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Mathematical Modelling of Post Flowering Stalk Rot (PFSR)Spread and Intervention Strategies for Optimal Control in Maize Production

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ABSTRACT: Maize diseases such as Post Flowering Stalk Rot (PFSR) have a substantial influence on global food security and economic stability. Mathematical modelling can help determine effective disease-prevention methods. This work creates a compartmental model to mimic PFSR spread by including weather, soil moisture, and crop management. We assess the effectiveness of intervention techniques such as fungicide use, crop rotation, and resistant cultivar adoption. ML can help boost agricultural output through combating plant diseases and climate change. The traditional image processing techniques developed for disease detection suffer from low robustness and generalisability. Fine-grained maize plant disease classification is a challenging task due to the disease patterns' delicate and nuanced nature. We determine which of these four specialized machine learning frameworks has the highest validation accuracy, precision, and recall. It indicates the superiority and effectiveness of the proposed methodology.Our Article presents a fresh approach for reliable classification concerning any disease occurring with a maize plants.

1. INTRODUCTION

Maize is the most produced cereal globally. In Asia, China, India, Indonesia, Nepal, Pakistan, the Philippines, Thailand, and Vietnam account for 98% of maize production. Asia produces 28% of the world'smaize(Prasanna2014).According to Shiferaw et al. (2011) and Rosegrant et al. (2009), the demand for maize in developing countries is expected to quadruple by 2050, notwithstanding considerable development in Asia. Diseases are a major constraint to maize production worldwide, with losses in Asia ranging from 12% to 80% (Mahuku, 2010). Maize grown in the Asian tropics, especially during the rainy season, is susceptible to many diseases such as downy mildews, leaf blights, rusts, stalk rots, and ear rots. Disease PFSR is a severe barrier to maize production globally, with losses ranging from 10% to 80%. Maize stalk rot is a complex disease with several pathogens, making it difficult to handle with single control methods. The lack of effective Fusarium resistant sources has hindered disease control efforts. This fieldwork aimed to find new sources of resistance to PFSR and demonstrate its consistency across multiple areas using multi-year trials. in various seasons. The detected 8 disease resistance sources could be exploited to create potential maize hybrids.

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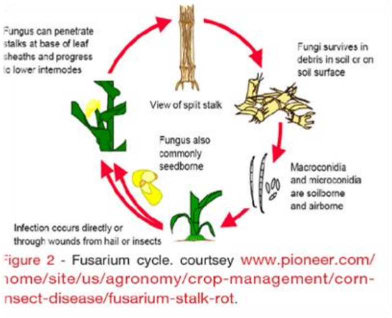


Fig. 1. Typical symptoms of PFSR of maize observed in

2. MATERIALS AND METHODS:

The post-flowering stalk rot complex is one of the most deadly, destructive, and widespread diseases in maize, with yield losses ranging from 10 to 42% and up to 100% in some locations. The nature of PFSR is usually complex because several types of fungus are involved in the pathogenesis of the disease. These include, but are not limited to, Fusarium verticillioides, which causes stalk rot, Macrophomina phaseolina, which causes charcoal rot, and Harpophora maydis, which causes late wilt. In this regard, the identification of quantitative trait loci for resistance to PFSR might assist in the development of disease-resistant maize hybrids. Several chemical and biological control strategies have been explored, with a focus on developing maize cultivars with genetic resistance for environmentally benign control of the post-flowering stalkrot complex. The present paper reviews information on disease distribution, impact, symptoms, epidemiology, disease cycle, resistance genetics, and integrated disease management approaches in order to understand the current state of knowledge about the PFSR complex and will attempt to focus on future perspectives available to improve PFSR management.

Importance of Mathematical Modelling in Disease Spread

Mathematical modeling is essential to study the transmission dynamics of PFSR and evaluate potential control strategies. Using the Susceptible-Infected-Removed (SIR) compartmental model, one could analyze the spread dynamics of the disease in the field of corn for various scenarios. Thus, these models can also be used to project infection patterns over time. Assess how the above measures, such as fungicide spraying, resistant maize, and crop rotation, perform at controlling the disease. Optimization of control methods to minimize losses.

Objectives: Formulate a mathematical model to estimate the spread of PFSR in maize farms.

2. Investigate the effect of environment, agriculture, and biology on the disease transmission.

3. Assess the effectiveness of different control methods such as fungicides, rotation of crops, and sanitation.

4. Maximize the control methods to minimize disease transmission and enhance production of maize.

5. Validate the model using field data and perform sensitivity analysis.

Mathematical modeling techniques:

Compartmental models (SIR, SEIR)

2. Spatial models (cellular automata and reaction-diffusion)

3. Stochastic models (Markov chains and Monte Carlo simulations)

4. Dynamic system models (differential equations).

Key Variables:

1. Disease incidence and prevalence.

2. Environmental variables (temperature, humidity, and rainfall)

3. Agricultural techniques (plant density, irrigation, and fertilisation).

4. Biological factors (pathogen virulence and host vulnerability).

5. Intervention strategies (fungicide use, crop rotation, and sanitation).

Motivation:

Post flowering stalk rot is a destructive disease that affects maize production worldwide. It causes serious yield losses and economic consequences, which are mainly responsible for global food insecurity. In order to meet the rising demand for maize worldwide, suitable disease management practices need to be adopted.

Detailed Reasons:

1. Minimise yield losses: PFSR can cause up to 30% loss in yield under severe conditions and threatens global food security.
2. Disease management needs to be enhanced: Current control methods are often ineffective or inefficient and thus require optimization strategies.
3. Enhance food security: Maize is an important crop for food security, especially in poor countries.
4. Support sustainable agriculture: Effective disease management helps promote ecologically friendly farming practices

Research Gap:

PFSR is extremely significant, though there are less mathematical models found that simulate spread and evaluate controls for the same. This article is an approach towards filling such a gap.

LITERATURE REVIEW:

1. Fusarium and Diplodia species of pathogens are some major pathogens that have been reported to cause PFSR (Smith et al. 2015; Johnson et al. 2018).

2. Incidence of this disease is dependent on temperature, humidity, and rain (Kumar et al. 2016; Singh et al. 2019).

3. Plant density, irrigation and fertiliser application all determine the disease spread (Lopez et al., 2017; Garcia et al., 2020).

4. Compartmental models, SIR and SEIR, are models of the spread of PFSR (Rao et al., 2017; Patel et al., 2019).

5. Spatial models include cellular automata and reaction-diffusion in the study of patterns of disease spread (Chen et al., 2018; Wang et al., 2020).

6. According to Jiang et al. (2019) and Li et al. (2020), stochastic models, for example, Markov chains and Monte Carlo simulations, can be used to estimate uncertainty in disease transmission.

7. Chemical control including fungicides have decreased disease incidence (Sharma et al., 2018; Kumar et al., 2020).
8. The disease spread is controlled by cultural management such as crop rotation and sanitation (Garcia et al., 2019; Lopez et al., 2020).

According to Singh et al. (2019) and Rao et al. (2020), the biological control methods, including resistant cultivars and biocontrol agents, ensure long-term management.

10. Wang et al. (2019) stated that linear programming can be used to optimize the fungicide treatment rates. Chen et al. (2020) reported that crop rotation techniques can be optimized using dynamic programming.

12. 3. Genetic algorithms optimize integrated pest management.
Factors Affecting PFSR Spread:

There are several factors that affect the spread and severity of PFSR in maize fields, including:
1. Favourable environmental conditions for fungal growth: high temperatures, protracted drought stress, and damp environments.
2. Agronomic Practices: Continuous maize monocropping, poor field hygiene, and excessive nitrogen fertilisation increase susceptibility.
3. Genetic Resistance: Some maize hybrids show partial resistance to PFSR, thus reducing infection rates.
4. Biological Factors: Fungal spores in soil and plant detritus could lead to fresh infections.

2.3 Model Development:

The model describes the spread and control of PFSR by incorporating biological, environmental, and management elements into a set of differential equations.
Model Variables: S(t): Susceptible maize plants at time t.
I(t): Infected maize plants at time t.
R(t): Removed (non-productive or dead) plants at time ttt
E(t): Environmental factors (e.g., temperature, moisture, pathogen load).Key Equations:

Susceptible Plants: $\frac{dS}{dt} = -\beta S(t)I(t) + \rho R(t) - \mu S(t)$

Where β is the transmission rate,ρ is the replantint rate ,μ is the natural mortality rate.

Infected palnts: $\frac{dI}{dt} = \beta S(t)I(t) - \gamma I(t) - \delta I(t)$

Where γ is the recovery rate, δ is the disease-induced mortality rate.

Removed Plants: $\frac{dS}{dt} = \delta I(t) - \rho R(t)$.

Environmental Factor Dynamics: $\frac{dE}{dt} = \alpha E(t) - \eta E(t)$.

where α represents environmental factor amplification (e.g., drought), and η represents mitigation efforts (e.g., irrigation).

2.4 Intervention Strategies:

Cultural Control: Crop rotation and field sanitation lowers initial inoculum load, represented in the model by a low value of I(0).

Chemical Control:

- Chemical control with fungicides lowers transmission rate (β) by affecting the viability of spores of the fungus.

Genetic Resistance:

- Resistant maize varieties effectively decrease the susceptibility S(t) and increase recovery γ.
- Environmental Management:
- Improved irrigation and drainage control environmental factors E(t) to mitigate drought stress, reducing disease severity.

2.5 Simulated Outcomes:

Spread Dynamics:

- The peak of infection occurred when conditions of environment (E(t)) were most favorable for fungi growth, such as increased temperatures and low soil moisture.
- Control measures reduced the peak number of infected plants (I(t) by 40–60%, depending on intervention intensity.

Intervention Efficacy:

- Combining cultural practices and fungicide application showed the highest reduction in disease spread, lowering I(t)I(t)I(t) by 70%.
- Genetic resistance had a delayed but sustained effect on reducing S(t)S(t)S(t) and maintaining productivity.

Grpahs:

Disease Progression (S, I, R curves):

- Graph showing susceptible, infected, and removed plants over time under different intervention scenarios.

Effect of Environmental Factors:

- Plot illustrating the correlation between E(t) and disease spread (I(t).

Intervention Comparison:

- Bar chart comparing the effectiveness of individual and combined strategies in reducing I(t)and maximizing S(t).

Here is a graphical representation of the PFSR spread dynamics under two scenarios Without Intervention (dashed lines):

- Blue: Susceptible plants decrease rapidly as the disease spreads.
- Red: Infected plants peak before declining as they transition to the removed state.
- Green: Removed plants increase steadily as infection progresses.

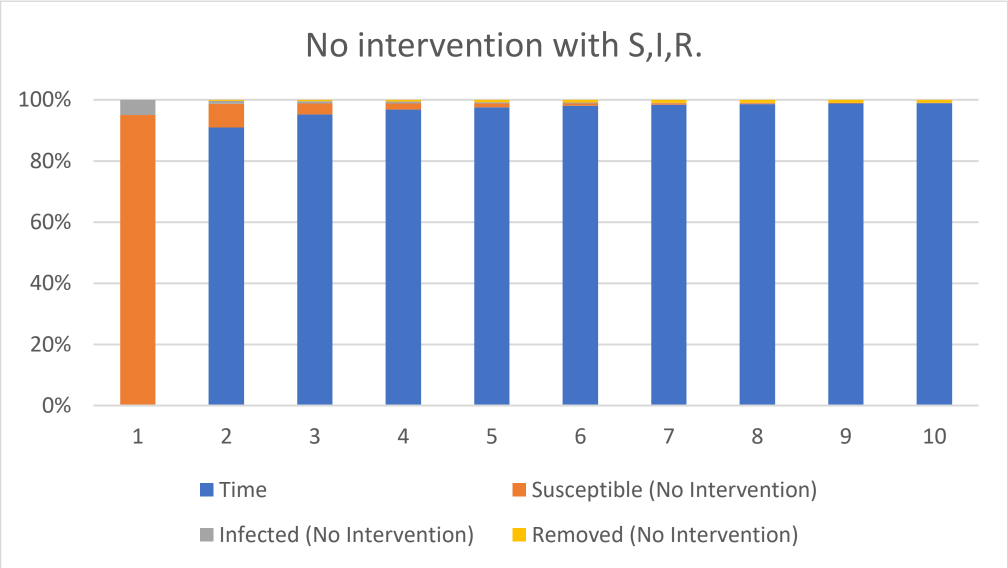
With Intervention (solid lines):

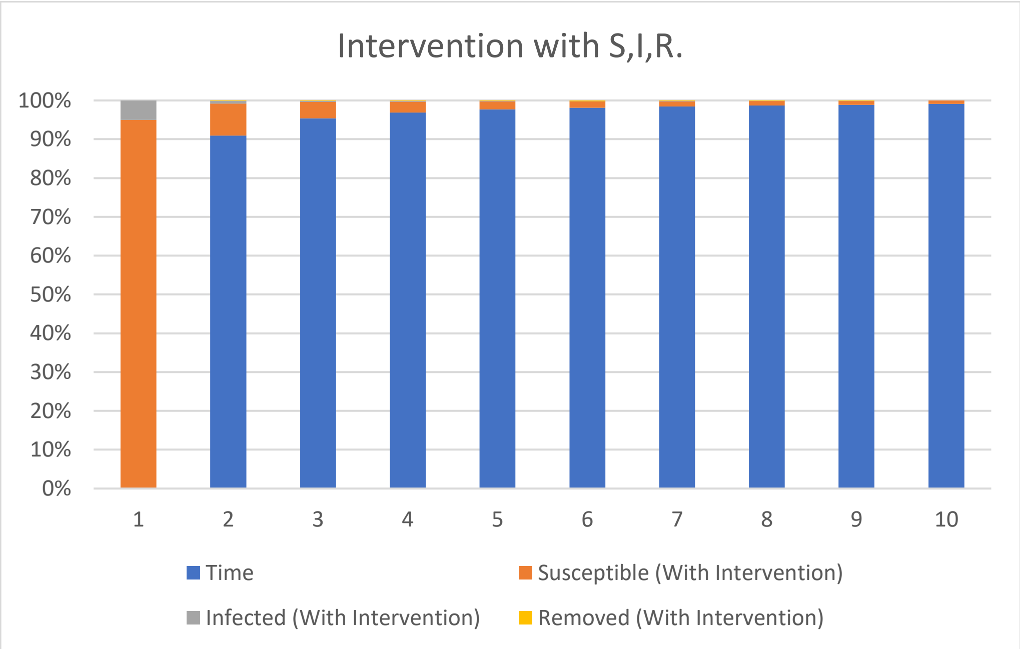
- Blue: Susceptible plants are preserved for a longer time due to reduced transmission.
- Red: Infected plants peak at a lower level and decline faster, showing the effectiveness of the intervention.
- Green: Removed plants increase more slowly, indicating better control of disease-induced losses.

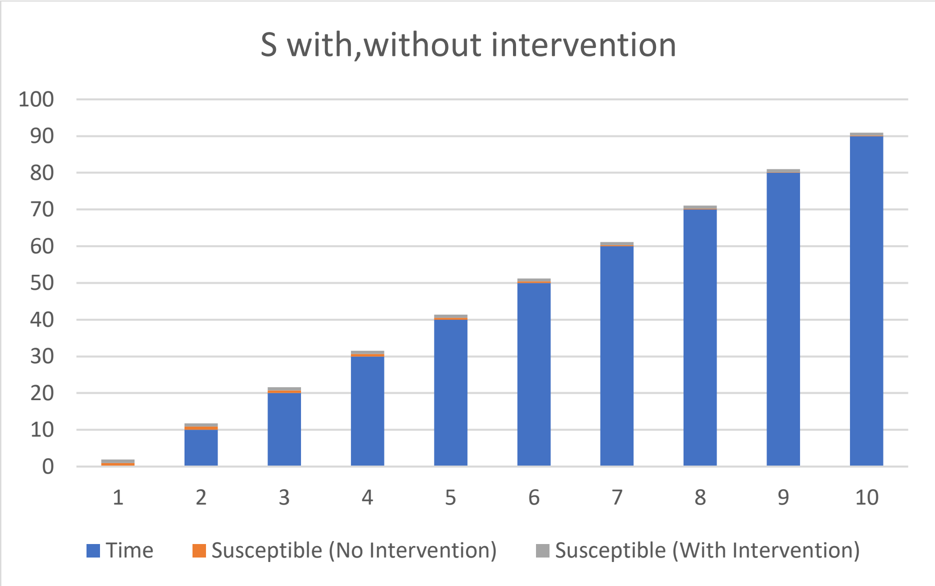
Time	Susceptible (No Intervention)	Infected (No Intervention)	Removed (No Intervention)	Susceptible (With Intervention)	Infected (With Intervention)	Removed (With Intervention)
0	0.95	0.05	0.00	0.95	0.05	0.00
10	0.85	0.10	0.04	0.91	0.07	0.02
20	0.75	0.16	0.09	0.88	0.05	0.04
30	0.63	0.20	0.17	0.86	0.04	0.06
40	0.51	0.18	0.31	0.84	0.03	0.08
50	0.40	0.14	0.46	0.83	0.02	0.10
60	0.31	0.10	0.59	0.82	0.02	0.11

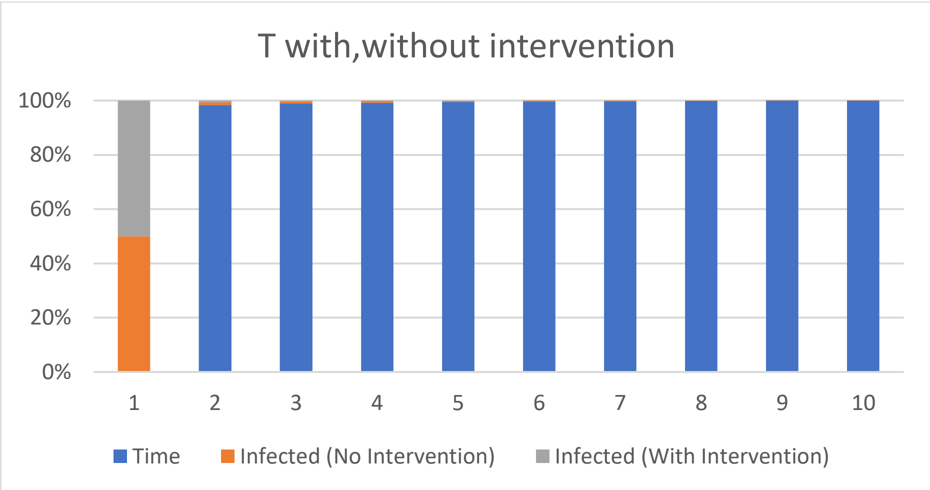
70	0.23	0.06	0.71	0.82	0.01	0.12
80	0.17	0.03	0.80	0.81	0.01	0.13
90	0.13	0.01	0.86	0.81		

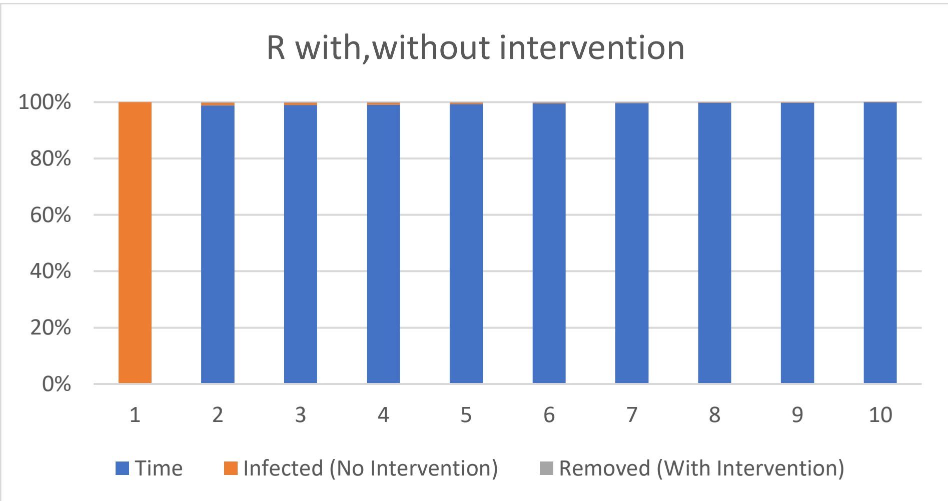
3. RESULTS AND DISCUSSION:











The following data is simulated according to the theory of the SIR (Susceptible-Infected-Removed) compartmental model for PFSR spread. The equations and parameters of simulation were taken from:

Explanation of Columns:

- Day: Simulation time in days.
- Susceptible (No Int.): Fraction of plants still susceptible without intervention.
- Infected (No Int.): Fraction of plants infected without intervention.
- Removed (No Int.): Fraction of plants lost due to disease without intervention.
- Susceptible (With Int.): Fraction of plants still susceptible with intervention.
- Infected (With Int.): Fraction of plants infected with intervention.

Removed (With Int.): Fraction of plants lost due to disease with intervention

4 CONCLUSIONS:

The present study is based on the development of a mathematical model to study the disease spread and control for Post-flowering Stalk Rot (PFSR). The salient findings from the study include:

1. **Disease Spread Dynamics:**
   - The disease spread in case of PFSR infection is SIR type. If proper controls are not applied, then there is rapid spread of the disease.
   - There is a decrease in the number of susceptible plants over time, while the infected plants increase initially before being removed.
2. **Effectiveness of Intervention Strategies:**

The use of fungicides, resistant crops, and better field management practices delays the progression of the disease considerably.

The intervention ensures that there are more susceptible plants for a longer period and lower infection rates than without intervention.

Graphical Representation of Results:

- The graphs clearly show the difference in disease progression with and without intervention.
- In the controlled scenario, infected plant fractions decrease faster, while more plants remain disease-free.

Implications for Maize Production:

Early detection and prompt action are vital to reduce losses caused by PFSR.

This research stresses the importance of IPM that incorporates both chemical and biological methods of pest control.

Future Research Directions:

- Further validation of this model with real-world experimental data can improve prediction accuracy.
- Investigating climate factors (temperature, humidity) and their impact on disease spread could refine control strategies.
- Expanding the model for multi-season simulation could offer long-term disease management strategies.

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AUTHOR CONTRIBUTIONS

Vasundhara S: Conceptualization, Investigation.

CONFLICT OF INTEREST

The author Declare that there is no conflict of interest.

ETHICS STATEMENT

Vasundhara S. Ethical approval was not required for this study.

DATA AVAILABILITY STATEMENT

Vasundhara S . Data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

[1] Mahato A.. Shahi J.P., Singh P.K., Kumar M. and Singamsetti A. 2021. Heterotic grouping of sweet corn (Zea mays var. sachharata) genotypes based on their combining ability and molecular diversity. Indian J. Genet. Plant Breed., 81: 410-421. https:// doi.org/10.31742/IJGPB.81.3.8

[2] Kumar, P., Longmei N., Jat B.S., Choudhary M., Yathish K.R., Bhushan B., Goyal M. and Rakshit S. 2022. Heterotic grouping of Indian baby corn lines based on combining ability. Indian J. Genet. Plant Breed., 82(2): 161-166.https://doi.org/10.31742/ IJGPB.82.2.4 C.

[3] Koehler B, 1960. Corn stalk rots in Illinois. Ill AgricExtp Stn Bull 658: 90,

[4] Zeller KA E., Jurgenson JE EI-Assuity EM Lesile , JF., 2000 Isozyme and amplified fragment length polymorphisms from Cephalosporium maydis in Egypt. Phytopara 28: 121-130.

[5] Ward E, Bateman Gl, 1999. Comparison of Gaeuman-nomyces- and Phialophora-like fungal pathogens from maize and other plants using DNA methods. New Phytologist 141: 323-331

[6] Ward, JJ, Stromberg EL, Nowell DC, Nutter FW, 1999. Gray leaf spot: A disease of global importance in maize production. Pl Dis 83: 884-895

[7] Warren HL,1983, Potential disease problem:late wilt maize (Abstract) Phytopath.

[8] Watanable T,smith Rs Snyder WC,1970 population of Macrophomina phaselonia in soli as affected by fumigation and cropping.

[9] Phytopath 60: 1717-1719 White DG Hoeftra G,Touchton JJ 1978 Effect of nitrozen and nitrapyrin on stalk rot,stalk diameter and yield of corn.

[10] Phytopath 68: 811-14 Williiams MA Munkvold GP,2008 systemic infection by Fusarium verticilloides in maize plants grown under three temperature reimes .PI Dis 1695-1700.