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EXPONENTIAL OF LATERAL BRANCHING, TIP-HYPHA ANASTOMOSIS WITH LOSS ENERGY

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ABSTRACT

In this paper we will study the biological phenomenon spatially Fungi, after that Conversion this fungi biological phenomenon to mathematical system as system of partial differential equations (PDEs). This method saves time, effort and money. Here we will illustrate the growth of fungi from type Lateral branching, Tip-hypha anastomosis with Loss Energy like salts or phosphate are feeding on the fungi, this salts and phosphate are loosed relatively for example maybe zero when the fungi is die or some relative until consumed all these slates and phosphate this mean complete relative 100%, that is mean is equal one.

Key words: Lateral tip-hypha, anastomosis and Hyphal.

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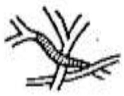
1. INTRODUCTION

Leah-Keshed in 1982 denoted that Lateral branching (F), Tip-hypha anastomosis (H) and Hyphal death (D), that is very clear in this below table (1-1) it is show these types and illustrate the function of them [5,7,8,9].

Table (1-1): Show branching, biological type, symbol of this type, version and description of these parameters.

Branching	Biological type	Symbol	Version	Parameters description
	Lateral branching	F	$\delta = \alpha_2 p$	α_2 is the number of branches produced per unit length hypha per unit time

	Tip-hypha anastomosis	H	$\delta = -\beta_2 np$	β_2 is the rate of tip reconnections per unit length hypha per unit time
	Hyphal death	D	$d = \gamma_1 p$	γ_1 is the loss rate of hyphal (constant for hyphal death)

2. MATHEMATICAL MODEL

In this paper, we take the exponential function $\exp(\sigma(\rho, n))$representing the behavior of the tip and hyphal. The loss function as salts and phosphate denoted by $\Psi(x)$ where $0 \le \Psi(x) \le 1$, that is mean if $\Psi(x) = 0$ this does not consume the food for the growth of fungi, but if $\Psi(x) = 1$ this consume all the food for the growth of fungi [1,3].

In our work, we will take $\Psi(x)=1$, that is meaning this install between two types of fungi; Lateral Branching, Tip-hypha Anastomosisare highest point of consumption energy (100 %). The model below represents our goal in this paper:

$$\left.\begin{aligned} &\frac{\partial \rho}{\partial t} = J - D, \\ &\frac{\partial n}{\partial t} = -\frac{\partial(nv)}{\partial t} + Exp\,(\sigma(\rho, n)) - \Psi(x) \end{aligned}\right\} \qquad (2\text{-}1)$$

Where: $J = nv$ is a flux, $D = \gamma_1 \rho$ is hyphal death, $\sigma(\rho, n) = \alpha_2 \rho - \beta_2 \rho n$ that is dented above and $\Psi(x)=1$. Then this is system (2-1) becomes [2, 4, 6]:

$$\left.\begin{aligned} &\frac{\partial \rho}{\partial t} = nv - \gamma_1 \rho, \\ &\frac{\partial n}{\partial t} = -\frac{\partial(nv)}{\partial t} + Exp\,(\alpha_2 \rho - \beta_2 \rho n) - 1 \end{aligned}\right\} \qquad (2\text{-}2)$$

3. NON-DIMENSIONLISION AND STABILITY OF UNIFORM SOLUTION

Leah-keshet (1982) and Ali H. Shuaa Al-Taie (2011) clear up how can put these parameters as dimensionless

$$\left.\begin{aligned} &\frac{\partial \rho}{\partial t} = n - d\rho, \\ &\frac{\partial n}{\partial t} = -\frac{\partial(n)}{\partial t} + Exp\,(\alpha\rho\,(1-n)) - 1 \end{aligned}\right\} \qquad (3\text{-}1)$$

Where

$$\alpha = \left(\frac{\alpha_2 v}{\gamma^2}\right)$$

Parameter is represented number of tip produced per unit hyphal per unit time. d : is hyphal death and here value of $d=1$.

From our model (3-1), we find steady states when take:

$n-\rho=0 \Rightarrow n=\rho$

And on the other side

$\exp(\alpha\rho(1-n))-1=0$

$\Rightarrow$

$\ln(\exp(\alpha\rho(1-n))=\ln(1)$

That is leads to

$\alpha\rho(1-n))=0 \quad \Rightarrow \rho=0\, then \quad (\rho,n)=(0,0)$

And

$(1-n))=0 \quad \Rightarrow n=1 then \quad (\rho,n)=(1,1)$

That is very clear the steady states are $(\rho,n)=(0,0)$ **and** $(1,1)$

Therefore we take the Jacobain of these equations

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

Now, determent the eigenvalues as $\lambda_i\,; i=1,2$

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

$\Rightarrow$

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

&

$$\lambda_2=\frac{-1-\sqrt{1+4\alpha}}{2}.$$

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

$\Rightarrow$

$\lambda_1=-1$

&

$\lambda_2=-\alpha$

In this case we will take this point $(0,0)$ is saddle point and the point $(1,1)$ stable node for α positive, see Figure (3-1).

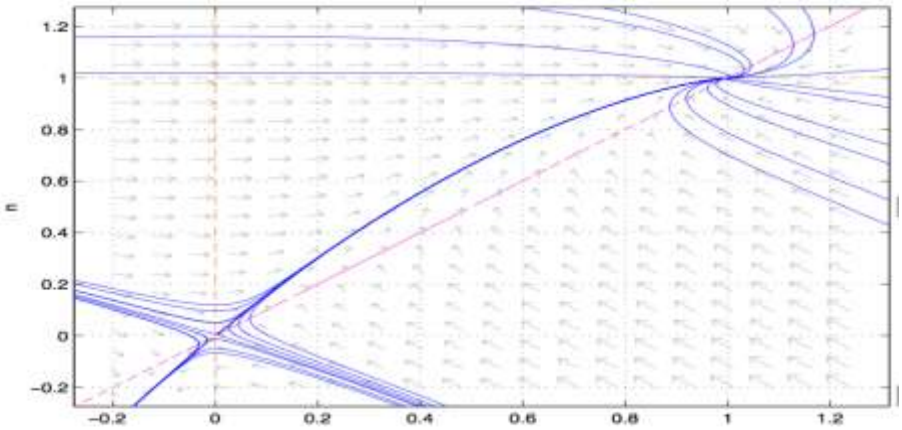


Figure 3.1: The $(n\rho)$ - plane: note that a trajectory connects the saddle point (0, 0) to (1, 1) for $\Psi(x)=1,\ and\ \alpha=1.$

4. TRAVELING WAVE SOLUTION AND NUMERICAL SOLUTION

In this section we will discuss the traveling wave solution, here we suppose that: $\rho(x,t)=P(z)$, and $n(x,t)=N(z)$ where $z=x-ct$, $P(z)$ and $P(z)$ are density profile and c rate of propagation of colony edge, $P(z)$ and $N(z)$ non-negative function of z. The function $\rho(x,t),\ n(x,t)$ are traveling wave sand are moves at constant speed c in positive x-direction, where $c>0$, $\Psi(x)=1,\ and\ \alpha=1$ to look for traveling wave solution of equations in x and t in the form (3-1).

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

And

$$\frac{dn}{dt}=\frac{dN}{dx}$$

See Edelstein-Kehet, L. (2005), therefore the above equation becomes:

$$\left.\begin{aligned}\frac{d\rho}{dz}&=-\frac{1}{c}[N-P],\\ \frac{dN}{dz}&=\frac{1}{(1-c)}[Exp(\alpha\rho(1-n)]-1.\end{aligned}\right\}\qquad (4\text{-}1)$$

To determent steady states of above system we get $(N,P)=(0,0)$ is saddle point and $(1,1)$ unstable node for c is negative. That help to determent the initial conditions of $\rho\ and\ n$ is the above system (3-1); see Fig (4-1).

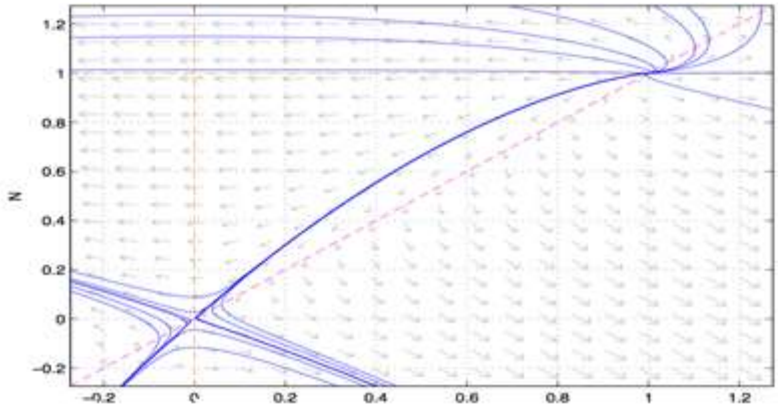


Figure 4.1: The (NP) - plane: note that a trajectory connects the unstable (1, 1) to saddle point (0, 0) to for c, $\Psi(x)=1,\ and\ \alpha=1$

Now, we will solve the above system (1-3) using pdepes code in MATLAB that is clear the initial condition start from 1 to zero for $\rho\ and\ n$. Figure (4-2) illustrates the behavior for $\rho\ and\ n$ that is very clear the traveling waves are regular for time shows in figure bellow:

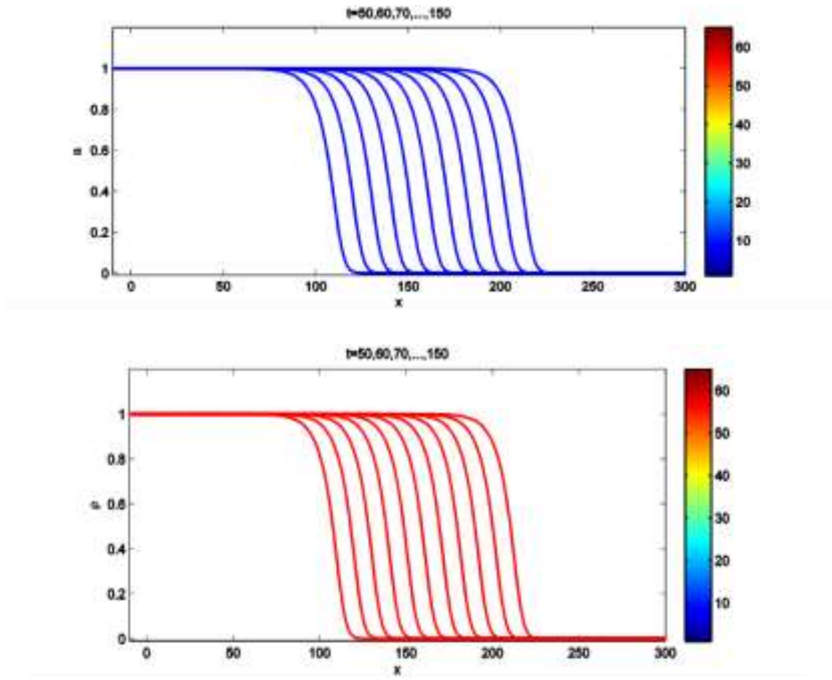


Figure (4-2) Solution to the equations (3-1) with the parameter $\Psi(x)=1,\ and\ \alpha=1.$ that clear the points of stability are $(0,\ 0)\ \ and\ \ (1,1)$. The time spacing: 50, 60, 70,…,150

Form above figure (4-2) we note the travelling weves solution c are the same in wave for all time t, that is mean the growth in this biological phonomena for fungi is very good and we can conclude that these models can succeed in their own growth. Figure (4-3) illustrates the relation between wave c and number of tip produced per unit hyphal α.

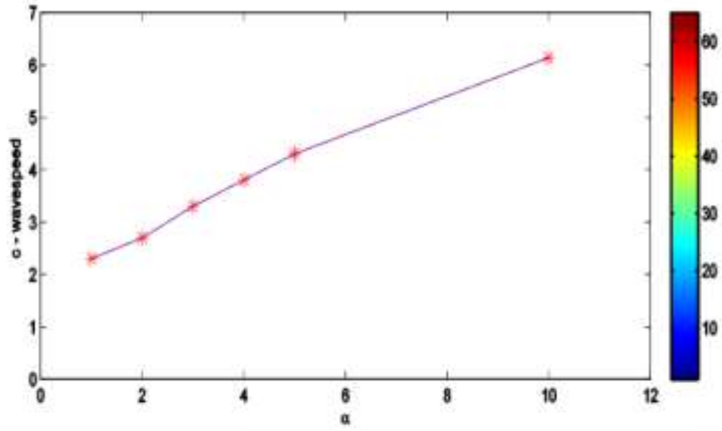


Figure (4-2) Relationship between α and wave speed c. for parameter d taken value 1

5. CONCLUSIONS

From the last method mathematically; the equilibrium in positive (P, N) quadrant is such that $N \neq 0$ and $P \neq 0$ implying that wave leave at $z \to -\infty$ is $N \neq 0$ and $P \neq 0$. There are many interesting implications of hyphal death. Tip density in interior of the colony is maintained at a nonzero level. Biologically, this mean that, while old hypha 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 rending the equations dimensionless one parameter remain. Thus, the possibility of modulating growth is also created. This study can be applied on the other types of branches of fungi and some type of biological phenomena.

REFERENCES

[1] Boswell, G. P. (2008), modeling mycelia networks in structured environments, Mycol Res., 112:1015, 1025.

[2] Davidson, F. A. (1998), modeling the qualitative response of fungal mycelia to heterogeneous environments. J. Theor. Biol., 195:281, 291.

[3] Davidson, F. A. (2007a), Mathematical modeling of mycelia: a question of scale, Fungal Biol. Rev, 21:30, 41.

[4] Davidson, F. A. (2007b), Mathematical modeling of the form and function of Fungal mycelian of scale, Fungal Biol. Rev, 21:30, 41

[5] Edelstein-Kehet, L. (2005), Mathematical Models in Biology, Duke University.

[6] Giovanetti, M., Fortuna, P., Citernesi, A., and Morini, S. (2011), the occurrence of anastomosis formation and nuclear exchange in intact arbuscularmycorrhizal network. New Phytol, 151:717, 724.187

[7] Jolicoeur, M., Bouchard-Marchand, E., Becard, G., and Perrier, M. (2003), Regulation of mycorrhizal symbiosis: development of a structured nutritional dual model, Ecol. Model., 163:247, 267

[8] Leung, A. W., Hou, X., and Li., Y. (2008), Exclusive traveling waves for competitive reaction-diffusion systems and their stabilities, Journal of Mathematical Analysis and Applications, 338:902, 924

[9] Murray, J. D. (2002), Mathematical Biology I: An Introduction. New York: Springer