

**AWARENESS AND TECHNOLOGICAL READINESS FOR BACTERIAL
BLIGHT DISEASE MANAGEMENT IN POMEGRANATE CULTIVATION****Mr. Rahul S. Navale¹, Dr. Nusrat Khan²**^{1,2} SIOM-SPPU Pune.Email: rahulnavale81@gmail.com¹, nusrat.khan@sinhgad.edu²**Abstract**

Bacterial Blight Disease (BBD) is one of the most destructive diseases affecting pomegranate cultivation, causing significant yield and economic losses among farmers. The present study investigates stakeholders' awareness, perceptions, and management practices related to BBD in pomegranate crops. A structured questionnaire survey was conducted among 109 respondents, including pomegranate farmers, agri-clinic owners, research scientists, and government agricultural officers from western Maharashtra, particularly the Solapur district. The questionnaire consisted of 12 items designed to evaluate awareness of disease symptoms, spread factors, management challenges, and acceptance of Artificial Intelligence (AI)-based disease detection technologies. Descriptive statistics, one-sample t-test, and multiple linear regression analysis were used for data analysis. The results revealed that 88.9% of respondents had experienced BBD in their crops, while 90% correctly identified major disease symptoms. Environmental and agronomic conditions such as high temperature, irrigation practices, flowering stage, humidity, and wind direction were perceived as major contributors to disease spread. A one-sample t-test confirmed a statistically significant level of awareness among stakeholders ($t(107) = 9.997$, $p < 0.001$). Multiple linear regression analysis demonstrated that climatic and agronomic factors significantly influenced disease severity ($F = 13.98$, $p < 0.001$), explaining 35% of the variance in BBD severity. Although awareness regarding AI-based early disease detection tools was limited, respondents showed strong willingness to adopt mobile and AI-driven technologies for disease management. The findings highlight the importance of integrating digital agriculture solutions, farmer awareness programs, and AI-enabled disease monitoring systems to support sustainable pomegranate cultivation.

Keywords: Bacterial Blight Disease, Pomegranate, Artificial Intelligence, Questionnaire Survey, Disease Detection, Smart Agriculture.

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1. Introduction

Pomegranate is one of the most economically important fruit crops cultivated in India, with Maharashtra contributing significantly to national production. Districts such as Solapur are particularly recognized for large-scale pomegranate cultivation due to favorable agro-climatic conditions. However, pomegranate productivity is severely affected by several biotic stresses, among which Bacterial Blight Disease (BBD), commonly known as "Telya," is considered one of the most destructive diseases.

BBD affects leaves, stems, flowers, and fruits, resulting in severe yield reduction and economic losses. The occurrence and spread of the disease are influenced by various environmental and

agronomic factors, including temperature, humidity, irrigation practices, rainfall, and flowering stage. Farmers frequently face challenges in early identification of disease symptoms and timely implementation of preventive measures.

Recent advancements in Artificial Intelligence (AI), deep learning, mobile computing, and image-based disease diagnosis systems have created opportunities for early disease detection and decision support in agriculture. AI-driven systems can potentially improve disease diagnosis accuracy, reduce crop losses, and support precision agriculture practices. However, awareness and adoption of such technologies among farmers remain limited.

Understanding stakeholders' awareness, perceptions, and readiness to adopt AI-enabled disease detection systems is essential for developing practical and field-deployable technological solutions. Therefore, the present study investigates awareness levels, disease management practices, and technological readiness among pomegranate stakeholders regarding Bacterial Blight Disease.

1.1 Research Objectives

The major objectives of the study are:

1. To assess the level of awareness and knowledge regarding Bacterial Blight Disease among farmers, agricultural experts, research scientists, and agri-clinic owners.
2. To identify climatic, environmental, and agronomic factors affecting BBD severity.
3. To examine stakeholders' perceptions toward AI-based disease detection technologies.
4. To provide a conceptual framework for real-time AI-based disease detection suitable for mobile or edge-device deployment.

1.2 Research Hypotheses

Hypothesis 1: Awareness among Stakeholders

H1₀: There is no significant level of awareness among stakeholders regarding symptoms, causes, and management of Bacterial Blight Disease in pomegranate crops.

H1₁: There is a significant level of awareness among stakeholders regarding symptoms, causes, and management of Bacterial Blight Disease in pomegranate crops.

Hypothesis 2: Factors Affecting Bacterial Blight Disease

H2₀: Climatic, agronomic, and environmental factors have no significant effect on the occurrence and severity of Bacterial Blight Disease in pomegranate crops.

H2₁: Climatic, agronomic, and environmental factors significantly influence the occurrence and severity of Bacterial Blight Disease in pomegranate crops.

Hypothesis 3: AI-Based Detection Performance

H3₀: Artificial Intelligence-based models do not significantly improve the accuracy of BBD detection compared to conventional visual inspection methods.

H3₁: Artificial Intelligence-based models significantly improve the accuracy of BBD detection compared to conventional visual inspection methods.

2. Literature Review

Several studies have highlighted the increasing impact of Bacterial Blight Disease on pomegranate productivity in India. Environmental conditions such as temperature, rainfall, humidity, and irrigation have been identified as major contributors to disease spread. Traditional disease diagnosis methods rely heavily on visual inspection and farmers' experience, which often results in delayed disease identification.

Recent developments in digital agriculture and Artificial Intelligence have enabled the use of image processing, machine learning, and deep learning techniques for early disease detection in

crops. AI-based disease detection systems have demonstrated promising performance in identifying plant diseases from leaf and fruit images. However, successful implementation of such technologies requires adequate awareness, training, and technological accessibility among farmers.

Existing studies primarily focus on disease diagnosis models, while limited research has explored stakeholders' awareness, management practices, and readiness to adopt AI-driven technologies for BBD management. Therefore, the present study addresses this research gap by combining awareness analysis with technological readiness assessment.

3. Materials and Methods

3.1 Survey Design

A questionnaire-based survey was conducted between January 2024 and March 2025 among 109 respondents from western Maharashtra, with special emphasis on Solapur district. Respondents included:

- Pomegranate farmers
- Agri-clinic owners
- Agricultural officers
- Research scientists
- Agricultural experts

3.2 Questionnaire Design

The questionnaire consisted of 12 structured items categorized into three sections:

- General awareness regarding pomegranate diseases
- Awareness and identification of Bacterial Blight Disease
- Management challenges and technological intervention

All responses were measured using a five-point Likert scale ranging from:

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

3.3 Data Analysis

The collected data were coded and analyzed using descriptive statistical techniques. Mean, standard deviation, minimum, and maximum values were calculated for all survey items. Microsoft Excel and statistical analysis software were used for data processing.

To evaluate the hypotheses, the following statistical techniques were applied:

- One-sample t-test
- Multiple linear regression analysis
- Reliability analysis using Cronbach's alpha

Cronbach's alpha value greater than 0.76 indicated acceptable internal consistency of the questionnaire.

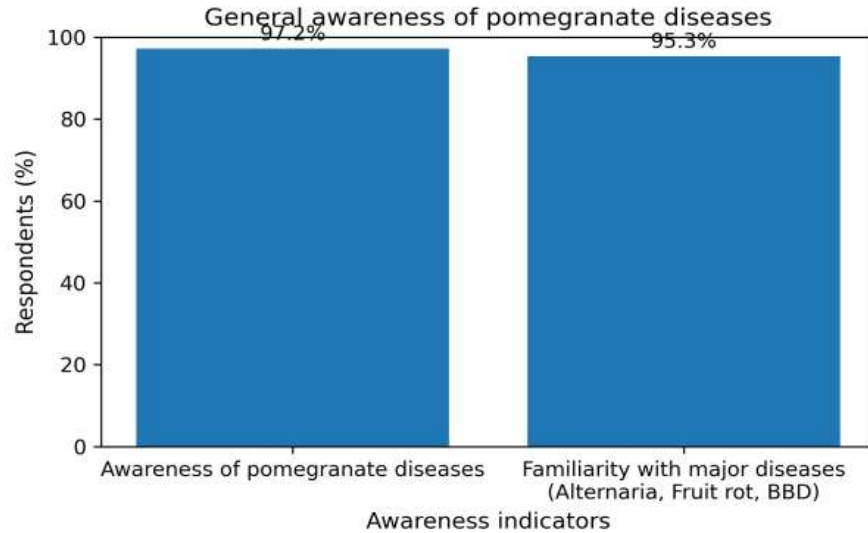
4. Results and Analysis

4.1 General Awareness Regarding Pomegranate Diseases

The findings indicate strong awareness regarding pomegranate diseases among respondents. Approximately 97.2% of participants reported awareness of diseases affecting pomegranate crops, while 95.3% demonstrated familiarity with major diseases such as BBD, Alternaria, fruit rot, and powdery mildew.

Table 1. General Awareness about Pomegranate Diseases

Item	Mean	SD	Min	Max
Awareness of common Pomegranate diseases	4.26	0.44	4	5
Familiarity with major pomegranate diseases	4.68	0.47	4	5



The high mean scores indicate strong awareness among stakeholders regarding pomegranate crop diseases.

4.2 Awareness and Identification of Bacterial Blight Disease

A significant proportion of respondents demonstrated practical experience and awareness regarding BBD.

88.9% reported experiencing BBD in their crops.

90% correctly identified major symptoms of BBD.

92.9% agreed that high temperature accelerates disease spread.

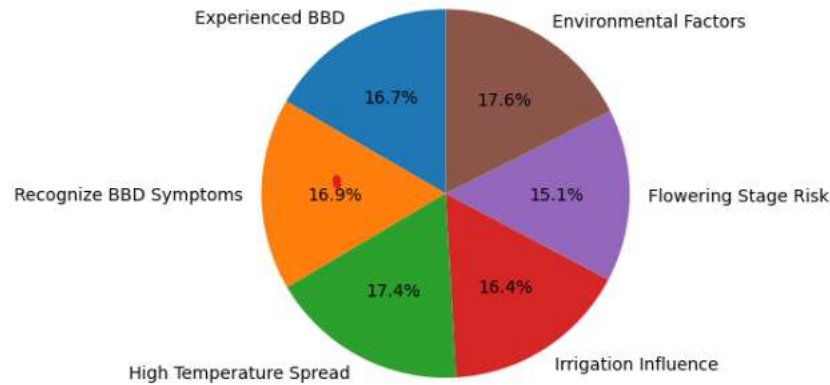
87.3% associated irrigation practices with disease transmission.

80.8% believed that flowering stage increases disease susceptibility.

94% recognized the influence of environmental factors such as humidity and wind direction.

Table 2. Awareness and Identification of Bacterial Blight Disease (BBD)

Item	Mean	SD	Min	Max
Experience of BBD in pomegranate crops	4.16	0.40	3	5
Identification of BBD symptoms	4.63	0.49	4	5
BBD spread during high humidity	4.40	0.52	3	5
BBD spread during irrigation practices	4.16	0.55	2	5
BBD spread during flowering stage	4.21	0.63	2	5
Influence of environmental factors on BBD	4.72	0.45	4	5



4.3 Management Challenges and Technological Intervention

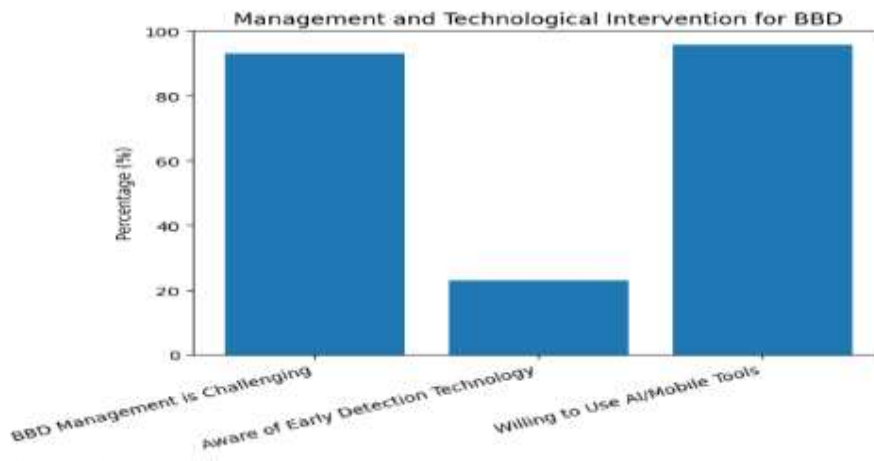
The study identified several challenges in effective BBD management.

- 93% of respondents reported difficulties in disease management.
- Only 23% were aware of AI-based early disease detection tools.
- 95.9% expressed willingness to adopt mobile or AI-based disease detection systems.

Table 3. Management and Technological Intervention

Item	Mean	SD	Min	Max
Awareness of early disease detection technologies	2.74	1.01	1	5
Interest in using mobile/AI-based tools	4.33	0.50	3	5
Challenges in managing BBD	4.40	0.49	4	5

The findings indicate high readiness for technology adoption despite limited awareness regarding advanced disease detection systems.



5. Hypothesis Testing

5.1 Hypothesis 1: Awareness among Stakeholders

A one-sample t-test was conducted to determine whether stakeholders possessed significant awareness regarding BBD.

Hypothesis Tested

H₀: Mean awareness \leq 3

H₁: Mean awareness $>$ 3

Statistical Results

- Sample size (n) = 108
- Mean awareness score = 3.698
- Test value = 3
- t-value = 9.9969
- Degrees of freedom = 107
- p-value $<$ 0.001
- 95% Confidence Interval = [3.582, ∞)

Interpretation

Since the mean awareness score was significantly greater than the neutral value and $p < 0.05$, the null hypothesis was rejected.

Conclusion

The results confirm that stakeholders possess a statistically significant level of awareness regarding Bacterial Blight Disease.

5.2 Hypothesis 2: Factors Affecting BBD Severity

Multiple linear regression analysis was conducted to examine the influence of climatic and agronomic factors on BBD severity.

Regression Results

- $R^2 = 0.350$
- Adjusted $R^2 = 0.325$
- F-statistic = 13.98
- p-value $<$ 0.001

Interpretation

The regression model explained 35% of the variance in BBD severity, indicating moderate explanatory power. The model was statistically significant, confirming that climatic and agronomic factors significantly influence BBD severity.

Conclusion

The null hypothesis was rejected, indicating that irrigation practices, temperature, humidity, and flowering stage significantly contribute to the spread and severity of Bacterial Blight Disease.

6. Discussion

The findings indicate that stakeholders possess strong experiential knowledge regarding Bacterial Blight Disease, particularly in symptom identification and environmental factors affecting disease spread. Farmers' practical understanding of disease behavior reflects the severity and recurring nature of BBD in pomegranate cultivation.

However, awareness regarding modern AI-based disease detection technologies remains limited. This gap suggests the need for extensive awareness programs, training workshops, and digital extension services to improve adoption of technological interventions.

The statistical results further confirm that climatic and agronomic factors significantly influence BBD severity. Similar findings have been reported in previous agricultural disease management studies where humidity, irrigation, and temperature were identified as major contributors to disease spread.

The high willingness among respondents to adopt AI-based disease detection systems highlights significant potential for integrating mobile applications, image processing systems, and edge-based AI frameworks into practical agricultural environments.

7. AI-Based CNN Model for BBD Detection

7.1 Deep Learning Model Architecture

To support real-time disease identification, a Convolutional Neural Network (CNN)-based deep learning model was designed and evaluated using pomegranate leaf and fruit image datasets. The proposed model utilized TensorFlow and Keras frameworks for disease classification.

The CNN architecture consisted of:

- Multiple convolutional layers for feature extraction
- Max-pooling layers for dimensionality reduction
- Flatten and dense layers for classification
- Binary classification output for healthy and diseased samples

The images were resized to 224×224 pixels and normalized before training. The dataset was divided into training and validation sets using an 80:20 ratio.

7.2 Model Training and Performance

The CNN model was trained for 10 epochs using the Adam optimizer and binary cross-entropy loss function. The training process demonstrated continuous improvement in accuracy and reduction in loss values.

Key performance observations include:

- Initial training accuracy: 46.6%
- Final validation accuracy exceeded 85%
- Overall classification accuracy achieved approximately 90%

The confusion matrix and classification report demonstrated strong predictive capability of the CNN model.

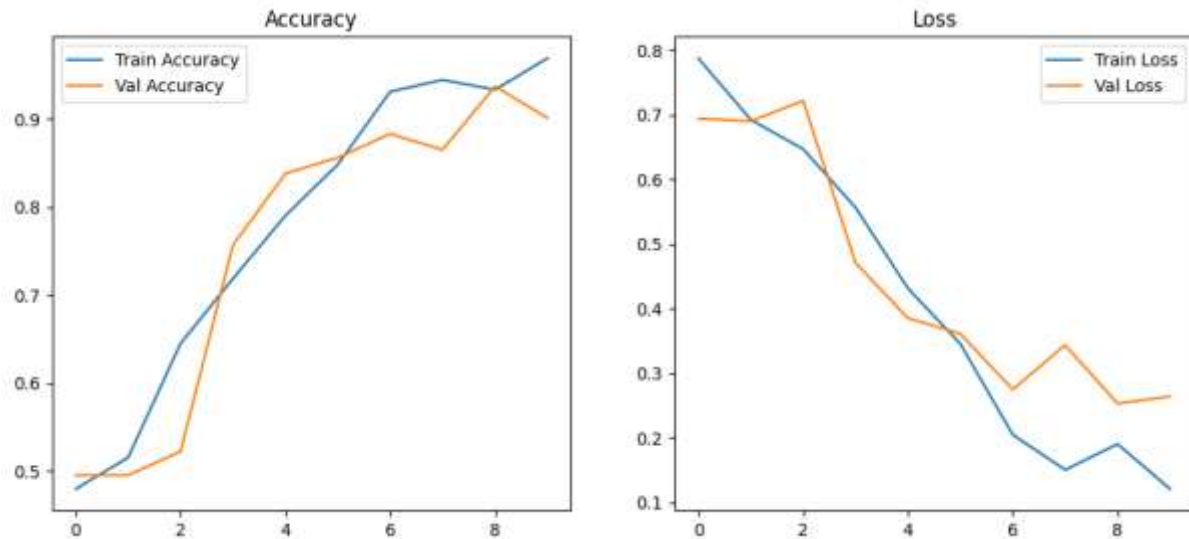
Classification Performance

Metric	Diseased	Healthy
Precision	0.92	0.88
Recall	0.88	0.93
F1-Score	0.90	0.90

Overall Accuracy = 90%

The confusion matrix results were:

Actual / Predicted	Diseased	Healthy
Diseased	49	7
Healthy	4	51



7.3 Insights from AI-Based Disease Detection

The CNN-based disease detection model demonstrated promising performance in identifying Bacterial Blight Disease from pomegranate images. The results indicate that AI-driven approaches can significantly improve early disease diagnosis compared to traditional visual inspection methods.

The major insights obtained from the AI model include:

1. Deep learning models can accurately distinguish between healthy and diseased pomegranate samples.
2. Image-based disease diagnosis reduces dependency on manual inspection.
3. Mobile-compatible AI systems can support real-time disease monitoring in field environments.
4. Integration of CNN models with smartphone applications can improve early warning and advisory services.
5. AI-assisted disease detection has the potential to reduce crop losses and improve precision agriculture practices.

The experimental findings strongly support the feasibility of deploying AI-enabled BBD detection systems for practical agricultural applications.

8. Proposed Conceptual Framework for AI-Based BBD Detection

The proposed framework for real-time BBD detection consists of the following stages:

1. Image acquisition using mobile devices or drones
2. Image preprocessing and enhancement
3. Feature extraction using deep learning techniques
4. Disease classification using CNN or hybrid AI models
5. Real-time disease alert and advisory system
6. Mobile-based recommendation support for farmers

The framework aims to provide:

- Early disease identification
- Real-time monitoring
- Reduced crop losses
- Improved decision-making

- Cost-effective disease management

9. Conclusion

The study reveals that stakeholders involved in pomegranate cultivation possess strong awareness and practical experience regarding Bacterial Blight Disease. Environmental and agronomic factors such as temperature, humidity, irrigation practices, and flowering stage significantly influence disease severity.

Although awareness regarding AI-based disease detection technologies is currently limited, respondents demonstrated strong interest in adopting mobile and AI-driven solutions for disease management. The findings emphasize the importance of integrating digital agriculture technologies with traditional farming practices.

The study provides a strong foundation for future development of AI-enabled early disease detection systems, farmer-centric mobile applications, and intelligent decision-support systems for sustainable pomegranate cultivation.

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