A Deep Dive into Phytophthora infestans: Late Blight in Tomato Production

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Abstract

Tomato crop is a major crop used in almost in every home. There are many buy products are available with adding tomatoes has basic ingredients. The formers in India are facing many problems in yielding tomatoes profitability. The economy of the formers and Indian economy also depends upon proper yielding of healthy tomato crop. Many infections and diseases causes sever damages to proper growth of tomato plant. Many diseases such as Early Blight, Leaf Mold, Septoria Leaf Spot and Target Spot and basic infections found on tomato crop. Virus infections such as Mosaic Virus and Yellow Leaf Curl some of viral attacks founds on tomato leaf. The problem discussed may affect the proper growth of tomato crop and results in major yielding. The research work focuses on early detection of tomato infection and giving a proper solution based on the historical data collected from previous infected crops. This paper gives an idea about various infection found on tomato plant and it also evaluate various methodologies and algorithm available for simulation. This detailed review shows the significant of using machine learning algorithms to find infection on tomato crop.

Keywords: Early Blight, Septoria Leaf Spot, Leaf Mold and Target Spot.

Introduction

Indian agriculture field basically depends upon two major crops namely onions and tomatoes. Experts in India determine the growth of the economy by estimating these crops growth and price. Almost every families live in India consumes these crops in daily bases. Sub sequence food items produced with these basic crops as raw materials are also developed day by day.The basic commodities used in restaurants, households and hotels are ketchup, puree and juice, which is also products of tomatoes. The products are very useful in enhancing the taste of dishes made. The fresh tomato for cooking is replaced with tomato puree in most of the places.

There are many infections causes Sevier damage in growth of tomatoes.Damping Off, Bacterial stem, Bacterial leaf spot, Septoria leaf spot, Early blight, Mosaic, Bacterial wilt, Tomato spotted wilt disease, Leaf curl, Fusarium wilt and fruit canker are few among infections.The symptoms found on tomato plans are very difficult to analyses for farmers in early stage. There are many systematic approaches solves those problem by implementing early disease identification process.

Image processing and data mining plays a major role in identifying severity level and inspecting the type of disease affects tomato plant. The data used for research work basically collected from farmers and disease types were categorized accordingly based on the type and severity levels. Necessary treatment and solutions are also inspected with agricultural officers are relevant disease types collected from various farm land. Many researches uses these image processing technique for producing a computerized applications, which generate a proper solution to relevant infections occurs in tomato crop.

The early identification processes are very much useful for farmers to give necessary solutions for infected crops. The process carried out in systematic approach should follow new technologies with latest disease updates in efficient way. Even though there are many systematic approaches are available, there is lot of problems in finding the results and giving the solutions accurately. Machin learning algorithms and neural network algorithms are used successfully to accelerate the disease finding ability with effective technological approaches.

This review paper gives a detailed view of approaches used in the field of image processing and Machin learning in finding the affected parts of tomatoes. The focus of the paper is not limited in using various approaches in finding the best algorithm for early identification of tomato infections with high accuracy. It also gives a detailed view of various researches work on tomato disease identification using various approaches.

Literature Review

The largest producer of potato plant in South American fields faces Late blight disease, which is known to be native for Late blight. The Late blight disease are notified in United States in the early 1843, which shows Sevier infections almost east coastal areas of North America [1]. The disease symptoms are observed in Belgium in 1845 and shows major impact in spreading throughout Scotland, Switzerland, France, Britain and many neighboring countries [2]. The spread of late blight throughout European countries make impact in downfall of economy and yielding of crops. The disease infections have started to damage potato plant every years from 1845 [3] and makes damage not only to potato plant, it also started to show its symptoms to other crops as well. Late blight A2 mating type of phytophthora infestans was found in Mexico, later the same type is reported in Switzerland in 1981 [4].

The spread of the disease might have happen due to migrations of potato pathogen from Mexico to other parts of Europe and the export of potato started from 1977 onwards [5]. The type A2 infections found in England are reported to be the potatoes imported from Egypt [6]. Most of Asian countries faced the same phytophthora infestans type A2during those period, which are not recorded properly due to technologies available on those days [7],[8],[9],[10],[11]. The type A2 disease infections are found in Africa [12], Europe [13 -16] and South America [17], [18] are also not

recorded properly. The demonstrations of phytophthora infestans Genetic analysis conducted by pan-global training systems 1980 [19] suggested that the type A2 worldwide spreading are not because occurs from disease originated county and not due mutations.

The type A2 infections transmission occurs around most of the parts in world are not only happened because of mutations or migrations, it may also happened due to the germination process happed between infected plant and uninfected plant [20]. The fungal effects found in the period of fertilization may have the possibility of phytophthora infestans in potatoes and tomatoes crop in Europe and North America [21-23]. The research work carried out in Japan found that the infections happening during the fertilization process of the plant has not occurred due to the factor of crop offspring [24]. Some research works carried in the United States have found few difference and variations in A2 type of phytophthora infestans found in potatoes. The finding of the research has globally made an impact on learning few different type of phytophthora infestans, such as US-8 (A2, the oldlineage), US-21 (A2, tomato-specific type), US-22 (A2,isolated from tomato and potato), US-23 (A1, isolated from tomato and potato) and US-24 (A2, potato-specific type) [25]. The survey conducted in Ireland found the decrease in percentage of disease from 70 percentage to 16 percentage in 13_A2 type infection. Few other infections 5_A1 and 8_A1 shows significant difference mutations, but it has not changed the structure of 6_A1 type infections.

The research work carried out in Britain show significant increase in genotype 6_A1, which is very different from other research work carried in the field of genotype [26]. The Chinese research conducted on domestic genotypes also shows some resemblances with the work carried out in research work conducted in Britain [27]. The came genotype research based on A1, US-1 and SIB-1 also reviled in Russia [28], which shows much more similarities in phytophthora infestans. The similarities in result of identifying phytophthora infestans symptoms all around the areas of Taiwan in later 2006 also shows significant similarities with other research work carried out in stating the phytophthora infestans severity level in potatoes and tomatoes.

Material and methods used in identifying phytophthora infestans

The research finding carried out in different parts of the world is different from each other in using materials and methods. Some researcher has used genotype difference in finding the disease affected in potatoes and tomatoes. Few researcher works on the image processing techniques and machine learning algorithms in finding out the best way of identification process. This particular session made an attempt to inspect the materials and methods used in the phytophthora infestans research.

Table 1: Existing methodologies in finding phytophthora infestans

Author	Year	Title	Methodology	Description
Hung K. Doan, et., al [29]	2016	Survey of Molds in California Processing Tomatoes	Fisher's exact test and the SAS/STAT	The associations at $\alpha = 0.10$ level have independent possibilities of incidence, which is taken for two pairwise types at the same time and failure occurs for null hypothesis.
Gentle 2003[30]	2003	Random number generation and Monte Carlo methods.	Monte Carlo simulation (Assay Design)	More than 10 fungal types are taken for 5 LFD immunochromatographicMAbs assay for performing conceptual multistrip.The data collected in the research work uses these fundal types for sampling tomato to inspect the contaminations based on fundal affects. Stemphylium, Alternaria, Rhizopus,Aspergillus,Rhizoctonia ,Botrytis,Penicillium,Cladosporium,Geotrichum and Fusarium are the discussed fundal types for the study.
K. Möller., et., al[31]	2009	Population studies on Phytophthora infestans on potatoes and tomatoes in southern German	1. Polymerase Chain Reaction (PCR) is taken for Mitochondrial DNA haplotypes 2. Research work uses mtDNA haplotype for classification process	The collected isolated samples in 1995 from German almost has total 56 A1 type and only one A2 mating type. The collected isolated samples from 1999 has 72 isolates mating for A1 and only 12 mating type for A2.

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J. Tumwine , H. D. Frinking& M. J. Jegerp[32]	2010	Tomato late blight (Phytophthora infestans) in Uganda	Compatibility test for Phytophthora infestans isolates	The samples collected from 10 different districts form Uganda classified based on the temperature, sunshine and rainfall are taken for identification of Tomato late blight. A1 and A2 mating type are found in the Oospores compatibility test.
Ha Tran., et., al[33]	2007	Role of the cyclic lipopeptide massetolide A in biological control of Phytophthora infestans and in colonization of tomato plants by Pseudomonas fluorescens	1. ANOVA 2. Wild -type 3. SS101 4. Mutant 10.24	The control measures taken for late blight are producting CLP surfactant massetolide A and versatile function in the ecology of stain Phytophthora infestans, which helps in giving additional support in measuring infections.
Reza Ghaffari., et., al[34]	2010	Early Detection of Diseases in Tomato Crops: An	Principal Component Analysis (PCA), Electronic Noses (ENs), K-Means clustering and Fuzzy C-Mean	Best means known as Electronic Noses was implemented for classifying diseased and healthy tomato plants. The classification rate can be increased with the use of ANN classification as enhanced strategy followed for different numbers of samples.

		Electronic Nose and Intelligent Systems Approach	(FCM)	The Electronic Noses usage can be considered as cheaper way for making decision support in instrumentation used with sensor channels.
F.Z. Rekad., et., al[35]	2017	Characterization of Phytophthora infestans populations in Northwestern Algeria during 2008 to 2014	Simple Sequence Repeat Marker analysis	The type Algerian Phytophthora infestansisolations are selected with copied alleles continuously for each venue and gene diversity. MATLAB Software is used as a basic tool for determining the SSR data collected based on gene classification.
Andrea P. Zuluaga., et., al[36]	2016	Transcriptional dynamics of Phytophthora infestans during sequential stages of hemibiotrophic infection of tomato	Macroscopic Observation, Microscopic Evaluation and Molecular Assessment are carried out for symptomatic leaves, Pathogen development and biotrophic/ necrotrophic development for Phytophthora infestans.	The comparisons are made for pathogen progresses from biotrophic to necrotrophic growth for plant are observed. The dynamic transcriptions for Phytophthora infestans affect are completed with pathogenicity during different stages of infections. The infections in each stage are calculated for further treatment stage.

The table 1 shows significant contributions made in identifying Phytophthora infestans among plants. The methodologies discussed in the existing papers follows scientific and genomics way for segregating the disease stage into different levels. Few research work focuses on using PCA and

clustering technique for segmentation process and they even use some machine learning algorithms. The classifications algorithms such as K-mean, ANN and FCM are also used for classifying diseases affected parts of plant from healthy parts.

Measurements used in identifications of phytophthorainfestans

Table 2: Measurements used in phytophthora infestans

Author	Year	Title	Algorithm / Software	Parameters/ Measurements Used	Description
E. Mine Soylu., et., al[37]	2006	Antimicrobial activities of the essential oils of various plants against tomato late blight disease agent Phytophthora infestans	Analysis of Variance (ANOVA),	Duncan's Multiple Range test (DMRT)	The pairs of means differences are calculated with the usage of Duncan's Multiple Range Test (DMRT). The gathered result from the earch work stages that the essential oils extracted or produced from the plant are used as protection and gradually control the Phytophthora infestans affects in plant. The study also suggests that instead of using synthetic fungicides, essential oils can be replaced for development of new antifungal compounds in disease affected parts of leaves.
Yuan-Yuan Zhang., et., al[38]	2021	Function identification of miR394 in tomato resistance to Phy	SPSS statistical software 22.0 (United States).	T-Test and Duncan's Multiple Range Test and Statistical evaluation	The competitions for treatment were given for Phytophthora infestans using three different techniques such as t-test, Duncan's Multiple Range and Statistical evaluation with setting $P<0.05$. The result collected form the experiments states that the expressions of JA related

		tophthora infestans			genes are frequently changes in various levels of LCR with the usage of miR394.
S.A. Miller., et., al[39]	2015	A systems approach to tomato disease management	Delphi Decision Making Process	Greenhouses test	The greenhouse samples of each leaves have resemblances of Botrytis cinerea. Continues simulations separate the pathogen from plant debris with the use of greenhouse test. The conducted tests are evaluated using data conversion process.
Yushi Luan., et., allllll[40]	2016	MiR1918 enhances tomato sensitivity to Phytophthora infestans infection	sly- and pi-miR1918 was performed using psRNATarget	i) Maximun expectation ii) Length for complementarity iii) Target accessibility iv) Range of central translational	The research work was conducted with ME as 3, Length of complementarity scoring as 20, 200, target accessibility to unpair the target site as 25, Flanking regions target accessibility as 13bp downstream and 17bp for upstream and range for mismatch leading inhibition as 9.The analyzing stage was carried out with SPSS and collected data was expressed as mean for each unique experiment. Duncan's Multiple Range test is conducted with setting range $P<0.05$ for experiment.
Alessandro Pirondi., et., al[41]	2016	Post-infection activity of fungicides against Phytophth	Arcsine Square Root transformation and SAS software version 9	TheDIFF option for the command LSMEANS and means were separated based on significance at $\alpha<0.05$	The post infections of LB activities on CAA are measured for better understanding the results of treatment. The results collected from the fields are mostly for developing a solution in minimizing the risk factor of infections.

		ora infestans on tomato (Solanum lycopersicum L.)			
M. Zhang., et., al[42]	2010	Spectral discrimination of Phytophthora infestans infection on tomatoes based on principal component and cluster analyses	Remote sensing technology,	PCA revealed that the first eigenvector accounted for 58.73% of the variance of the original data set and the second for 35.51%. All of the other eigenvectors only accounted for the remaining 5.76%.	The PCA segmentation used in the research work is very useful in extracting the necessary disease affected parts from healthy parts. The result suggested that applying proper pest control solutions cannot cure the disease, but it can reduce the probability change of spreading the disease to neighbor plant.
[43]Y. Cohen., et., al	1996	Oospore Production of Phytophthora infestans in Potato	Duncan new multiple range test	The number of oospores was counted at each of two 8-mm2 sites per leaflet.	The clustering technique of grouping identical data based on oospore count are taken for analyzing mating type ratio. The analyzing stage uses Duncan New Multiple Range test for establishing significant difference in probability level.

		and Tomato Leaves			

Table 2 shows various research work carried out in exploring the treatment and necessary identification process followed in Phytophthora infestans. The algorithms and parameters used for evaluation process are also every clearly explained. The researchers are common in using Duncan New Multiple Range test for finding mating type ratio and PCA technique for segmentation of diseased plant from healthy plant.

Similarities between Potato and Tomato Phytophthora infestans

The research work carried out in different parts of the work are common in examining Phytophthora infestans affected crops. Some of the work focuses on examining cauliflower, beans, potatoes and tomatoes in common. Among many research work it is states that the Phytophthora infestans affected plant are identified as potato and tomatoes. The measurement and algorithms used in examining the severity level of Phytophthora infestans among different plans are also similar, which makes an idea for researchers to use similar methodologies for identifying disease affected parts of tomatoes and potatoes.

Table 3: Potato and TomatoPhytophthora infestans

Potato	**Tomato**
The infections are first found in potato (as per record given from various survey works)	The Phytophthora infestans found in Tomatoes are considered to be transmitted disease from potatoes
The DNA and RNA Extractions methods followed in finding Late Blight-Infected areas of potato are tested under same conditions.	Few researches have used new techniques in extracting DNA and RNA process. (e.g.: sly- and pi-miR1918)
Most of the research work conducted for potato infections are carried out with Duncan new multiple range test	Most of the research work conducted for tomatoes infections is not limited in using Duncan new multiple range tests. They also used PCA and Clustering techniques for enhancing the accuracy of predictions.
Disease identification process followed for potatoes have used basic classification	Disease identification process uses some of classification algorithms such as K-Means

algorithmic technique such as PCA for categorization.	clustering and Fuzzy C-Mean (FCM)

Conclusion

Phytophthora infestans on tomato and potato crops are mostly affecting proper yield and gives serious problems to formers. This research paper gives review on showing significant different between tomato and potato infection and it also discusses techniques used for DNA and RNA processing between tomato infection and potato infection. DUNDAG new multiple range test, PCA (Principle Component Analysis) and clustering techniques followed for enhancing the accuracy of prediction this also reviewed and detailed. This disease identification process using different classification techniques such as K-means, Clustering, and Fuzzy C-means discussed in this paper. Gives an idea for identification process followed for tomato infections. This parameters and measurements used for evaluation process by different researchers and used algorithms or software's for evaluation process are also discuss clearly. Image processing and data mining algorithms used for finding tomato infections are also discussed with proper solutions.

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