

A prey–predator model approach to increase the production of crops: Mathematical modeling and qualitative analysis

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Received 24 July 2021

Revised 25 December 2021

Accepted 22 January 2022

Published 18 March 2022

This paper expresses the concepts, methods, and applications of mathematical models in agriculture. We propose and analyze an ecosystem consisting of two types of preys and their predators; here the prey-I like sugarcane crops that take a long time to grow and prey-II like vegetables, which have a short life, are grown with sugarcane crops and predators that harm both prey-I and prey-II. The various equilibria of the system are obtained, and the stability conditions are analyzed. Furthermore, a comprehensive analysis of the optimal control strategy is also performed. The optimal control model includes the use of three control variables, such as pesticide application rate, biomass application rate, and control of Cassava mosaic virus in the system. Finally, we apply Pontryagin's maximum principle to find the optimal control. Furthermore, analytical results are verified by numerical simulations.

Keywords: Prey–predator; crop; pest; optimal control; Pontryagin's maximum principle.

Mathematics Subject Classification 2020: 92B05, 37M05, 34D20, 93C10, 93A30

1. Introduction

Population constitutes the key elements of human geography. Due to the dynamic phenomenon of the population, it has been increasing at an alarming rate. India is the second most populous country, and it constitutes over 16% of the total population of the world. India has seen four distinct phases of demographic change during the 20th century: the phase of the stagnant population (during 1901–1921, the population of India increased from 238 million to 251 million), phase of steady growth (a period 1921–1951, the population of India increased from 251 million

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