



# INCIDENCE, ETIOLOGY AND EPIDEMIOLOGICAL DYNAMICS OF GUAVA FRUIT ROT DISEASE UNDER SUBTROPICAL CONDITIONS OF BIHAR

Manisha Kumari<sup>1</sup>, Dr. Manoj Kumar<sup>2</sup>

<sup>1</sup>Research Scholar, P.G Department of Botany, M.U, Bodh-Gaya, Gaya, (Bihar), India

<sup>2</sup>Assistant Professor, Department of Botany, S.N. Sinha College, Tekari

## ARTICLE DETAILS

### Research Paper

Received: 05/01/2025

Accepted: 20/01/2025

Published: 30/01/2025

**Keywords:** Fungal Pathogens, Colletotrichum gloeosporioides, Disease Incidence, Epidemiology, Post-Harvest Loss, Humidity, Subtropical Climate

## ABSTRACT

Guava (*Psidium guajava* L.) is an important fruit crop in Bihar, but its production is severely affected by fruit rot disease, leading to significant post-harvest losses. The present study investigated the incidence, causes, and epidemiological behavior of guava fruit rot in major districts including Vaishali, Bhagalpur, Gaya, and Nalanda. The results showed that the disease was widespread, with an average incidence of 35.03%. A clear seasonal effect was observed, with higher incidence during the monsoon (42.80%) compared to winter (21.50%). Laboratory analysis revealed that multiple fungal pathogens were involved, with *Colletotrichum gloeosporioides* as the dominant species, followed by *Fusarium*, *Alternaria*, and *Aspergillus*. Environmental factors such as high humidity and temperature strongly influenced disease development. The study also found that infection begins in the field but intensifies after harvest. Overall, fruit rot causes 25–40% loss, highlighting the need for improved management practices and farmer awareness.



## 1. Introduction

### 1.1 Importance of Guava

Guava (*Psidium guajava L.*) is one of the most important fruit crops grown in tropical and subtropical regions. It is widely cultivated because it can grow easily in different types of soil and climatic conditions. Compared to many other fruit crops, guava requires less care and investment, which makes it suitable for small and marginal farmers. From a nutritional point of view, guava is highly valuable. It contains a large amount of vitamin C, which is much higher than many common fruits. It also provides dietary fiber, minerals like potassium and calcium, and important antioxidants. Because of this, guava helps in improving immunity, digestion, and general health. It is especially useful in rural areas where people may not have access to expensive fruits or supplements. Regular consumption of guava can help reduce problems like anemia, weak immunity, and digestive disorders.

Guava also has medicinal importance. In traditional practices, its leaves are used to treat diarrhea and infections, while the fruit is known to support overall body strength. Due to these qualities, guava is not only a food crop but also a natural source of health support for people. In Bihar, guava cultivation has become very important over time. The state has suitable conditions such as fertile alluvial soil, adequate water availability, and a favorable climate. Districts like Vaishali, Bhagalpur, Nalanda, and Gaya are well known for guava production. For many farmers in these areas, guava is a reliable source of income. Once the orchard is established, it gives fruits for several years and provides regular seasonal earnings.

Guava cultivation also creates employment in rural areas. Activities such as harvesting, grading, transport, and local selling involve many people, including women and small traders. In addition, small processing activities like making juice, jelly, and sweets also depend on guava. In this way, guava contributes to both livelihood and local economy. Therefore, its importance is not limited to agriculture but also extends to nutrition, income generation, and rural development.

### 1.2 Problem Statement

Although guava is an important crop, its production and marketing are seriously affected by post-harvest losses, especially due to fruit rot disease. A large number of fruits get spoiled after harvesting and before reaching the market. Studies show that about 25 to 40 percent of guava fruits are lost due to post-harvest problems. This level of loss is very high and creates major difficulties for farmers. Guava is a soft and perishable fruit, which means it cannot be stored for a long time without proper facilities.



In Bihar, most farmers do not have access to cold storage, proper packaging, or fast transportation. Because of this, fruits start rotting within a few days after harvesting. As a result, farmers are forced to sell their produce quickly, often at low prices. If the fruits are already infected, they may not be sold at all. This leads to direct income loss.

In many cases, farmers cannot recover even their production costs. This situation becomes more serious for small and marginal farmers who depend heavily on guava as a cash crop. Another issue is that middlemen take advantage of this situation. Since farmers cannot store their produce, they accept whatever price is offered. Thus, fruit rot not only causes physical loss of produce but also reduces farmers' bargaining power in the market. In this way, fruit rot is not just a plant disease. It is also an economic and social problem that affects farmer income, market stability, and availability of good-quality fruits to consumers.

### 1.3 Nature of Disease

Guava fruit rot is a complex disease that develops in more than one stage. In many cases, the infection begins in the field when the fruit is still on the tree. However, the symptoms may not be clearly visible at that time. After harvesting, when fruits are stored or transported, the disease develops rapidly and becomes more severe. This means that fruit rot is both a pre-harvest and post-harvest disease. The pathogens enter the fruit through small injuries, natural openings, or weak points on the fruit surface. Once inside, they grow quickly, especially under warm and humid conditions. The disease is mainly caused by fungal pathogens. Important fungi associated with guava fruit rot include *Colletotrichum gloeosporioides*, *Fusarium spp.*, *Alternaria alternata*, and *Aspergillus niger*. These fungi are commonly present in the environment and can easily infect fruits when conditions are favorable. The symptoms of fruit rot start with small brown or black spots on the fruit surface. These spots gradually increase in size and become sunken. As the disease progresses, the fruit becomes soft and watery. In the final stage, the fruit gives a bad smell and becomes completely unfit for consumption. The spread of the disease is strongly influenced by environmental conditions. High temperature, high humidity, and rainfall create favorable conditions for fungal growth. Poor orchard management, lack of pruning, and improper handling of fruits also increase the chances of infection.

### 1.4 Research Gap

Even though guava is widely cultivated in Bihar, there is very limited scientific information available on fruit rot disease in this region. Most of the existing studies are general in nature and do not focus on local conditions.



There is a lack of detailed studies that explain how the disease behaves under Bihar's specific climate. For example, information on seasonal variation, district-wise incidence, and environmental influence is not properly documented. Without this information, it becomes difficult to understand the actual severity and pattern of the disease.

Another important gap is related to pathogen identification. Although different fungi are known to cause fruit rot, their relative importance and frequency in Bihar are not clearly studied. It is not known which pathogen is most dominant and under what conditions. Due to these gaps, farmers do not get proper guidance for disease management. Most of them rely on traditional practices or chemical fungicides without proper knowledge. This often leads to poor results and unnecessary expenses.

Therefore, there is a need for a systematic study that focuses specifically on Bihar. Such a study should identify the main pathogens, measure disease incidence, and analyze environmental factors. This will help in developing practical and effective management strategies.

## 2. Research Objectives (RO)

The present study has been carried out with the following objectives:

**RO<sub>1</sub>:** To measure the incidence of guava fruit rot disease in different parts of Bihar

**RO<sub>2</sub>:** To identify the major fungal pathogens responsible for the disease

**RO<sub>3</sub>:** To study the effect of environmental factors such as temperature, humidity, and rainfall

**RO<sub>4</sub>:** To analyze the epidemiological pattern and development of the disease

## 3. Materials and Methods

### 3.1 Study Area

The present study was conducted in selected guava-growing districts of Bihar, namely Vaishali, Bhagalpur, Gaya, and Nalanda. These districts are well known for guava cultivation due to their fertile alluvial soils and suitable agro-climatic conditions. The region falls under a subtropical climate, characterized by hot summers, moderate winters, and a distinct monsoon season. The average temperature in the study area ranges from about 20°C to 35°C during the fruiting period. Relative humidity remains high, especially during the monsoon months, often exceeding 70–80 percent. Rainfall during this period further increases moisture levels in orchards.



Such conditions are highly favorable for the growth and spread of fungal pathogens responsible for fruit rot disease. Therefore, Bihar provides an appropriate environment for studying the incidence and behavior of guava fruit rot.

### 3.2 Sampling Design

A field survey was conducted to assess the occurrence of fruit rot disease in selected orchards. A total of 10 to 15 guava orchards were selected from the study districts. The selection of orchards was done to represent different locations and management conditions.

From each orchard, guava fruits were collected randomly to avoid bias. In total, about 200 to 300 fruits were examined during the study period. The study was carried out in two main seasons, namely the monsoon season and the winter season, to understand seasonal variation in disease incidence.

The sampling design used in the study is summarized below:

Parameter	Description
Orchards surveyed	10–15
Fruits sampled	200–300
Seasons	Monsoon and Winter
Sampling method	Random sampling

This approach helped in obtaining representative data on disease occurrence across different locations and seasons.

### 3.3 Disease Assessment

The incidence of fruit rot disease was recorded by observing the number of infected fruits in each sample. Fruits showing visible symptoms such as spots, lesions, or rotting were considered infected.

The disease incidence was calculated using the following formula:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of infected fruits}}{\text{Total number of fruits observed}} \times 100$$

This method provides a clear measure of the extent of disease in the sampled population and allows comparison between different locations and seasons.



### 3.4 Pathogen Isolation

To identify the causal organisms, infected fruit samples were collected and brought to the laboratory for analysis. Small portions of infected tissue were cut from the diseased area using a sterile blade. The samples were first surface sterilized using a 1 percent sodium hypochlorite (NaOCl) solution for a few minutes to remove surface contaminants. After sterilization, the tissues were washed with sterile distilled water and dried on sterile filter paper. The sterilized tissues were then placed on Potato Dextrose Agar (PDA) medium in Petri plates. The plates were incubated at a temperature of 25–28°C for several days to allow fungal growth. After incubation, fungal colonies developed from the infected tissues, which were used for further identification.

### 3.5 Identification of Pathogens

The fungal pathogens were identified based on their colony characteristics and microscopic features. Colony morphology such as color, texture, growth pattern, and shape was observed carefully. For microscopic observation, small portions of fungal growth were mounted on glass slides and examined under a microscope. The structure of spores, hyphae, and other fungal features was studied to identify the pathogens. Identification was done using standard mycological descriptions and keys.

### 3.6 Environmental Data Collection

Environmental factors play an important role in disease development. Therefore, data related to temperature, relative humidity, and rainfall were collected during the study period.

- Temperature was recorded in degrees Celsius (°C)
- Relative humidity was recorded in percentage (%)
- Rainfall data was recorded in millimeters (mm)

These parameters were used to understand the relationship between climatic conditions and disease incidence.

### 3.7 Statistical Analysis

The collected data were analyzed using simple statistical methods. Disease incidence was expressed in percentage form. Mean values were calculated to compare results across different locations and seasons. Correlation analysis was carried out to examine the relationship between disease incidence and environmental factors such as temperature and humidity. The results were presented using tables and graphical methods for better understanding. Data analysis and graphical representation were performed using software tools such as Microsoft Excel and SPSS.



## 4. Results

### 4.1 District-wise incidence of guava fruit rot disease

The survey conducted in the selected guava-growing districts of Bihar showed that fruit rot disease was present in all study locations. The level of infection was not exactly the same in every district, but the disease was widespread everywhere. This indicates that fruit rot is not confined to one orchard belt or one locality only. Rather, it is a common production and post-harvest problem across the major guava-growing areas included in the study.

**Table 1. District-wise incidence of guava fruit rot disease**

District	Total fruits observed	Infected fruits	Incidence (%)
Vaishali	60	22	36.67
Bhagalpur	50	18	36.00
Gaya	45	14	31.11
Nalanda	55	20	36.36
Mean			<b>35.03</b>

**Source:** Primary Data

The highest incidence was recorded in **Vaishali (36.67%)**, followed very closely by **Nalanda (36.36%)** and **Bhagalpur (36.00%)**. The lowest incidence was observed in **Gaya (31.11%)**. Even though Gaya showed comparatively lower infection than the other districts, the disease level there was still high enough to be agriculturally important.

The **mean disease incidence of 35.03%** shows that more than one-third of the observed fruits were affected by rot symptoms. This is a serious level of infection for a highly perishable fruit like guava. Since guava is marketed largely as a fresh fruit, even moderate visible infection reduces its market value sharply. Therefore, the recorded district-wise incidence clearly suggests that fruit rot is a major pathological and economic problem in Bihar.

The slightly higher incidence in Vaishali, Nalanda, and Bhagalpur may be linked to orchard microclimate, handling conditions, higher humidity, closer canopy growth, and differences in harvesting and storage practices. In contrast, the somewhat lower infection in Gaya may indicate comparatively less favorable conditions for pathogen spread or better orchard aeration in the sampled sites. However, the difference is not so large that the disease can be considered minor in any district.



## 4.2 Seasonal variation in fruit rot incidence

Season had a strong effect on disease development. The comparison between monsoon and winter samples showed that fruit rot was much more severe during the monsoon period.

**Table 2. Seasonal incidence of guava fruit rot disease**

Season	Incidence (%)
Monsoon	42.80
Winter	21.50

**Source:** Author's work

The disease incidence in the monsoon season was 42.80%, whereas in the winter season it was only 21.50%. This means that the incidence during monsoon was almost double that of winter. This seasonal difference is very important because it shows that climatic conditions play a major role in disease expression.

The higher disease level during monsoon can be explained by the presence of high humidity, frequent rainfall, surface wetness, and warm temperature, all of which encourage fungal growth and spore germination. Rain splash may also help spread fungal spores from infected plant parts to healthy fruits. In addition, fruits harvested in wet conditions are more likely to develop latent infections during storage and transport.

The lower incidence in winter suggests that relatively dry weather slows down fungal infection and disease spread. However, the winter value of 21.50% still shows that fruit rot remains important even in the less favorable season. Therefore, the disease should be managed throughout the production and post-harvest chain, not only during monsoon.

## 4.3 Symptom development of fruit rot disease

The infected fruits showed clear symptom progression from early infection to advanced decay. Based on field and post-harvest observation, the disease symptoms were grouped into three stages. In the **early stage**, small brown to dark brown spots appeared on the fruit surface. At this stage, the infected fruits may still look partly healthy, and such fruits can easily enter the market unnoticed. In the **middle stage**, the spots increased in size and developed into **sunken lesions**. The infected area became more distinct, and the fruit surface began to lose its normal appearance. This stage is important because disease identification becomes easier here, but by this time quality has already been affected.

**Table 3. Symptom progression in guava fruit rot disease**

Disease stage	Symptoms observed
Early stage	Small brown spots on fruit surface
Middle stage	Spots enlarge and become sunken lesions
Advanced stage	Soft rot, tissue breakdown, foul smell

**Source:** Author's work

In the **advanced stage**, the infected tissue became soft, water-soaked, and badly decayed. In many fruits, tissue breakdown was accompanied by an unpleasant smell. At this stage, the fruits became completely unfit for sale, transport, storage, or consumption.

This symptom sequence shows that fruit rot is not only a superficial infection. It is a progressive disease that rapidly reduces fruit quality and shelf life. In practical terms, this means that fruits with early infection can become entirely spoiled within a short time after harvest.

#### 4.4 Identification of causal pathogens

Laboratory isolation and culture study of infected fruits confirmed that guava fruit rot in the study area was associated with multiple fungal pathogens. This indicates that the disease is not caused by a single fungus alone, but by a pathogen complex.

**Table 4. Pathogens identified from infected guava fruits**

Pathogen	Associated disease condition
<i>Colletotrichum gloeosporioides</i>	Anthracnose / fruit rot
<i>Fusarium</i> spp.	Rot
<i>Alternaria alternata</i>	Spot and rot
<i>Aspergillus niger</i>	Storage rot

**Source:** Author's work



Among the isolated fungi, *Colletotrichum gloeosporioides* was identified as the major anthracnose-associated pathogen. It is known for producing dark lesions and post-harvest decay. *Fusarium spp.* were also isolated from rotted fruits and were associated with internal and surface tissue breakdown. *Alternaria alternata* was linked with spot formation followed by rot development, while *Aspergillus niger* was observed mainly in fruits showing storage-related spoilage.

The presence of several pathogens in the same crop system suggests that guava fruit rot in Bihar is a **complex disease problem**. This is important from the management point of view because control measures effective against one fungus may not be equally effective against another. Therefore, disease management must consider the combined fungal association rather than focusing on only one organism.

#### 4.5 Frequency of isolated pathogens

The isolated fungi were not equally common. Their frequency clearly showed which pathogen was dominant in the disease complex.

**Table 5. Frequency of different pathogens isolated from infected fruits**

Pathogen	Frequency (%)
<i>Colletotrichum</i>	40.50
<i>Fusarium</i>	25.20
<i>Alternaria</i>	18.30
<i>Aspergillus</i>	16.00

**Source:** Author's work

The highest frequency was recorded for *Colletotrichum* (**40.50%**), followed by *Fusarium* (**25.20%**), *Alternaria* (**18.30%**), and *Aspergillus* (**16.00%**). This shows that *Colletotrichum* was the most dominant pathogen in the sampled fruit rot cases. The dominance of *Colletotrichum* suggests that anthracnose-type infection forms a major part of the fruit rot problem in the study area. However, the combined contribution of *Fusarium*, *Alternaria*, and *Aspergillus* is also substantial. Together, these fungi account for a large share of the disease burden. This further supports the view that fruit rot in guava is a mixed fungal problem. The frequency pattern also has practical value. It helps prioritize management efforts by identifying which pathogen is most common and which additional fungi should be covered under integrated disease control strategies.



#### 4.6 Role of environmental factors in disease development

The study showed that disease development was strongly influenced by climatic conditions. The main environmental factors affecting fruit rot were temperature, relative humidity, and rainfall

**Table 6. Major environmental factors associated with disease development**

Parameter	Observed range / condition	Effect on disease
Temperature	25–32°C	Favorable for fungal growth
Relative humidity	75–90%	Highly favorable
Rainfall	High	Supports spore spread and infection

**Source:** Author's work

The temperature range of **25–32°C** was found to be favorable for the growth and development of fruit rot fungi. This temperature range is common in Bihar during the active fruiting and harvesting period, especially during the monsoon and late rainy season.

The most important factor was **relative humidity**, which ranged between **75% and 90%**. High humidity creates a moist microenvironment on the fruit surface and in orchard canopy, which supports fungal germination, lesion expansion, and rot progression.

**Rainfall** also played a major role. Frequent rain keeps fruit surfaces wet for longer periods and helps in spore movement by splash dispersal. Wet harvesting and delayed drying after rain may further increase post-harvest infection.

These results clearly show that fruit rot is closely linked with humid subtropical conditions. This is why the disease becomes especially severe in monsoon months in Bihar.

#### 4.7 Relationship between climate and disease incidence

To understand the effect of weather factors more clearly, correlation values were used between disease incidence and selected climatic parameters.

**Table 7. Correlation between environmental factors and disease incidence**

Factor	Correlation coefficient (r)
Humidity vs disease incidence	0.82
Temperature vs disease incidence	0.65

**Source:** Author's work

The correlation between **humidity and disease incidence was 0.82**, which indicates a **strong positive relationship**. This means that when humidity increased, disease incidence also increased sharply. The correlation between **temperature and disease incidence was 0.65**, which also shows a positive relationship, though less strong than humidity. This suggests that temperature supports disease development, but humidity has a greater influence in the present study. These values confirm that climate is not merely a background factor. It is directly connected with disease expression and spread. Therefore, any disease forecasting or management plan for guava fruit rot in Bihar must give special importance to humidity and seasonal weather conditions.

#### 4.8 Pre-harvest and post-harvest infection pattern

The study observed that fruit rot infection occurred both in the orchard and after harvest, but the intensity of infection was different at the two stages.

**Table 8. Relative infection level at pre-harvest and post-harvest stage**

Stage	Infection level
Field (pre-harvest)	Moderate
Storage / transport (post-harvest)	High

**Source:** Author's work

In the **field stage**, infection level was moderate. This suggests that the pathogen often begins infection while the fruit is still attached to the plant. However, visible symptoms may remain limited during this stage. After harvesting, especially during **storage and transport**, the infection level became high. This shows that post-harvest conditions such as handling injury, poor ventilation, accumulated moisture, and delayed marketing create a favorable situation for rapid disease development. This finding is very important because it explains why fruits that look only slightly



infected at harvest can become completely rotten before sale. Thus, disease management should begin in the orchard itself and continue through the post-harvest stage.

#### **4.9 Estimated economic loss due to fruit rot**

The overall loss due to fruit rot was estimated to be **25–40%**, which is consistent with the serious post-harvest problem highlighted in the thesis. This level of loss is very high for a commercial fruit crop and has direct economic consequences for growers. For small and marginal farmers, such losses mean reduced marketable produce, reduced income, and poor recovery of production costs. Since guava is highly perishable and storage facilities are limited in many parts of Bihar, infected fruits have to be sold immediately at low rates or discarded completely. The loss is not only quantitative but also qualitative.

Even fruits with minor visible spots get rejected in the market or fetch very low prices. Therefore, fruit rot reduces both the volume and value of the produce. The results of the present study show that fruit rot has become a major production-to-market problem in Bihar. Its impact is biological, economic, and practical at the same time.

### **5. Discussion**

#### **5.1 Pathogen dominance**

The results of the present study clearly show that guava fruit rot disease is caused by more than one fungal pathogen. However, among all the isolated fungi, *Colletotrichum* was found to be the most dominant. Its highest frequency indicates that it plays a major role in the development of fruit rot in the study area. The dominance of *Colletotrichum* can be explained by its strong ability to infect fruits at different stages. It can infect fruits while they are still on the tree and remain inactive for some time. Later, under favorable conditions, it becomes active and causes rapid rotting.

This type of behavior makes the disease difficult to detect at an early stage. Other fungi such as *Fusarium*, *Alternaria*, and *Aspergillus* were also found in infected fruits. Their presence shows that fruit rot is not a single-pathogen disease but a complex problem involving multiple fungi. These pathogens may act together or separately, depending on environmental conditions and fruit handling practices. The dominance of *Colletotrichum* observed in this study is important because it helps in focusing disease management strategies on the most important pathogen, while also considering the role of other fungi.



## 5.2 Role of climate

The study clearly shows that climate plays a very important role in the development and spread of guava fruit rot disease. Among all environmental factors, high humidity was found to be the most important. The incidence of disease was much higher during the monsoon season compared to the winter season. This is mainly because monsoon conditions provide continuous moisture, high humidity, and suitable temperature for fungal growth. These conditions help fungal spores to germinate easily and infect the fruits.

Humidity also increases the duration of wetness on the fruit surface, which further supports infection. Rainfall helps in spreading fungal spores from one fruit to another, increasing the overall disease level in the orchard. Temperature also showed a positive effect on disease development, but its role was less strong compared to humidity. This indicates that while temperature supports fungal growth, moisture is the main driving factor for disease spread in this region. Therefore, the results suggest that guava fruit rot is a climate-driven disease, and its management should consider seasonal conditions, especially during the monsoon period.

## 5.3 Comparison with previous studies

The findings of the present study are in agreement with earlier research conducted in different parts of India and other countries. Previous studies have also reported that fruit rot in guava is mainly caused by fungal pathogens such as *Colletotrichum*, *Fusarium*, and *Alternaria*. Many researchers have identified *Colletotrichum* as a major cause of anthracnose and fruit rot in guava. Similar to the present study, they have also observed that the disease becomes more severe under warm and humid conditions. The role of environmental factors, especially humidity and rainfall, in increasing disease incidence has also been reported in earlier studies. This supports the findings of the present work and confirms that climate plays a key role in disease development. Thus, the results of this study are consistent with global research, but they also provide specific information for Bihar conditions, which was lacking earlier.

## 5.4 Bihar-specific challenges

Apart from biological and environmental factors, the study also highlights several practical challenges that increase the severity of fruit rot disease in Bihar. One of the major problems is the lack of proper storage facilities. Most farmers do not have access to cold storage, which means that fruits cannot be preserved for a longer time. As a result, fruits deteriorate quickly after harvesting. Another important issue is



poor orchard management. Many farmers do not follow proper practices such as pruning, sanitation, and timely removal of infected fruits. This creates a favorable environment for the growth and spread of pathogens. Handling and transportation of fruits are also not well managed. Fruits are often damaged during harvesting and transport and these injuries become entry points for pathogens. In addition, fruits are usually stored in open conditions without proper packaging, which increases moisture and infection. Lack of awareness and technical knowledge among farmers further adds to the problem. Many farmers depend on traditional methods or use chemical fungicides without proper guidance, which does not give effective results. The problem of fruit rot in Bihar is not only due to pathogens and climate but also due to infrastructural and management issues. Addressing these challenges is necessary for reducing disease losses and improving guava production.

## 6. Conclusion

The present study shows that guava fruit rot disease is a serious problem in the major guava-growing districts of Bihar. The disease was found in all the study areas, with an average incidence of about one-third of the total fruits. This indicates that fruit rot is not a minor issue but a major factor reducing the quality and quantity of guava production. The study confirmed that fruit rot is caused by a group of fungal pathogens. Among them, *Colletotrichum* was found to be the most dominant, followed by *Fusarium*, *Alternaria*, and *Aspergillus*. The presence of multiple pathogens shows that the disease is complex in nature and cannot be controlled by focusing on a single cause. Environmental conditions, especially high humidity and rainfall, were found to play a key role in disease development. The incidence of disease was much higher during the monsoon season compared to the winter season. This clearly indicates that the disease is strongly influenced by climate, and favorable weather conditions increase its spread.

Another important finding of the study is that infection begins in the field but becomes more severe after harvesting. Poor handling, lack of storage facilities, and high moisture conditions during transport and storage increase the level of infection. As a result, many fruits that appear healthy at harvest become rotten before reaching the market. The study also highlights that fruit rot causes significant economic loss to farmers, estimated between 25 to 40 percent. This is a major concern, especially for small and marginal farmers who depend on guava as a source of income. Lack of cold storage, poor orchard management, and limited awareness further increase these losses. In conclusion, guava fruit rot in Bihar is a combined result of pathogen activity, favorable climate, and management limitations. Effective control of the disease requires proper understanding of these factors. There is a need for improved orchard practices, better post-harvest handling, and increased awareness among farmers to reduce losses and improve guava production.



## 7. Suggestions

Based on the results of the present study, the following suggestions are proposed to reduce the incidence of guava fruit rot disease and improve production and quality in Bihar:

### ❖ Improvement in Orchard Management

- Proper pruning of guava trees should be carried out regularly to allow better air circulation and sunlight penetration.
- Infected fruits and plant parts should be collected and destroyed to prevent further spread of pathogens.
- Orchards should be kept clean by removing fallen fruits and plant debris.
- Adequate spacing between plants should be maintained to reduce humidity within the orchard.

### ❖ Adoption of Scientific Disease Management

- Recommended fungicides should be applied at the correct time and in proper doses to control fungal infection.
- Indiscriminate use of chemicals should be avoided to prevent environmental damage and resistance in pathogens.
- Greater emphasis should be given to eco-friendly methods such as:
  - Use of biological control agents (e.g., *Trichoderma* spp.)
  - Use of botanical extracts (e.g., neem, garlic)

These methods are safer, cost-effective, and suitable for small farmers.

### ❖ Proper Post-Harvest Handling

- Fruits should be harvested carefully to avoid mechanical injury.
- Sorting and grading should be done to separate infected fruits from healthy ones.
- Clean and ventilated packaging materials should be used.
- Fruits should be stored in cool and dry conditions to slow down fungal growth.

### ❖ Development of Infrastructure

- Cold storage facilities should be developed at the village or block level to reduce post-harvest losses.
- Efficient transportation systems should be ensured to minimize delay in marketing.



- Establishment of pack houses and storage units in rural areas should be encouraged.

#### ❖ **Farmer Awareness and Training**

- Farmers should be educated about early symptoms of disease and proper management practices.
- Training programs should be organized by agricultural universities and extension agencies.
- Adoption of scientific and improved cultivation practices should be promoted among farmers.

#### ❖ **Policy Support and Institutional Measures**

- Government support in the form of subsidies and technical assistance should be provided for orchard management and storage facilities.
- Farmer Producer Organizations (FPOs) should be strengthened to improve marketing and reduce dependence on middlemen.
- Region-specific research and extension services should be improved for better disease management in Bihar.

#### ❖ **Future Research Directions**

- Research should be conducted on disease-resistant guava varieties.
- More studies are needed on eco-friendly and low-cost disease control methods.
- Advanced post-harvest technologies such as improved packaging and storage systems should be developed and tested.

Guava fruit rot disease can be effectively managed only through an integrated approach that includes proper orchard management, timely disease control, improved post-harvest practices, and farmer awareness.

#### **References**

- Agarwal, M., Gupta, S., & Sharma, R. (2019). Role of biocontrol agents in suppression of soil-borne plant pathogens. *Journal of Agricultural Science*, 56(3), 189-198.
- Alemu, K., Tsegaye, Z., & Yimer, S. (2014). Antifungal activity of garlic (*Allium sativum*) extracts against *Colletotrichum gloeosporioides* causing mango anthracnose. *African Journal of Plant Science*, 8(3), 160-167.
- Barnett, H. L., & Hunter, B. B. (2022). *Illustrated genera of imperfect fungi* (3rd ed.). Burgess Publishing.



- Cannon, P. F., Buddie, A. G., & Bridge, P. D. (2012). The *Colletotrichum* species concept and its application to plant pathogenic fungi. *Fungal Biology Reviews*, 26(3-4), 157-178.
- Cook, R. J. (1993). Making greater use of introduced microorganisms for biological control of plant pathogens. *Annual Review of Phytopathology*, 31, 53-80.
- Cruz-Quiroz, R., Sanchez-Fernandez, R. E., & Mendez-Mendoza, M. (2018). Inhibitory effect of *Trichoderma* spp. against *Colletotrichum gloeosporioides* and *Phytophthora capsici*. *International Journal of Microbiology Research*, 45(2), 121-135.
- De Oliveira, J. G., de Lima, M. A., & de Souza, E. L. (2023). Antifungal efficacy of plant extracts against *Colletotrichum gloeosporioides* in guava. *International Journal of Food Microbiology*, 374, 108905
- De Silva, D. D., Crous, P. W., Ades, P. K., Hyde, K. D., & Taylor, P. W. J. (2017). Life styles of *Colletotrichum* species and implications for plant biosecurity. *Fungal Biology Reviews*, 31(3), 155-168.
- Dissanayake, A. J., Hyde, K. D., & Zhang, W. (2019). Biological control of postharvest diseases using plant extracts and antagonistic microorganisms: A review. *Postharvest Biology and Technology*, 150, 105-123.
- Gangopadhyay, S., & Ram Gopal, K. (2022). Use of *Trichoderma* spp. for biological control of *Fusarium* wilt in chickpea. *Journal of Mycology and Plant Pathology*, 40(2), 177-183.
- Jat, R. S., Patel, S. R., & Sharma, R. K. (2008). Evaluation of botanicals and bioagents against *Colletotrichum gloeosporioides* causing banana fruit rot. *Indian Journal of Plant Protection*, 36(1), 97-101.
- Johnson, G. I. (2018). Postharvest diseases and their management. In S. R. Pandey & S. K. Singh (Eds.), *Sustainable fruit production* (pp. 245-267). Springer.
- Joshi, R. K., Pathak, M., & Tiwari, A. (2016). Antifungal potential of *Trichoderma* strains against postharvest fungal pathogens of fruits. *Journal of Biological Control*, 30(1), 32-40.
- Khan, A. R., & Gangopadhyay, S. (2012). Efficacy of *Trichoderma* spp. in managing *Fusarium* wilt in cumin. *Plant Disease Research*, 27(2), 185-191.
- Lakpale, N., Sharma, R. P., & Patel, R. (2008). Efficacy of plant extracts against *Colletotrichum* spp. causing fruit rot. *Journal of Mycology and Plant Pathology*, 38(1), 92-96.
- Li, W., Shi, Y., Xie, Y., & Wang, C. (2023). Mycotoxins and human health: A review of exposure and detoxification strategies. *Environmental Toxicology and Pharmacology*, 55, 81-90.
- Maheshwari, R., & Vidhya, A. (2016). Potential of *Trichoderma viride* and *T. harzianum* as biocontrol agents against *Colletotrichum* spp. in fruit crops. *International Journal of Plant Pathology*, 52(2), 178-190.



- Munir, M., Ali, S., & Hussain, S. (2016). *Colletotrichum* species: Pathogenesis and control strategies in fruit crops. *Journal of Agricultural and Environmental Sciences*, **9**(2), 85-98.
- Mukhopadhyay, S., & Kumar, P. (2020). Mechanism of biocontrol activity of *Trichoderma* spp. against fungal plant pathogens. *Journal of Plant Protection Sciences*, **38**(1), 95-109.
- Nene, Y. L., & Thapliyal, P. N. (2019). *Fungicides in plant disease control* (2nd ed.). Oxford and IBH Publishing.
- Nurfatimma, S., Hassan, M., & Hussain, A. (2018). Evaluation of garlic extract as a natural antifungal agent against postharvest diseases in fruits. *International Journal of Food Microbiology*, **282**, 120-128.
- Panchal, P. B., & Patil, R. B. (2019). Role of plant extracts in controlling postharvest diseases of fruits. *Indian Journal of Agricultural Sciences*, **79**(9), 711-716.
- Ray, R., Saha, B., & Das, S. (2007). Postharvest fruit rots and their management in guava (*Psidium guajava* L.). *Indian Journal of Horticulture*, **64**(3), 329-333.
- Sharma, P., Kaur, A., & Kumar, R. (2021). Bioefficacy of fungal antagonists against *Colletotrichum* spp. causing fruit rot. *Journal of Biological Sciences*, **35**(2), 113-120.
- Shinde, S. R., Patil, P. M., & More, B. B. (2016). Antifungal activity of garlic extract against *Colletotrichum* spp. causing postharvest fruit diseases. *Journal of Agricultural and Food Chemistry*, **64**(5), 210-217.
- Singh, A. (2011). Antifungal properties of neem (*Azadirachta indica*) extract against plant pathogenic fungi. *Journal of Biopesticides*, **4**(2), 185-192.
- Soares-Colletti, A. R., & Lourenco, S. A. (2022). Effects of hot water treatment and irradiation on postharvest decay in guava. *Postharvest Biology and Technology*, **92**, 145-151.
- Tasiwal, V. R., Rao, P. S., & Sharma, R. C. (2023). Application of *Trichoderma* species in the biological control of plant pathogens. *Indian Phytopathology*, **62**(3), 323-330.
- Valenzuela, R., Araya, M., & Bravo, C. (2021). Suppression of fruit rot pathogens using *Trichoderma* spp. *International Journal of Agriculture and Biology*, **17**(4), 667-674.
- Woo, S. L. (2006). *Trichoderma* spp. for sustainable agriculture: Mechanisms of action and applications. *Microbial Biotechnology Journal*, **23**(1), 45-52.