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EFFECT THE ENERGY ON(Y-H-D)TYPES OF FUNGI

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ABSTRACT. The mathematical model is model shows the behavior for the growth of Tip-tip anastomosis, Tip death hyphal death and we show the consumption of energy. In general, To mathematical modeling shortens the effort, time, and money to get the right result even though there is an error ratio. In this paper, we will study a mathematical model of branching using the solution of a system of partial equations (PDEs). The results of this solution will describe the success or failure of the growth of the fungus species studied, and we used some codes in numerical analysis because of some difficulty in direct mathematical solutions.

JEL Classification: example
D02, O17, P31

Keywords: Dichotomous branching, Tip-hypha anastomosis, Hyphal death

Introduction

The mathematical model theoretically describes an object that exists outside the field of mathematics, for example, Weather forecasts and economic forecasts, are based on mathematical models. Its success or failure depends on the accuracy with which this numerical representation is built, and the sincerity with which natural facts and attitudes are embodied in the form of interrelated variables. We note in the mathematical model three stages [3].

In 1982, Leah-Keshed denoted that Dichotomous branching (Y), Tip-hypha anastomosis (H), and Hyphal death (D). Table (1) illustrates these types. [1]

Table 1. Illustrate branching, Biological type, a symbol of this type, and version

Biological type	Symbol	Version	Parameters Description
Dichotomous branching	Y	$\delta = \alpha_1 \eta$	α_1 = Is the number of tips produced per tip per unit of time
Tip-hypha anastomosis	H	$\delta = -\beta_2 np$	β_2 =Is the rate of tip reconnections per unit of time
Hyphal death	D	$d = \gamma_1 p$	γ_1 =Is the loss rate of hyphal (constant for hyphal death)

1. Literature review

-In (2011) Shuaa [1], Studied to develop a model for the growth of fungi which can be used to create a source term in a single root model to account for nutrient uptake by the fungi. Therefore, focus on the hyphal loss or death.

-In (2013) Mudhafar [2], Proposed different modeling procedures, with a special emphasis on their ability to reproduce the biological system and to predict measured quantities that describe the overall processes. A comparison between the different methods is also made, highlighting their specific features.

2. Mathematical Model

We will study a new type of branching of fungal growth with hyphal death and Consumption of whole vegetarian food, we can call it energy, this energy function lies between one and zero. Here it means the growth to die if it does not consume energy but that means the growth is very good if the fungi consume all the energy.[1,3]
We can describe hyphal growth by the system below:

$$\begin{aligned}\frac{\partial \rho}{\partial t} &= nv - d\rho \\ \frac{\partial n}{\partial t} &= -\frac{\partial(nv)}{\partial x} + e^{[\delta(p,n)]} - E(\psi)\end{aligned}\quad (1)$$

Where: $\delta(p, n) = \alpha_1 n - \beta_2 np$ that is dented above and $E(\psi) = 1$. Then this system (1) becomes: [2]

$$\begin{aligned}\frac{\partial \rho}{\partial t} &= nv - \gamma\rho \\ \frac{\partial n}{\partial t} &= -\frac{\partial(nv)}{\partial x} + e^{[\alpha n(1-p)]} - 1\end{aligned}\quad (2)$$

$$\text{Where: } \alpha = \frac{\alpha_1}{\gamma_1}$$

3. Non-dimensionlision and Stabilit

Leah Keshet (1982)[4] and Ali Shuaa Al-Taie (2011)[1], demonstrate how these parameters can be positioned as lower dimensionlision.

$$\begin{aligned}\frac{\partial \rho}{\partial t} &= nv - \gamma\rho \\ \frac{\partial n}{\partial t} &= -\frac{\partial(nv)}{\partial x} + e^{[\alpha n(1-p)]} - 1\end{aligned}\quad (3)$$

Where: $\alpha = \frac{\alpha_1}{\gamma_1}$ the parameter is represented the rate of hyphal branching per unit hyphal per unit length hypha per unit time, and $\alpha n(1-p)$ thus represented the number of branches produced per unit time per unit length of hyphae.[2,4]

now, to find steady states when taking from the system (2):

$$\frac{\partial \rho}{\partial t} = n - \rho = 0 \rightarrow n = \rho \tag{4}$$

And on the other hand

$$\begin{aligned} \frac{\partial n}{\partial t} &= e^{[\alpha n(1-p)]} - 1 = 0 \rightarrow e^{[\alpha n(1-p)]} = 1 \\ \ln[e^{[\alpha n(1-p)]}] &= \ln[1] \rightarrow \alpha n(1-p) = 0 \tag{5} \\ \rho = 0, \text{ then } &\rightarrow (p, n) = (0, 0) \text{ and } (1-p) = 0 \\ n = 1, \text{ then } &(p, n) = (1, 1) \end{aligned}$$

So that is clear the steady state is $(p, n) = (0, 0)$ and, $(p, n) = (1, 1)$ therefore, we take Jacobain of these equations. [1,4]

$$J_{(p,n)} = \begin{bmatrix} -1 & 1 \\ -\alpha n & \alpha(1-p) \end{bmatrix}$$

We can classify the critical point according to the eigenvalues of this matrix. Jacobain at $(0, 0)$:

$$J_{(0,0)} = \begin{bmatrix} -1 & 1 \\ 0 & \alpha \end{bmatrix}$$

Thus, $|A - \lambda I| = 0$ we get two values of (λ) :

$$\lambda_1 = -1, \quad \lambda_2 = \alpha$$

Then we take the Jacobain at $(1, 1)$:

$$J_{(1,1)} = \begin{bmatrix} -1 & 1 \\ -\alpha & -0 \end{bmatrix}$$

Thus $|A - \lambda I| = 0$, then we get two values of (λ) :

$$\lambda_1 = \frac{-1}{2} - \frac{\sqrt{1-4\alpha}}{2}, \quad \lambda_2 = \frac{-1}{2} + \frac{\sqrt{1-4\alpha}}{2}$$

We note the probabilities of the α .

If α is negative, we get the point $(1, 1)$ stable spiral and the point $(0, 0)$ is the saddle point. See Fig (1). Using (MATLAB pplane7). [3, 5]

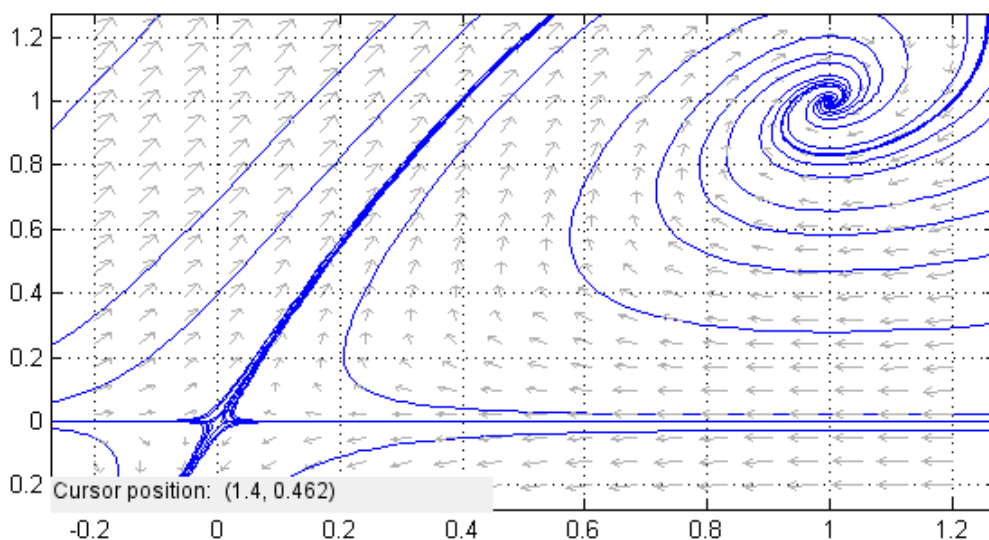


Figure 1. The (p,n) plane note that a trajectory connects in the point $(0,0)$ is the saddle point and in the point $(1,1)$ the stable spiral.

4. Traveling wave solution

We will now discuss the traveling wave solution, we assume that: $\rho(x, t) = \rho(z)$ and $n(x, t) = N(z)$ where $z = x - ct$, $P(z)$ profile density and propagation rate c of the edge of the colony. $P(z)$ and $N(z)$ is a non-negative function of z . The function, $p(x,t)$, $n(x,t)$ are moving waves, moving with a constant speed c in a positive x direction, where $c > 0$, $E(\psi) = 1$, and $\alpha = 1$ to search for a traveling wave solution to the equations in x and t of the system (3).

$$\frac{d\rho}{dt} = -c \frac{d\rho}{dx}, \quad \frac{dn}{dt} = -\frac{dN}{dx}, \quad \text{And, } \frac{dn}{dt} = \frac{dN}{dx}$$

See [3] Therefore, the above equation becomes:

$$\begin{aligned} \frac{dP}{dz} &= \frac{-1}{c}[N - P] \\ \frac{dN}{dz} &= \frac{1}{1-c} e^{[\alpha N(1-p)]}, \quad c \neq 1, \quad -\infty < z < \infty \end{aligned} \quad (6)$$

To deter the steady states of the above system, we get $(N, P) = (0,0)$ stable node saddle point and $(1, 1)$ saddle point constant for negative c and $\alpha = 1$. This helps us to determine the initial conditions of p and n which is the above system (3). See Fig (2).

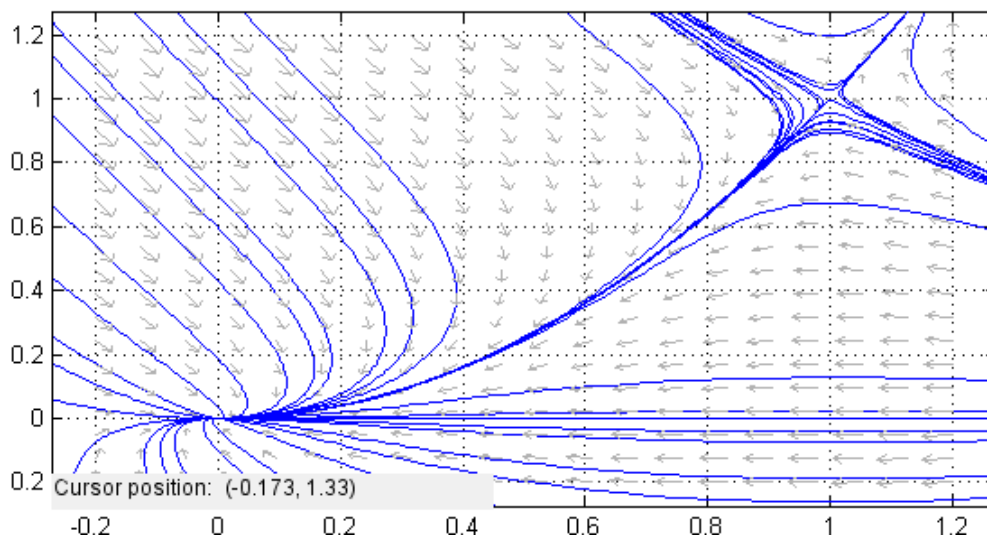


Figure 2. The (p,n) plane notes that a trajectory connects in the point $(0,0)$ is the stable node and in the point $(1,1)$ the saddle point.

5. Numerical Solution

Since the system (3) is not completely solvable, we resort to numerical solutions, here we use the (pdepe) code in (MATLAB), which shows that the initial condition starts from 1 to zero for ρ , and n , Fig (3) shows the behavior of ρ and n is very clear. That traveling waves are regular for time.

Fig (3) shows the solution of system (3) with parameters $\alpha = 1$ and $c = 2.0409$ for time $t=1, 10, 20, 30 \dots 300$.

In (Fig (4)) where the blue line represents tips (n), in (Fig (5)) the red line represents the branches (p), in (Fig (6)) where the blue line represents the tips (n), with the red line represents the branches (n), and solve p and n explained numerically with taking values of $\alpha = 1$ it is very clear that The solution of the traveling wave starts from left to right and is still the same wave.

From this process we get the relationship between the traveling wave solution (c) and the modulus α where α is increasing in the traveling wave solution (c) is increasing, using (Matlab) pdepe.

Of hyphal death. Tip density in the interior of the colony is maintained at a nonzero level. Biologically, this means that, while old hyphae are weeded out, new growth is continually taking place so that the density level is regulated in the older section colony, as well as at expanding margin, and a new rate constant is added to the parameter set that after rendering the equations dimensionless one parameter remain. Thus, the possibility of modulating growth is also created. This study can be applied to the other types of branches of fungi and some types of biological phenomena. Biologically means, new growth is continually taking place, while old hyphae are eradicated. We note slightly alter the wave speed, if a large value for the imaginary part of the eigenvalues then the oscillation for probe of and n is increasing, and a small value for the imaginary part of the eigenvalues then the slight oscillation for prole of and n or close to stable node.

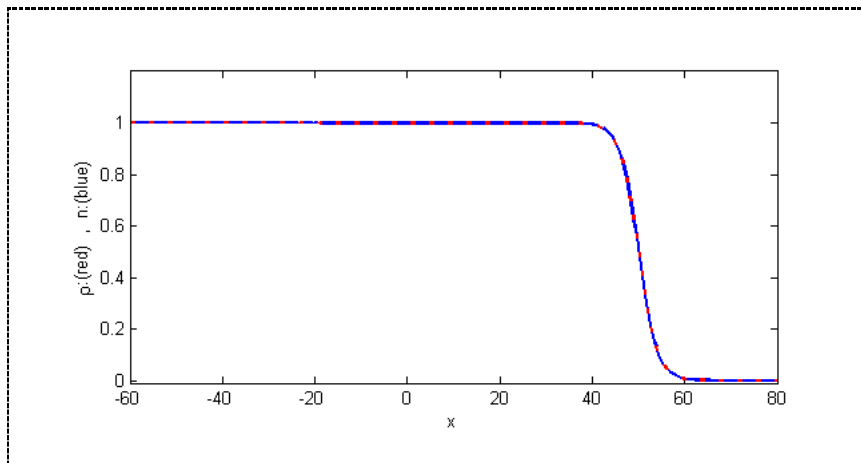


Figure 3. The initial condition of the solution to the system (3) with the parameters, $\alpha=1$

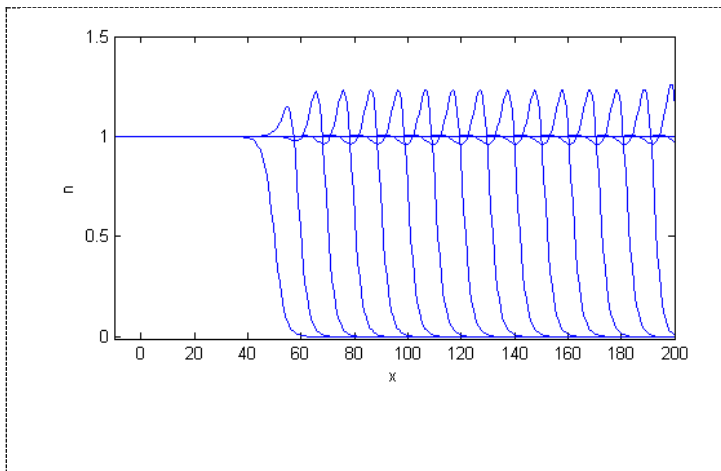


Figure 4. The blue line represents tips (n)

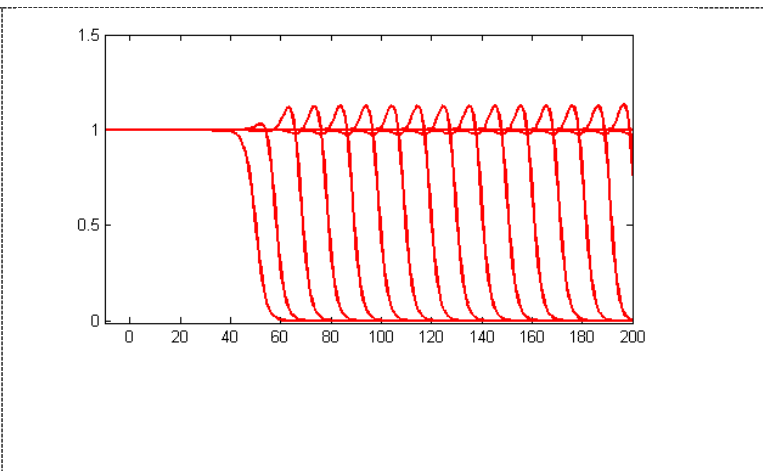


Figure 5. The red line represents the branches (p)

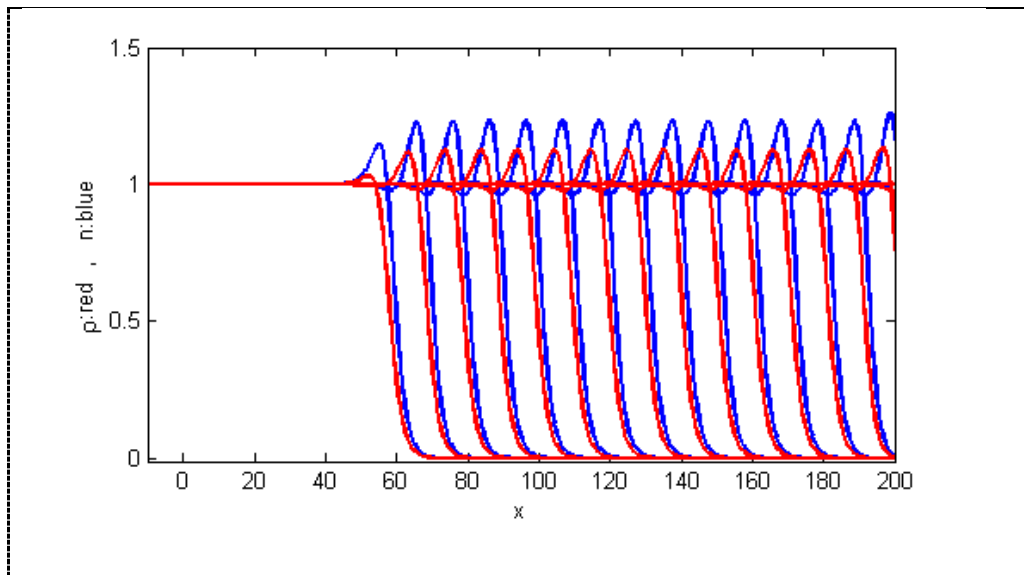


Figure 6. The blue line represents the tips (n), with the red line representing the branches (n), and solve p and n explained numerically by taking values of $\alpha = 1$

From this operation, we get the relation between traveling waves solution c and α values by taking $v = d = 1$, we can show that the (2) table. Where α increases the traveling waves solution C is increasing, (See Figure 7).

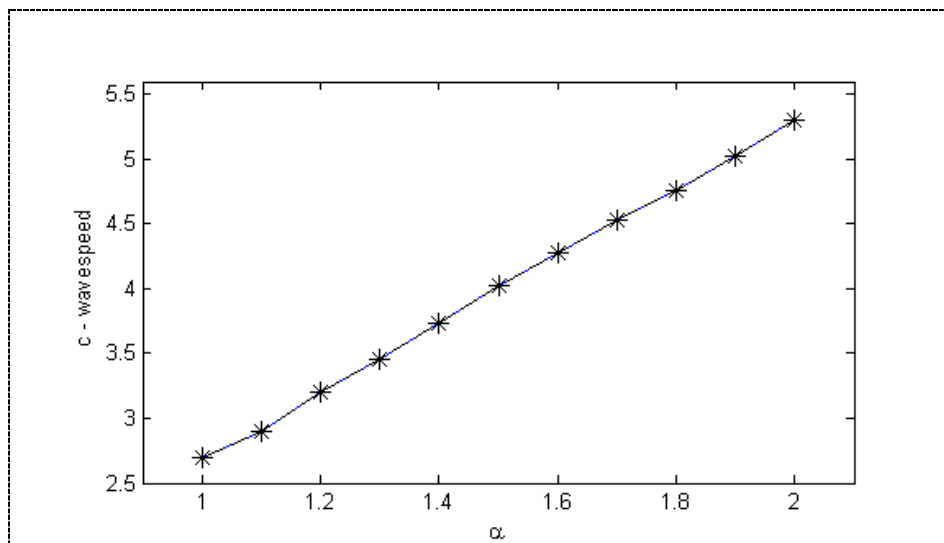


Figure 7. The relation between waves speed c and α values by taking $v=d=1$

Conclusion

We plot the relationship between c and α , see Fig(7), that is clear the wave speed c is increasing when α an increase function of α . Since $(\alpha = \frac{\alpha_1}{\gamma_1})$, therefore the growth rate is increasing with α_1 while keeping γ_1 fixed, while, the growth rate is decreasing with γ_1 increases while keeping α_1 fixed. We note that changing the rate of anastomosis, β_1 , cannot alter the

colony growth rate, since the growth parameter α has no dependence on β_1 . However, increasing β_1 would decrease the density levels accumulated in the interior. [1]

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