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List of Research Papers presented in Conferences and Seminars

- Title of talk/paper is “On the stability of an Eco- epidemic model under pesticide as control measure”. The 4th International Conference on Mathematical Modelling, Applied Analysis Computation and (ICMMAAC2021), organised by Department of Mathematics, Faculty of Science, JECRC University, Jaipur (Raj.), India during 5-7 August, 2021.
- Title of talk/paper is “On the Local Stability of An Eco-Epidemic Model with Holling type II response between susceptible and infective plants and Linear response between infectives and application of pesticides”. International Conference on Recent Developments in Mathematics and Mathematical Sciences (ICRDMMS 2021), organised by Department of Mathematics, Calcutta Mathematical Society, Kolkata, India during 09-11 December, 2021.
- Title of talk/paper is “An Eco-epidemic model with disease in Plant populations and Pesticides as control measure”. International Conference on Mathematical Analysis and Applications (ICOMAA - 2022), organised by the Department of Mathematics, University of Kalyani, INDIA, during June 28-29, 2022.
- Title of talk/paper is “Analysis of stability, sensitivity index and Hopf bifurcation of Eco-epidemiological SIR model under pesticide application”. International Conference on Dynamical Systems, Control and their Applications, organised by Department of Mathematics, IIT Roorkee during July 01-03, 2022.
- Title of talk/paper is “Stability, sensitivity index and bifurcation analysis of an SIR eco-epidemic model under pesticide control”. Nonlinear Analysis and Application

(ICNAA2022), organised by the Department of Mathematics, Sonapur, Guwahati, India November 22 - 23, 2022.

- Title of talk/paper is “Bifurcation and stability analysis of crops eco-epidemic model”. Conference on Nonlinear Systems & Dynamics (CNSD), organised by the Department of Mathematics, IISER Pune, Pune, Maharashtra, India during 15-18 December 2022.
- Title of talk/paper is “Optimizing Plant Epidemic Control: A Mathematical Model Integrating Susceptible Plants, Infectives, and Herbivores with Pesticide Intervention”. 13th International Conference on Mathematical Modeling in Physical Sciences, held from September 30 to October 3, 2024, in Kalamata, Greece.

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- Balajied Me Syrti, Anuradha Devi, Ankur Jyoti Kashyap, *Analysis of Stability, Sensitivity Index and Hopf Bifurcation of Eco-Epidemiological SIR Model under Pesticide Application*, Communication in Biomathematical Sciences, e-ISSN: 2549-2896, Accreditation No. 85/M/KPT/2020. Vol. 6, No. 2 (2023), page no. 126-144, Published: 19-12-2023, SCOPUS indexed.
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- Balajied Me Syrti, Anuradha Devi, *Stability and control of a plant epidemic model with pesticide intervention*, International Journal of Advanced and Applied Sciences (IJAAS), Print ISSN: 2313-626X, EISSN: 2313-3724, Vol. 11, No.2 (2024), page no. 82-93 (SCOPUS indexed).
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- Balajied Me Syrti, Anuradha Devi, Aditya Ghosh, *A Mathematical Analysis of Plant-Pesticide Interaction: Existence, Uniqueness, and Optimal Control*, Global Journal of Pure and Applied Mathematics [GJPAM Print ISSN: 0973-1768, Online ISSN: 0973-9750]. Volume 20, Number 2 (2024), pp. 291-303.

First page of paper 1

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An Eco-epidemic model with disease in Plant populations and Pesticides as control measure

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Abstract
An eco-epidemic model with diseases in populations of plants is proposed and analysed in the present study, and pesticides are used as a control mechanism. Pesticides are assumed to be sprayed to populations of both susceptible and infected plant species. Linear responses between susceptible and infective, between susceptible and pesticides, and between infective and pesticides are also considered. The positivity and boundedness of the system have been proven. The conditions for the existence of all possible equilibrium points and local stability have been carried out. The Routh-Hurwitz Criterion has been used to demonstrate the model's endemic equilibrium point. In order to address the analytical results, numerical simulations were finally conducted.
Keywords: *Eco- epidemic model, Pesticides, Jacobian matrix, Stability analysis, Routh-Hurwitz Criterion.*

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I. Introduction

Ecology is the study of how organisms interact with their surroundings. Ecosystems are a subfield of ecology and are made up of both biotic (living things like plants, animals, and other species) and abiotic (non-living things components) in the environment [1]. Eugene Odum defined ecosystem as "A unit that includes all the organisms, i.e., the community in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles, i.e., exchange of materials between living and non-living, within the system".

Two crucial subfields of biological mathematics and applied mathematics are mathematical ecology and mathematical epidemiology. The amount of research in this area has increased over time, and a new field known as mathematical eco-epidemiology has formed [2]. For many years, the impact of pests on the agricultural sector has been a major disaster not only for farmers, but also on the ecosystems, human health and the environment in general. For the purpose of preventing and managing diseases brought on by pests to agricultural crops, the use of pesticides and other natural enemies of pests are becoming more and more crucial. As a result, mathematical models have emerged as a crucial tool for studying the transmission and management of such diseases. Mathematical modeling is the process of transforming real-world problems into mathematical equations and mathematically solving these equations, and the resulting solutions are then transformed into real-world phenomena [3].

Alfred Hugo et al. analysed an environmental epidemiological model with optimal control strategies for infected prey [4]. They noticed that spreading disease within the population tended to decline when the control rate of contaminated prey increased. To prevent contamination, it is advised to keep the infected population separate from the susceptible population. A Prey-Predator Model with Two-Stage Infection in Prey combined with pest control was developed by Swapan Kumar Nandi et al. [5]. They used the prey population as pests, and the chosen pests are then eaten by predators. Additionally, they draw the conclusion that providing food for the insect population's natural enemies has a significant impact on the pest population's eradication.

An eco-epidemiological model with a Z-type control mechanism was presented and examined by AK Alzahrani et al. [6]. They looked at a predator-prey paradigm in which the prey is exposed to disease transmission and has a Holling type II functional response. They noted that the disease's ability to produce chaotic vibrations can destabilised the system. They created a Poincare map and compute the Lyapunov

First page of paper 2

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Stability and control of a plant epidemic model with pesticide intervention

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ABSTRACT

This paper introduces a model for studying plant epidemics that applies pesticides to control disease spread among two types of plant populations: those that are susceptible and those that are already infected. The model uses non-linear ordinary differential equations and the Holling type II response function to depict how disease spreads based on the number of susceptible plants available. The model is carefully checked for biological accuracy, ensuring characteristics such as positivity and boundedness. It defines points of equilibrium where the numbers of susceptible and infected plants stabilize. The study looks at scenarios with no infected plants (disease-free equilibrium) and scenarios where the disease continues to exist within the plant population (endemic equilibrium). The basic reproduction number, R_0, is calculated to assess the system's stability. If R_0 is less than 1, the disease is unlikely to spread widely, and the system is likely to return to being disease-free, both locally and globally, over time. However, if R_0 is greater than 1, it indicates that the disease will persist in the population. This endemic state has also been shown to be stable both locally and globally. A sensitivity analysis helps identify key factors that affect disease spread and assists in forming strategies to manage the disease. Finally, numerical simulations are used to support the findings of the analysis.

1. Introduction

Mathematical models play a crucial role in understanding the impact of pesticides on various mathematical models can be used to study the unintended consequences of pesticide use. These include effects on non-target organisms, ecological disruptions, and shifts in the balance of predator-

First page of paper 3

Analysis of Stability, Sensitivity Index and Hopf Bifurcation of Eco-Epidemiological SIR Model under Pesticide Application

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Abstract

In this paper, a deterministic SIR plant mathematical model is proposed and analysed with the application of pesticides as a control measure. The primary purpose of this model is to study the role of pesticides in controlling disease prevalence in plant populations. The total plant population is subdivided into three categories: susceptible, infected, and recovered. Pesticides are considered to be applied to both susceptible and infected populations to prevent the spread of infection to unaffected plant populations. It is considered that plant populations can be recovered only through the use of pesticides. To ensure the biological validity and well-defined nature of the model, the positivity, boundedness, uniqueness and existence of solutions are analysed. The basic reproduction number (R_0) of the infection is determined and observed that the disease-free equilibrium state is locally asymptotically stable whenever (R_0) is less than unity and unstable otherwise. The sensitivity analysis of the basic reproduction number is carried out, and it is observed that the value of R_0 decreases as the value of the death rate and the recovery rate of plants increases. Moreover, it is revealed that above a critical parameter value of the infective induce rate, the population starts oscillating periodically, and the endemic equilibrium state becomes unstable. Finally, numerical simulations are conducted in MATLAB software to compare the analytical findings. Overall, the results obtained from this analysis are both novel and significant, making them an intriguing and potentially valuable contribution to the field of theoretical ecology.

Keywords: basic reproduction number, Hopf bifurcation, Routh-Hurwitz criterion, sensitivity index, stability
2010 MSC classification number: 34C23, 34D20, 49Q12, 92D25

1. Introduction

A plant is considered susceptible to infection when environmental factors alter its physiological processes, resulting in disruption of structure, growth, function, or other parameters. Plant diseases are classified into infectious and non-infectious according to the type of pathogen. Symptoms of the disease depend on its cause, nature and location of the affected area. Plant disease-causing factors can be both biotic and abiotic in nature. Non-infectious diseases are caused by unfavourable growing conditions. They are not transferred from diseased plants to healthy plants. On the other hand, infectious diseases can multiply inside or on the surface of plants, so infections can spread from one susceptible host to another [31].

Various infectious diseases that are frequently brought on by fungi, viruses, or bacteria affect plant ecological populations. These diseases can range in severity from minor leaf or fruit damage to death, and as a result, the plant populations lose their fertility, which causes a reduction in their population size. Some of the most prominent plant diseases are Algal leaf spot of tea: (Cephaleuros virescens), Pineapple mealybug: (Dysmicoccus brevipes), Brown Spot: (Helminthosporium oryzae), Cedar Apple Rust (Gymnosporangium juniperi-virginianae Schwein), Red rot: (Glomerella tucumanensis) and so on. Crop damage due to pests is a major cause of concern worldwide. According to a recent report released by the U.N. Food and Agriculture Organization in 2021, about 40 percent of the world's agricultural crops are lost to pests each year. Therefore, it is important to study plant infectious diseases in the ecosystem and find ways to control these diseases. One of the significant ways of combatting pests is the utilisation of pesticides which in the 21st century has become more and more necessary. In India, the production of pesticides began in 1952 with the construction of the BHC manufacturing plant near Calcutta, and India is presently the second largest producer of pesticides

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First page of paper 5

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A Mathematical Analysis of Plant-Pesticide Interaction: Existence, Uniqueness, and Optimal Control

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Abstract

This paper analyses the existence and uniqueness of solutions to the model equations established in [1], with an emphasis on plant population dynamics during pesticide application. The conditions that guarantee the existence of these solutions and their uniqueness are determined by using mathematical analysis. In addition, optimal control mechanisms are explored to successfully regulate plant population dynamics. The goal is to strike a balance between the benefits of pesticide use and the environmental and economic concerns that come with it. The findings contribute to a more comprehensive understanding of plant population regulation in agricultural systems and provide critical insight into sustainable pesticide application.

Keywords: Plant diseases, Mathematical Modelling, Pesticide, Optimal control, Pontryagin's Maximum Principle.