

# COCONUT PALM DISEASES CAUSED BY FUNGI, BACTERIA, PHYTOPLASMA AND VIRUS – AN ULTIMATUM TO PALMS OF GLOBAL ECONOMY

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## Abstract

Coconut is a predominant crop cultivated in more than 93 countries in the world, especially in tropical regions. Among the major coconut cultivation states in India such as Kerala, Karnataka, Odisha, Maharashtra, Tamil Nadu, Gujarat, Assam and Andhra Pradesh, Kerala has the longest history of cultivation. However, it is affected by various kinds of diseases such as lethal yellowing, red-ring, bud rot, ganodarma, stem bleeding, leaf rot, leaf blight, root wilt and cadang-cadang diseases leading significant losses in production. Major coconut products in the market includes Kernal Based, Water based, Coconut shell based, inflorescence based and convenience based items. It consists of virgin coconut oil, neera, coconut milk, desiccated coconut powder, activated carbon, shell powder, ball copra, tender coconut water, coconut vinegar, coconut wood, shell charcoal and coconut handicrafts. This paper reviews the common fungi, bacteria, phytoplasma and virus diseases found in coconut and their symptoms. The review concludes that proper management strategies should be taken for reducing the impact of diseases on coconut and thereby maintaining the productivity.

## INTRODUCTION

On the edge of escalating popularity of coconut among health-conscious customers, countries are implementing various strategies to increase their production in coconut. Coconut farming plays a salient part in the agrarian economy of Kerala and ranked one in the production of Coconut besides its unique place ' in the socio-cultural fabric of the region. Coconut has been cultivated in large number of countries, around more than 93 countries in the world having a high economic and social impact and India place one of the top among them. Coconut production in Kerala contributes major part in the economy [1]. According to the world wide census conducted by Food and Agriculture Organization from the years 2016 to 2020, top 10 countries producing coconut are India, Indonesia, Philippines, Brazil, Sri Lanka, Vietnam, Papua New guinea, Mexico, Thailand and Malaysia [2]

Rainfall during 3<sup>rd</sup> to 4<sup>th</sup> quarter has negative impact on coconut production whereas rainfall on first and second quarter has positive impact on the production of coconut. Coconut cultivation areas are shrinking drastically due to various factors inversely affecting the production. Crop loss is happening because of the pest attacks and diseases [3-4]. In Kerala, Coconut Development Board started in the year 1981 that comes under the Ministry of Agriculture and Farmers Welfare, Govt. of India with the aim of development in the coconut cultivation. The Board set up a Technology Development Centre at Aluva in Kerala provides

ambient support for the expansion of coconut industry in India. Coconut industry plays a significant role in foreign exchange. There are Coconut Producer Organizations formed in Kerala comprising Coconut Producer Societies (CPS), Coconut Producer Federations (CPF) and Coconut Producer Companies (CPC). CPS has 40 – 100 farmers as members dealing with procurement, processing and marketing phases of Coconut. Coconut Producer Company comprises of several Coconut Producer Federations and each CPF has many Coconut Producer Societies that directly interact with coconut farmers [5].

Various products that can be developed from coconut are available in the global market. Some includes [6-7]:

**Desiccated Coconut:** Desiccated coconut is used by confectionary and food industries in large quantity which is made up of grating the dehydrated coconut. Depending upon the fineness of the product, it is divided into a number of grades.

**Coconut Milk:** Coconut Milk deriving out of fresh grated coconut kernel is rich in protein can be used as coconut cream or diluted makes dishes such as puddings and sweets makes more healthy. Preserved forms of coconut milk are available in all countries. Fully defatted coconut milk is coconut cream, which can be used as an ingredient in house hold recipes and is available in global market. Coconut Development Board made new technologies to prepare coconut cream in a low cost mode.

**Coconut Skimmed Milk:** a soluble component is also prepared from coconut after removing cream using cream separator. Dried form can be kept as coconut milk powder. Nata-de-coco is a floating type dessert, a white creamy substance made from coconut. Other coconut products developed are coconut chips, squash, neera, jiggery, palm sugar, flower syrup and coconut toffee,

**Coconut Oil:** It is significant cooking oil apply in Kerala. Considering the peculiarity of low melting behavior and good digestibility, good scent oil is preferred most people. It has more medicinal values like shortening blood cholesterol and diminishes serum triglycerides. Among all vegetable oils, coconut oil has lowest unsaturated fatty acids. Milling copra is used for oil preparation as it contains highest percentage of oil than other oil seeds. The edible copra is a good dry fruit that can be used for confectionaries.

**Tender Coconut Water:** A health drink offered by Doctors that contain rich in potassium and minerals and is a thirst quenching health drink. 100 gram of tender coconut water has 17.4 caloric values. Tender coconut is a pre-maturing stage of fully matured nut.

**Coconut Vinegar:** A preservative agent made from fermented coconut water is coconut vinegar used in pickles, sauces and various food products. It contains minerals and vitamins and is natural than the synthetic vinegar.

**Coconut Candy and Biscuits:** By mixing coconut powder and maida in a convenient proportion make a ready to eat snack products biscuits

Coconut Development Board constituted in the state gives ambient technical advisory, training sessions and support for setting products based on coconut. Also quality testing criteria has

been incorporated to ensure the quality of the coconut product. CPCs installed high quality plants and machineries for the processing of neera and other coconut products like coconut honey and jiggery, making it an expert quality. New technologies such as pasteurization and chilling are used for preserving neera in CPCs.

In this paper, we are going to discuss various diseases found in coconut and related symptoms. The review pointed out different diseases found in various parts of different countries.

## LITERATURE REVIEW

Most phytoplasma associated vector found in area of Jamaica is the pest named leafhopper and in Florida, insect named *Haplaxius crudus*.

The integrated disease management package is adopted in Jamaica to protect the coconut crop. The package consists of surveillance, in which the symptom should be reported as early as possible. If symptoms are found, eliminate those plants and replant with resistance effective one to keep the density. Make the plantation free of all types of weeds so that the plants could grow healthy and proper measure should be taken to control vectors [8-12]. Previous researches show that there are around 750 species types attacking coconut worldwide. Insect's pests causes severe damage that may incur losses in number and size of coconut [13].

Spreading is controlled by removing the infected trees and replanting with resistant variety trees. To control infection of phytoplasma in individual host plants, injecting antibiotic such as tetracycline is preferable but is not economically viable for small farmers. Climate disturbances impact the spreading of LYD and other phytoplasma associated diseases [14]. Phytoplasma 16SrIVA-F subgroups are found in 8 Mexican states.

In [15], the author implemented a Deep Learning based unsupervised learning algorithm to detect the pest attack on coconut palm. They used camera interfaced drone to collect images of coconut in the farm and then applied cropping technique for normalization and then created a database using NVIDIA Tegra System on Chip. The database includes the images of coconut segments such as leaves, trunks and nuts. Smoothing followed by Image Enhancement technique used on the plant images. Healthy and unhealthy images and severity of the disease are classified along with the level of health based on the intensity and variation of green color. The GoPro camera mounted drone used for capturing images fly under the height of 400 feet which is in the line of sight of the operator [16].

## Frequent Diseases Found in Coconut

### 1. LYD (Lethal Yellowing Disease)

Around more than 50 types of diseases have been effected by coconut worldwide. Lethal Yellowing and root wilt diseases are commonly found causes reduction in nut production in Kerala and thereby incur losses to farmers. Most of the diseases have the symptom of yellowing and necrosis of leaves [2, 17]. Many diseases attacked by coconut plant leads to low growth of tree and ultimately lead to stubby production. Major pest types attacking coconut are coconut caterpillar and lack beetle and minor pests are bagworm, coconut scale and leaf minors.

Previous research has been pointed out that diseases affect coconut production inversely and thereby a threat to coconut farmers [3, 8]. Lethal Yellowing is treated as the first phytoplasma related disease in coconut. The first visual symptom shown in coconut palms is the premature drop of fruit. No fruit set on inflorescences as most of the male flowers die during the second stage. With the development of necrosis in more than two inflorescences, leaves starts to become yellow. Yellowing of leaves begin from oldest one, and then spread to the middle one and finally the upper leaves. Yellow leaves then turns brown and finally die within a period of 3 – 6 months. Symptoms shown in one or two palms in the initial spread and randomly spread up to 100m in the secondary stage and jumped anywhere upto 100km in final stage [14-20, 53].

Vector transmission is the main cause of spreading LYD most probably through the movement of plant materials. Diagnosis of LY phytoplasmas was done using transmission electron microscopy in early days but it was more time consuming [21-22]. Dot blot analysis is a modified molecular technology that can detect more samples but the disadvantage is that the sensitivity and specificity were limited. Afterwards PCR technique has been introduced for phytoplasma detection, ensuring specificity and sensitivity [23-24].

## 2. Red Ring Diseases

Red ring diseases are commonly found in Trinidad and Tobago recent years and are known to be root disease. The vector named *Bursaphelenchus cocophilus* nematode is the main cause of Red Ring Disease. Symptom is that, a plumping appearance shown by shortening the leaves of the central package [21, 25]. In Ecuador, research has been conducted to find out the Bud Rot disease of coconut and they found VARI (Visible Atmospherically Resistant Index) as the best vegetation index for the early diagnosis of Bud Rot disease. They used high resolution multi spectral cameras for acquiring images of both healthy and diseased palm images for the analysis. Points of plants showing BR and RRD symptoms collected using GPS system and experts gone directly to the farm for analyzing the spatial behavior of the disease. Vegetation index shows the difference between healthy and diseased palms [26]. For diagnosing red ring disease, an identification procedure was applied, a Loop Mediated Isothermal Amplification (LAMP) to the causative agent *Bursaphelenchus cocophilus* [27]

Red ring disease have initial symptom within 14-21 days after infestation and shows the yellowing of oldest 2-3 leaflets and get maximum population of nematode in around 42 days and then petioles and roots also get infected and the leafs become bronze colored. Meanwhile nuts also fell down in a premature stage and red ring of 2-6cm has been formed. It has been found out that premature death of coconut palms at the age of 3-10 years occurred and older age palms, especially of 20years survive from red ring diseases. The end of monsoon and the starting of dry season affect inversely on palms and causes to the death of palms. It is found that Sugarcane weevils and American weevils are the nematodes spreading red ring disease [29-30]. Red ring nematode is found in some areas of South America, Central America and many Caribbean islands. Red ring nematodes block water pathways in leaves, roots and stem and new leaves become short. An integrated pest management system should be followed to control the insects, keeping hygiene and minimization of pesticides [32].

### 3. Bud Rot Disease

Bud Rot is a most forbidding disease found in Ecuador, South Colombia and in South American Countries. Symptom is necrosis and disintegration of younger arrows with a yellow color and finally palms fell into sick and in unproductive state. The dreaded fungus named *Phytophthora palmivora* attacks results in bud rot disease [30]. In Bangladesh, study was conducted on different locations for an environmental friendly disease management method and the main diseases found in coconut were grey leaf spot or blight and bud rot disease. Weather factors such as temperature, rainfall and relative humidity and location of plant plays a major role for varying the disease [31]. Bud Rot effected palm shows the detachment of external tissues by leaving the secondary ribs. In the final stage of the disease, plant can't issue new arrows which indicate the total damage. Even though palms of all age are to be attacked, young ones are more susceptible. This disease is found in climate of humidity and low temperature such as monsoon season. Symptoms are black spots on the leaves followed by yellowing and finally spindle withers and drops down with a foul smell. Nuts are retained in their palms goes maturity.

From the previous studies, it is found that bud rot disease was commonly found in environment conditions of high humidity and low temperature. Heavy rains and cyclones increase the intensity of the disease in 2020-2022 year. Spreading of disease in the garden soil is carried out through communication and movement of human, birds, insects and snails, especially in rainy season [32]. Preventive measures should be taken to come down the disease such as proper spacing should be maintained and can apply copper oxy chloride 3g/lit of water [33].

### 4. Ganoderma Butt Rot

Ganoderma is a wood stinking fungus attacking old or weak palms, especially coconut palms throughout the world. It is also known as Basal Stem Rot (BSR) and is spread through soil. Species like *G. applanatum*, *G. boninense*, *G. lucidum*, *G. zonatum* are the causal agents of the disease. Even though Ganoderma species have important economic value, it has the dark side to spoil living trunks coconut palms. Symptoms shown are the diminishing of the palm from normal growth, becoming pale green color of the leaves and fungus kills the trunk and drops the entire palm while the disease progresses [34].

Lower leaves become yellow color and fine roots become decayed. Just near the ground level of the stem, bleeding patches appeared that extends upwards on the progress of the disease and parallel shedding of nuts occurs. Stem decay also takes place with a bad smell as fluid of reddish brown color comes from the stem and decay moves upwards. Meanwhile leaf production becomes reduced and also shortage of leaves turned out [35]. Young palms infected by Ganoderma disease die within 6-24 months after the first appearance of the symptom. Mature plants take some more time probably 2-3 more years to complete drop [36]. Two diagnostic methods available today for the diagnosis of Ganoderma are Pabs(Polyclonal antibodies) and PCR(Polymerase Chain Reaction) methods. Ganoderma survives in the soil for a long time. The transfer of proteins and nutrients, water irrigation causes the disease spreading as there are more fungus resides in a plant. It is also know by name Tanjore wilt, leaf blight found in Pollachi area of Tamilnadu. Survey conducted to assess in coconut growing districts



of Tamil Nadu [37].

Symptoms found on Tanjore wilt starts with withering, yellowing and drooping of the outer whorl of leaves and reddish brown liquid spread out from the stem and moves upward with a bad smell. Bracker forms at the base of the trunk in rainy seasons and finally palm dies [38-39].

### **5. Stem Bleeding**

*Thielaviopsis paradoxa* (de Seyness) Von Hohnel is the cause of Stem bleeding disease. The symptom of Stem Bleeding starts with the emission of dark reddish liquid from the barks and turns black for a distance of not very many inches and spreading upwards gradually as the disease progresses. When it damages stem tissue, leaflets become yellow and drop one by one and nut falls prematurely and crown size become shrunk.

Back water soil and other sandy soils are found as more suitable for the spread of stem bleeding disease in coconut but also rarely found in all soil types. Also hard soil types of dry spells with high temperature circumstances are favors for the pathogen for increasing disease to an extent [40].

### **6. Leaf Rot**

Water-soaked brownish lesions can be seen in the spear leaves at the earlier stage and then enlarges and get dry giving a fan shape is the symptom of the leaf rot affected palm. Unopened leaflets with pale yellow color are more susceptible to this disease. Wall less prokaryotes phytoplasma is the cause of leaf rot disease. [41-45].

### **7. Leaf Blight**

It is a non-lethal, exhausting disease found in all parts of the country. In draught climatic conditions especially in summer season, the airborne disease is found out as leaf blight severely affecting the production of nuts in coconut plants. Initial symptom of the disease is the yellowish spots surrounded by grayish line appear on the older leaflets and burnt afterwards [46]. Weligama coconut leaf wilt disease spread by insect vector found in coconut of Sri Lanka

### **8. Root Wilt Disease (Kerala Wilt)**

Symptoms found on root wilt disease are the flexibility of leaves curving inwards totally, found in palms having more than 30 months old. Yellowing of leaves followed by wilting, necrosis of leaflets and falling of nuts also occur. There is curtailment in amount of leaves as well as in size. Matured nuts seem to be smaller than normal and size of the crown get reduced. Roots also show symptoms like cracks and rotting [47-49].

It is a phytoplasma associated disease commonly found in South India causing economic loss and yield reduction. Phytoplasmas have wall-less cells and unculturable. Through insect vectors, pathogens transmit to other plants. It has different names in different areas like Weligama coconut leaf wilt in south region of Sri Lanka and Klimantan in Indonesia. The root wilt affected palm shows delaying in flowering. It was first observed in Kerala in the year 1882. It takes nearly 6-24 months to show the clear symptoms and take 3 years in rare cases [50].

## 9. Cadang-Cadang Disease

A lethal viroid named Coconut cadang-cadang viroid (CCCVd) is the source of lethal cadang-cadang disease. Symptom shows very slowly. Just after the flowering, leaf shows yellow spots. Yellow spots spread everywhere in the initial stage, coconut production become very slow in the intermediate stage and in the final stage no more coconuts are produced at the end of 4-6 years after first symptom has been found out. Palms of less than 10 years are found to be less affected by cadang-cadang disease. CCCVd killed millions of palms in Philippines [51-52].

Viroid is a small single stranded RNA molecule and could not have protein coating with the property of self-replicating property. The already damaged palm by some insects is the place of viroids as they infiltrate cells of the damaged membrane. Viroids are resistant to high temperatures and it spread disease to healthy plants [53-54]. The spreading of virus may take place through farm tools of poor sanitation

### COMPARATIVE ANALYSIS

The listed diseases are commonly found in Asian countries like India, Indonesia, Malaysia, Philippines, Sri Lanka and in Thailand. Red ring disease is commonly found in Pakistan. Ganoderma, Leaf root and root wilt diseases are found in Bangladesh, Coconut in Myanmar is affected by Ganoderma disease. African countries such as Ghana, Ivory Coast, Nigeria, Tanzania, Mozambique and Kenya found almost all diseases except cadang-cadang. Lethal yellowing, red-ring, bud rot, leaf wilt and root wilt diseases are common in both central and south American places such as Costa Rica, Honduras, Nicaragua, Panama and in Colombia, Guyana, Suriname, Venezuela and Brazil. Red ring disease was found in Ecuador of South America. Bud rot and Leaf rot are identified in Peru, a South American state. Caribbean islands such as Jamaica, St. Lucia, Trinidad and Tobago, Cuba, Haiti are famous for coconut plantations and various diseases such as lethal yellowing, bud rot, leaf rot and root wilt diseases are affecting their economic status of the country. Country, Papua New Guinea mainly found the ganoderma, cadang-cadang and leaf blight diseases. Stem bleeding is found in Fiji, Samoa, Solomon Islands and Vanuatu part of Oceania. Also Samoa, Indonesia and Malaysia of Oceania affected by the cadang-cadang disease. Asia, Africa, Central and South America, Caribbean and Oceania of the world countries cultivated coconut and the diseases affects inversely on the production of coconut. Table 1 depicts common coconut diseases found in various part of the world along with their affected area of the coconut tree and the figure 1 represents the plot on diseases vs countries.

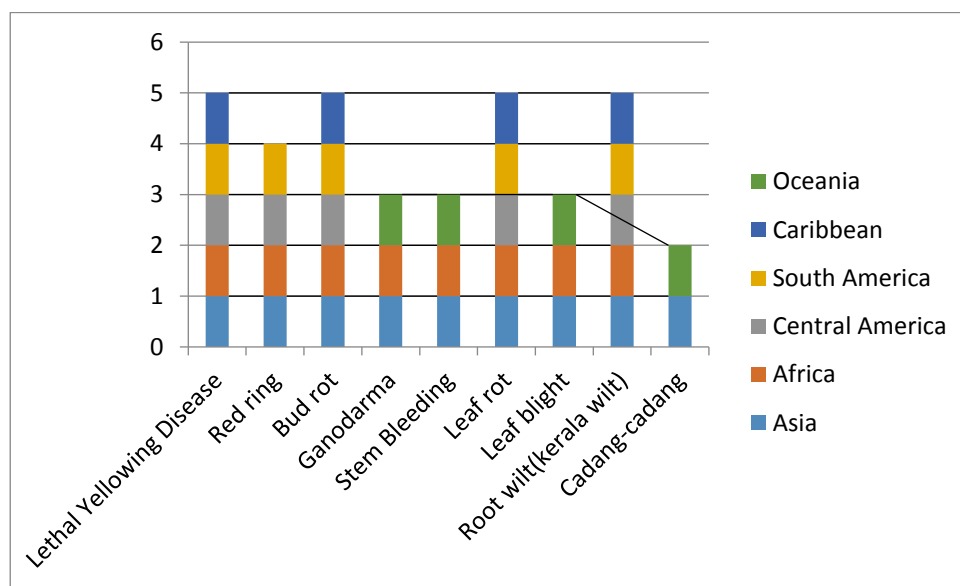
**Table 1: Coconut diseases found in different locations in various countries**

Disease	Author	Location	Affected area
Lethal Yellowing Disease	[3,8,10-20,22-25,40]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand <b>Africa:</b> Ghana, Ivory Coast, Nigeria, Tanzania, Mozambique, Kenya, Zanzibar <b>Central America:</b> Costa Rica, Honduras, Nicaragua, Panama <b>South America:</b> Colombia, Guyana, Suriname, Venezuela, Brazil <b>Caribbean:</b> Jamaica, Puerto Rico, St. Lucia, Trinidad and Tobago, Antigua and Barbuda, Bahamas, Barbados, Belize, Cuba, Dominical Republic, Grenada, Haiti, Guadeloup, Martinique, Monteserrat, St. Vincent and the Grenadines, Kitts and Nevis	Leaf
Red ring	[21,28-30,32]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Pakistan <b>Africa:</b> Ghana, Ivory Coast, Nigeria, Tanzania, Mozambique, Kenya, Zanzibar, Cameroon, Democratic Republic of Congo, Gabon, Togo <b>Central America:</b> Costa Rica, Honduras, Nicaragua, Panama, Guatemala, Mexico <b>South America:</b> Colombia, Guyana, Suriname, Venezuela, Brazil, Ecuador	trunk and leaves
Bud rot	[29, 34]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand <b>Africa:</b> Ghana, Ivory Coast, Nigeria, Tanzania, Mozambique <b>Central America:</b> Costa Rica, Honduras, Nicaragua, Panama, Guatemala, Mexico, Belize, El Salvador <b>South America:</b> Colombia, Guyana, Suriname, Venezuela, Brazil, Peru, Ecuador <b>Caribbean:</b> Jamaica, Puerto Rico, St. Lucia, Trinidad and Tobago, Antigua and Barbuda, Bahamas, Barbados, Belize, Cuba, Dominical Republic, Grenada, Haiti	buds
Ganodarma	[35-37]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Bangladesh, Myanmar <b>Africa:</b> Ghana, Ivory Coast, Nigeria, Tanzania, Cameroon <b>Oceania:</b> Papua New Guinea	trunk
Stem Bleeding	[2,26,42]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand <b>Africa:</b> Ghana, Ivory Coast, Nigeria, Tanzania, Mozambique <b>Oceania:</b> Fiji, Samoa, Solomon Islands, Vanuatu	trunk
Leaf rot	[32,35,36]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Bangladesh <b>Africa:</b> Ghana, Ivory Coast, Nigeria, Tanzania, Mozambique, Kenya <b>Central America:</b> Costa Rica, Honduras, Nicaragua, Panama <b>South America:</b> Colombia, Guyana, Suriname, Venezuela, Brazil, Peru, Ecuador	leaves



		<b>Caribbean:</b> Jamaica, Puerto Rico, St. Lucia, Trinidad and Tobago, St. Vincent and the Grenadines	
Leaf blight	[26,32,50]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand <b>Africa:</b> Ghana, Ivory Coast, Tanzania, Mozambique, Kenya <b>Oceania:</b> Australia, Fiji, Papua New Guinea	leaves
Root wilt(kerala wilt)	[2,32,47,48]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Thailand, Bangladesh <b>Africa:</b> Ghana, Nigeria, Tanzania, Mozambique <b>Central America:</b> Costa Rica, Honduras, Panama <b>South America:</b> Colombia, Guyana, Suriname, Venezuela, Peru <b>Caribbean:</b> Jamaica, Puerto Rico, St. Lucia, Trinidad and Tobago, Barbados, Dominican Republic, Grenada, Haiti	roots
Cadang-cadang	[30,51-54]	<b>Asia:</b> India, Indonesia, Malaysia, Philippines, Thailand <b>Oceania:</b> Papua New Guinea, Samoa, Indonesia, Malaysia	Growing point

Figure 1: Graphical representation on coconut diseases vs countries



## CONCLUSION

As replanting of each palm is not economically viable, proper control measurements should be adopted to limit the diseases of coconut. This paper illustrates the common diseases found in coconut and it will help to take early adoption of control strategies to limit the economic loss of the country to some extent. Further research is required in the field to identify the early detection of disease and implement innovative disease management strategies for the sustainable crop production.

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