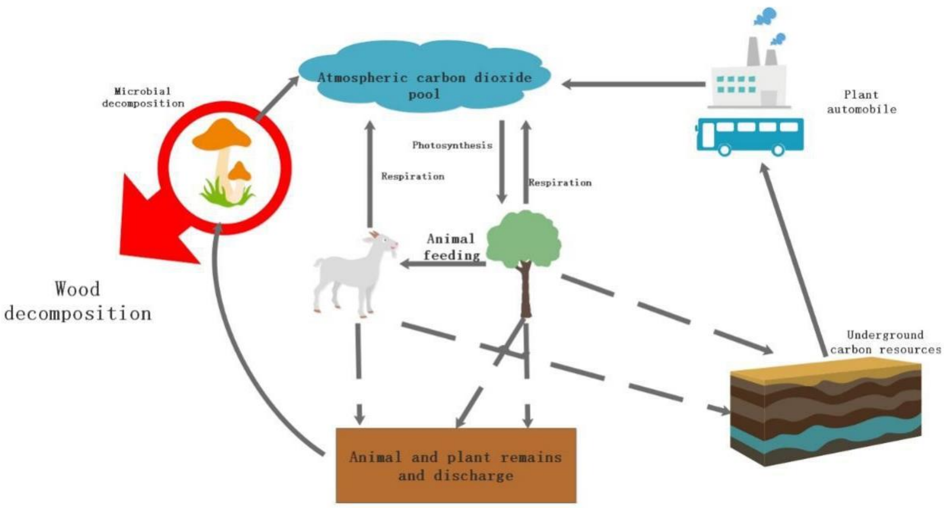

Figure 1

2. Analysis of growth and decomposition ability of single species of fungi

2.1 Description of the embodiment of the growth of a single fungal species

According to literature, the growth of fungi is greatly affected by the temperature and humidity in the environment. In order to more intuitively explore the influence of temperature and humidity on the elongation of mycelia and establish the growth model of fungi, we assumed that the pH value, carbon dioxide and oxygen concentration and other factors of the surrounding environment all meet the growth

ISSN 2616-5872 Vol.3, Issue 1: 38-42, DOI: 10.25236/AJEE.2021.030108

environment of fungi. In addition, fungi cannot grow metamorphosis, which ensures that there is little difference in the growth rate and the elongation rate of mycelia between individual fungi during the fungal growth process.

In order to better explore the influence of air relative humidity on the elongation rate of fungal hyphae, through the website We extract the relevant soil matric potential and part of fungal hyphae elongation relation data set, based on the data set, we introduce the soil water characteristic curve, through the matrix of soil water potential and water content in the soil.

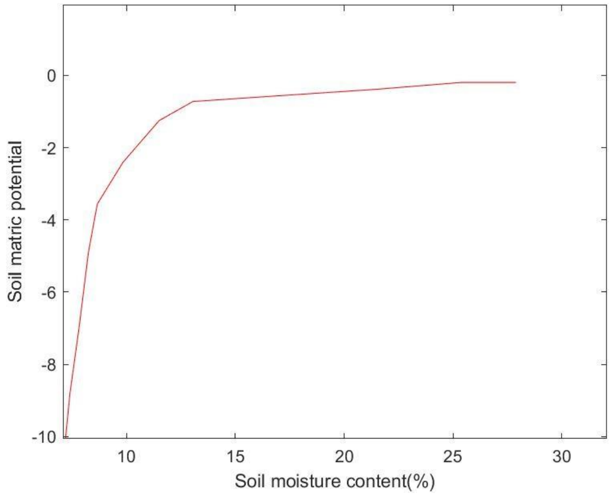

Figure 2

the relationship between our soil matric potential and fungal hyphae elongation of some species, data sets, converted to soil moisture content and some species of fungi hyphae elongation data set.Since fungi degrade and grow wood in the vicinity of the soil, we use the evaporation moisture of the soil to express the air humidity at the location of fungi.Based on the above analysis, we introduced the evaluation model of soil moisture content and evaporation moisture proposed by Liu Yajun.

$$B=\left(\frac{k_2G}{20}-25.9k_3S\right)\frac{1}{k_1|T_1-T_2|}+\frac{\sqrt{\left(\frac{538.8k_3S-1.04k_2G}{T_1-T_2}\right)^2\frac{-15.17568k_1k_3S}{|er_2-er_1|}}}{20.8k_1} \quad (1)$$

The parameters T1,T2,S and M are respectively derived from The experimental process.Meanwhile, based on the experiments conducted by the team and the results obtained, we can get the fitting result of K1, K2 and K3 in the model as K1 = 0.5, k2 =0.0358, k3 = 0.0018.The correlation between the fitting results and the real results is as high as 98.4%, and the maximum error is not more than 6%.Based on this model, we input the obtained soil moisture content data set into the model, and then we can reverse solve the evaporation moisture near the soil under the soil moisture content environment, so as to obtain the data set of evaporation moisture and mycelial extension of some species of fungi.

Considering the fungal growth process, the growth of fungal mycelium is increases over time, while fungal hyphae elongation or fungal growth rate, so we have expressed in fungal mycelia fungus growth, we assume that the fungi in the growth process always stay active, temperature and humidity are the main influence factors in the process of fungal growth. Based on the above assumptions, we use S (t) to represent the growth of mycelium.

First of all, we do not consider any factor limiting the growth of the fungus, in this case, satisfies the equation:

$$\frac{dS(t)}{dt}=rS(t) \quad (2)$$

Then, considering the restriction of resources on the growth of fungi, the maximum growth delay factor (1– S(t) Smax) was introduced to modify equation (2), and equation (3) was obtained.

$$\frac{dS(t)}{dt}=rS(t)\left(1-\frac{S(t)}{S_{\max}}\right) \quad (3)$$

ISSN 2616-5872 Vol.3, Issue 1: 38-42, DOI: 10.25236/AJEE.2021.030108

According to the description of the growth of fungi, the growth of fungi is mainly affected by the temperature and humidity in the environment.

$$\frac{dS(t)}{dt} = rS(t)\left(1 - \frac{S(t)}{S_{\max}} - \sigma H - \mu T\right) \tag{4}$$

We assume that the initial quantity S (0) =10, and take the parameter to solve the growth-time differential equation (4), and finally get the function (5) of the growth of mycelia against time:

$$S(t) = 10\alpha S_{\max}\frac{e^{art}}{\alpha S_{\max} + 10e^{art-1}} \tag{5}$$

Values for parameters, due to the influence of different strains by humidity and temperature is different, we ring Gaul bacteria, for example, the fastest growth rate of the data and the temperature and humidity data input for multiple regression analysis, and carries on the test of significance, in do not break general situation, set the following parameters, among them, because the data for the fastest growth rate of the fungus, max $S=0.5*S_{max}$at this time.

The regression results show that the value of μand σ are, where the goodness of fit R squared =0.998, indicating that the model has a good fitting effect.

Based on the above model and hypothesis, the growth-time graph of Armillaria galummiae was drawn.

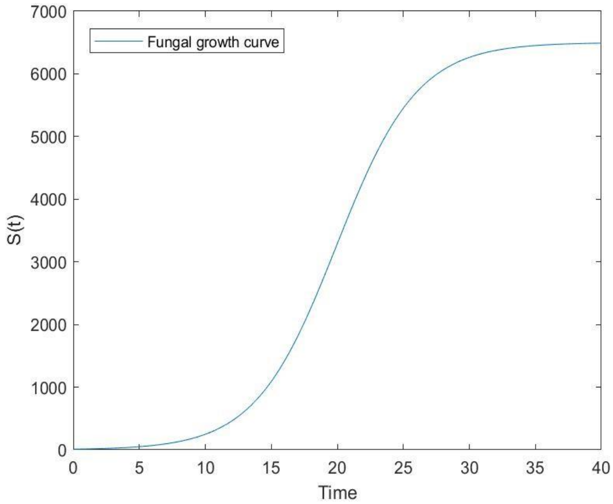

Figure 3

2.2 A description of the factors that influence the decomposition ability of individual fungi

In nature, there are many factors that affect the decomposition ability of fungi. Pointed out in the latest research, fungal decomposition ability phenotypic level related to growth rate, and promote resistance genes, genetic level, therefore, can reflect is the growth rate and wet resistance and decomposition, the relationship between, therefore, we then will mainly discuss the growth rate of fungi and wet resistance and decomposition capability.

Based on the above analysis, we will mainly explore the relationship between the growth rate and the moisture tolerance of fungi and the decomposition rate.

Firstly, Q(t) and K(t) were used to represent the decomposition rate of wood and the growth rate of fungus at time t, and R was used to represent the moisture tolerance rate of the strain.

Since the moisture resistance rate is inversely proportional to the decomposition rate of fungi, M=1/R , so the relationship between the three can be expressed as:

$$Q(t) = F(K, M) \tag{6}$$

Where, function F is an undetermined function. In order to obtain the functional form of F, two signs are introduced, respectively:

$$z = \frac{Q}{M}, y = \frac{K}{M} \tag{7}$$

ISSN 2616-5872 Vol.3, Issue 1: 38-42, DOI: 10.25236/AJEE.2021.030108

Since M is a constant, they are only related to the rate of fungal decomposition of wood and the rate of fungal growth, respectively. From literature, it can be concluded that the decomposition rate increases with the growth rate of fungi, but the growth rate decreases, that is, Z increases with the increase of Y, but the growth rate decreases. This conclusion can be expressed as:

$$z = cg(y), g(y) = y^{\alpha} \tag{8}$$

From (7) and (8), the specific form of F in formula (6) can be written

$$Q = cK^{\alpha}M^{\beta}, 0 < \alpha, \beta < 1 \tag{9}$$

Where C represents the influence of external environmental factors on the decomposition rate of fungal wood, α represents the influence degree of growth rate on the decomposition rate of fungal wood, and β represents the influence degree of moisture tolerance on the decomposition rate of fungal wood.

We still take Armillaria gallica as an example and assume that the current ambient temperature is 22℃, which is the same as the temperature in the growth model of Armillaria gallica. Multivariate nonlinear regression is carried out for a pair of Q in the figure given in the question, and the relevant coefficients are obtained Q(t) ,The goodness of fit value of R square is 0.967, so the fitting result is more accurate. Based on the above models and assumptions, we drew the decomposition rate curve of Armillaria gallica:

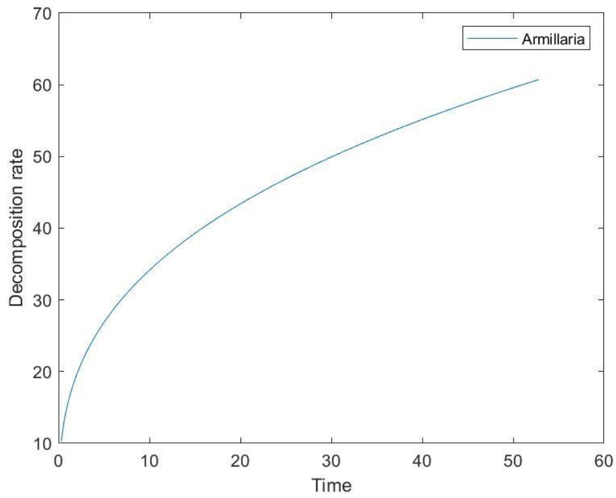

Figure 4

3. Test the sensitivity of the model to environmental fluctuations

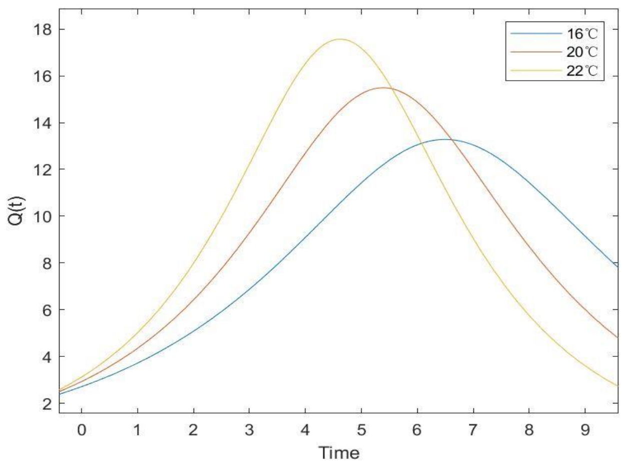

Figure 5

In order to explore the sensitivity of the model to environmental fluctuations, we used the control variable method to compare the changing trends of the model by changing the values of temperature and humidity.

ISSN 2616-5872 Vol.3, Issue 1: 38-42, DOI: 10.25236/AJEE.2021.030108

By linearly increasing the value of temperature, it was substituted into the model for simulation, and the results were obtained as shown in the figure. As shown in the figure, the variation trend of the model under different temperature conditions was almost the same, indicating that the effect was good and acceptable.

By linearly increasing the value of humidity, it was substituted into the model for simulation, and the results were obtained as shown in the figure. As shown in the figure, the variation trend of the model under different humidity conditions was almost the same, indicating that the effect was good and acceptable.

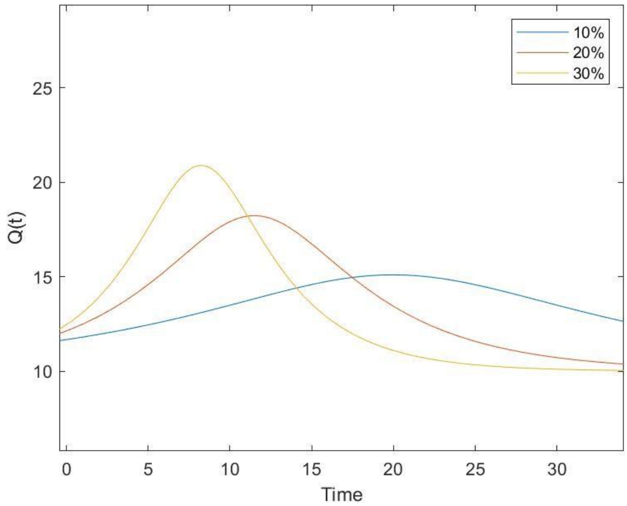

Figure 6

In the decomposition capacity model of fungi, the growth rate of fungi, humidity tolerance, the growth rate of the number of fungi and the maximum capacity of the environment all affect the results of the decomposition capacity model. Since the growth rate of fungi is closely related to the growth rate and humidity tolerance, we only consider the effects of the growth rate of fungi and the maximum environmental capacity on the model.

4. Model evaluation

The establishment of the model is from shallow to deep, gradually deepening, the idea is more rigorous, and the result of the model solution is more reliable.

In the whole modeling process, we set reasonable assumptions to facilitate the construction and solution of the model. At the same time, sensitivity analysis is carried out to verify the stability of the model. We innovatively revised the basic model to make it meet the requirements of the topic and improve the accuracy of the model.

In order to simplify the model, we only consider the effect of fungi growth rate and humidity tolerance on decomposition ability.

References

[1] Nicky Lustenhouwer, Daniel S. Maynard, Mark A. Bradford, Daniel L. Lindner, Br ad Oberle, Amy E. Zanne, and Thomas W. Crowther, "A traitbased understanding of wood decomposition by fungi," Proceedings of the Natio nal Academy of Sciences of the United States, May 13, 2020.

[2] Liu Yajun, Zhu Lianqing, Yang Debin, et al.Research on estimation model of soil moisture content based on air humidity [D]. Beijing: School of Mechanical Engineering, University of Science and Technology Beijing, 2016.

[3] Fukami T, Dickie I A, Wilkie J P, et al. Assembly history dictates ecosystem functioning: evidence from wood decomposer communities [J]. 2010, 13(6): 675684.

[4] Chen Y , Pu G , Lian B, et al. Interactions between Two Fungi Strains during Litter Decomposition through a Microcosm Experiment: Different Degradative Enzyme Activities [J]. Advances in Enzyme Research, 2018, 06(1): 1-9.