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Understanding the some aspects of Alternate Bearing Phenomenon: cycle of three years

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Abstract– Alternate bearing is a common phenomenon in plants having big seed where fruiting occurs in alternate years i. e. cycle of two years. In this paper we explore the possibility of three years cycle instead of two years. Nonlinearity is used in energy resource model to understand this enhanced cycle.

1. Introduction

We have considered a well known/studied system which captures many of the alternate bearing phenomena. However other variants may be considered for generalization of the presented results. Experimenting this observed results are also possible. However it will take years/decades to check the useful of these results. However in this work a made an attempt and discuss the feasibility for experimentation in real field. Question is why does it happen? Is it possible to model such behavior using the energy resource [1] which is based on energy generated by photosynthesis? Answer to these questions are the main aim of this present work.

2. Model

A constant amount of photosynthate is produced every year in individual plant. This photosynthate is used for growth and maintenance of the plant. The remaining photosyn-thate (P_s) gets stored in the plant body. The accumulated photosynthate stored in plant is expressed as I. In a year when accumulated photosynthate exceed a certain threshold L_T then the remaining amount, $I - L_T$, is used for flowering as the cost of flowering, C_f. These flowers are pollinated and bear fruits which cost is designated as C_a. Usually, the fruiting cost is a function of the cost of flowering, i. e., $C_a = F(C_f)$ where F (.) is a function. The accumulated photosynthate becomes $I = L_T$ after flowering. Once fruiting is over it becomes $L_T - C_a$, i.e., $I = L_T - F(C_f)$. Under the less fluctuating conditions we may consider the function $F(C_f)$ as a linear one i.e., $C_a = RC_f$ where R is a constant. In this case this phenomenon is modeled as [1] this is termed as Isagi Model or Resource Budget Model which is given as

$$I_{n+1} = -RI_{n+}L \quad I_n > L_T - P_s$$
$$= I_n + P_s \quad I_n \le L_T - P_s \qquad (1)$$

where $L = L_T - (1+R) - RP_s$. This model has been extensively studied in literature [1,2]. Let us consider the situation when function $F(C_f)$ is nonlinear, which varies with C_f as $C_a \propto C_f^\beta$ i. e. $C_a = RC_f^\beta$; where R is a proportionality constant and β is the scaling factor determining the nonlinearity. In the presence of this nonlinearity, the Model, Eq. (1), becomes

$$I_{n+1} = L_T - R(I_n + P_s - L_T)^\beta \quad I_n > L_T - P_s$$
$$= I_n + P_s \quad I_n \le L_T - P_s \qquad (2)$$

3. Results and discussions

Results are shown in Fig. 1. The bifurcation diagram in Fig. (1) shows that if α < 1.15 the motion is periodic while afterward it is chaotic. An important observation is the occurrence of period-3 type window near α=1.4 which trajectory is shown in Fig. 1(b). It shows that once there is heavy fruiting then there is certain that there is no fruiting in the following year. Whoever there is intermediate fruiting before heavy year one. This happens as certain energy (photosynthate) after intermediate yield remains available for next year for heavy fruiting. This suggests that there is possibility of three years cycles instead of two years if nonlinear variation in C_f is considered.

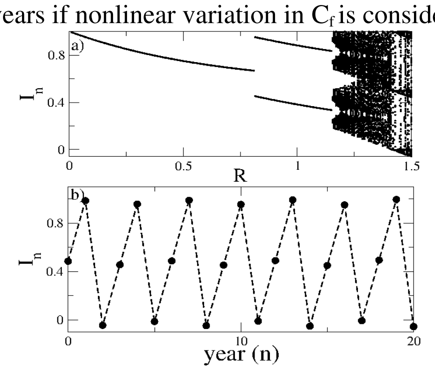

Fig.1. (a) Bifurcation diagram as a function R and (b) trajectory at R=1.4 for fixed β=0.5, L_T=1 and P_s=0.5.

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