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Disease Management of Cashew in Tamil Nadu

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Abstract

Cashews are an extremely important source of income for thousands of people in Tamil Nadu Southern India in growing the plant harvesting the nuts, processing the kernels and apples, and marketing the products. Diseases have been reported to cause significant cashew yield loss in Tamil Nadu, a major cashew-producing country. Anthracnose is by far the most important disease. Other foliar infections, namely black mold, angular leaf spot, and powdery mildew, are considered less important. Gummosis of branches and trunks has increased its severity in all southern-producing states. A nematode attack has so far not been detected in this crop. Fungal deterioration of kernels, a pre-and post-harvest problem, causes losses of millions of dollars per annum. The spraying of pesticides in Tamil Nadu cashew plantations is seldom practiced by most farmers due to economic and social reasons. Some diseases are more severe in dwarf cashew clones than in common tall cashew plants.

Keywords: Cashew, diseases, Tamil Nadu, epidemiology, etiology, control

Introduction

One of the most significant cash crops in the northeastern part of Tamil Nadu is the cashew nut (Anacardium occidentale L.). More than 100,000 people are employed by this crop, which is grown on about 700,000 acres and generates an annual revenue of $200 million dollars. (Freire *et al*., 2002) [12]., The Indian cashew market is expected to reach USD 2.31 billion in 2023 and grow at a CAGR of 3.80% to reach USD 2.79 billion by 2028. The processed kernels were the principal commodity exported to the USA, Canada, Japan, the Middle East, Singapore, Australia, the U.K., and other EEC countries in 1963. The kernel of the kidney-shaped fruit is available to consumers in its most natural and pure form, which is how the proverb "cashews care for your health" came to be. In India, the cashew processing business has a long history of being centered on agriculture (Vyavahare *et al*., 2020) [31], since its humble beginnings as a crop intended to prevent soil erosion, cashew has developed into the third-largest earner of foreign exchange, behind tea and coffee. Cashews are one of the most important nuts produced globally, producing 37.20 lakh tonnes from a harvested area of 40.97 lakh hectares, according to FAO Stat (2008). A notable plantation crop that starts to bear after the third year and is spaced far apart is the cashew nut. Eight states in our nation, primarily on the west and east coasts, include Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu, and West Bengal. Additionally, a small amount of Assam, Chhattisgarh, Gujarat, Meghalaya, Nagaland, and Tripura also grow cashews. An estimated 6.95 lakh tonnes of raw cashew nuts are produced annually on an area of 8.93 lakh acres (2008-09) in India. Next only to Vietnam, India is the world's second-largest producer and exporter of cashews. It is both the biggest processor with the most cropped acres and the second-largest consumer of cashews. (Deivasigamani, 2016) [11],

In actuality, cashew is not only an essential resource for the survival of smallholder farmers, who make up the majority of producers and processors globally but also an important agricultural commodity in developing countries by significantly contributing to GDP and export exchanges at the country level. (Monteiro *et al*., 2017) [19]. Because of this, the cashew sector should be used positively within the framework of the MDGs to empower smallholder farmers, generate income, and create job opportunities by encouraging small-to medium-scale industrialization processes, particularly in rural regions.

However, a concerted attempt to enhance cashews started in the 1950s with the University Cashew Research Centres and ICAR (Indian Council of Agricultural Research, New Delhi) compiling the varied varieties that were accessible throughout the nation. In India, it is a seasonal crop that is harvested between March and May. (Sivagurunanthan *et al*., 2011) [27].

It was introduced in India by Portuguese travelers in the 16th century for afforestation and soil conservation. India was the first country in the world to exploit international trade in cashew kernel in the early part of the 20th century. Cashew is a versatile tree nut presently cultivated in more than 10 tropical countries and consumed almost all over the world. Botanically, cashew is a wonder nut because it is the only nut

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that appears outside the fruit. The nut is a storehouse of nutrients (Pattnaik & Mohanty, 2021) [24].

The disease cashew dieback, which currently accounts for roughly 25-30% of yield loss, is one of the worst. The illness was particularly bad during the monsoon season. The drying of floral branches and small, water-soaked lesions on the primary and secondary rachises are the defining symptoms. The pinkish-brown sores get larger and quickly develop scabs. The affected areas exhibit gummy exudates. The inflorescences dry out as a result of the lesions growing into larger regions. When there is a lot of cloud cover, the incidence is particularly severe. (Associate Director, 2020).

Despite the cashew tree's prolific flowering each season, fruit set is only said to be as low as 1% to 2%. Heavy blossom and fruit drop in cashew is mostly caused by the plateau region's unfertilized soil and rough texture. This will ultimately result in low yield and subpar nuts. The cashew plant needs enough nutrients for the growth of fresh flowers, fruit set, and the production of high-quality nuts because it is a regular bearer that produces flowering and sets fruits on the flush of the current season. The fertilizer NPK 19-19-19 is entirely water-soluble and comprises nitrogen in three different forms: NO-N (45.0%), NH-N (4.5%), 3-4, and NH-N (10.5%), as well as water-soluble phosphorus and potassium, each of which have a low salt index and contain 19%. Maintaining plant health, increases resistance to pests and diseases, reducing the need for agrochemicals and promoting more uniform flowering with fewer acorns, which increases crop output. (Ramteke *et al*., 2022) [25].

The creation of high-quality planting stock, which depends on the right potting mixture, is essential for the establishment and survival of the planting stock in the field. Better graft establishment is feasible if the field is healthy, free of pests and diseases, and has a robust root system for anchoring in the soil. On a healthy medium with adequate nutrients and aeration for roots, which enhance their growth and vigor, interns are conceivable. In light of this, the current experiment was conducted to identify an appropriate potting medium to guarantee the proper growth of cashew grafts. (Ayare *et al*., 2021) [7].

The current study's objective was to assess the impact of the defense activators ASM, DCINA, SA, and K2HPO4 on the kind of disease reaction in cashews. Experiments expose leaves to C. gloeosporioides infection. It was carried out in a glasshouse and under strict control. Circumstances, as well as in North-East Brazil's field plots, to determine whether this strategy has any chance of succeeding application for the prevention of the disease anthracnose in the crop of cashews. (Lopez & Lucas, 2002) [16]. This paper reports on the main diseases of cashew nut plants in Tamil Nadu. Epidemiology, symptoms, and casual agents of disease are discussed as well as measures to control them.

Disease Management in Tamil Nadu

The cashew tree is vulnerable to numerous diseases. However, the severity of the disease problem is not as serious as the number of insect pests attacking cashews and the extent of the damage they do. Only a few of the more than a dozen fungi that have been found in cashews are harmful.

Diseases in Cashew

Damping-off

- A range of soil-and seed-borne fungi, the bulk of which are soil critters, are responsible for damping down. These include Rhizoctonia solani, Pythium spp., Phytophthora spp., and Fusarium spp. Botrytis species, Sclerotinia sclerotiorum, Sclerotium rolfsii, and Cylindrocladium may also occasionally result in damping-off. In nurseries with poor drainage, the disease manifests itself.
- Affected plants become drab and have darkish tissue girdles around the stem that have been moistened by water. Such seedlings ultimately collapse or decay. In extreme situations, the leaves also exhibit wet spots that grow and combine.
- Diseases are more easily dampened off by close spacing, continuous nursery development, chilly, wet, highly organic, and basic to neutral soils.

Seedling Blight

A fungus causes seedling blight. Causing agents have been identified as Fusarium sp., Pythium sp., Phytophthora palmivora, and Cylindrocladium scoparium. The illness strikes poorly ventilated nurseries and is particularly bad during the rainy season. Small, yellowish dots that emerge on the rootstock leaves are the disease's signature. The size of these tiny, pinhead-like dots steadily grows. The surrounding tissues subsequently change color from brown to ash. As a result, the leaf tips get dry. Petioles and leaves are also affected by the infection. Petioles develop elliptical lesions that encircle the stem tissues.

Gummosis

- Ceratocystis sp is the culprit behind the illness. The main stem and branches of the plant start to exude a reddish-brown liquid, which later turns black in color. Additionally, longitudinal fissures can be seen on the area where gum is oozing. Small cavities filled with reddish fluid can be seen inside the reddish-brown interior tissues of the affected areas.
- Remove the damaged area with a chisel, then apply Bordeaux paste or swab the cut area with copper oxychloride suspension.

Symptoms

- This illness is widespread, particularly during the monsoon season. In conjunction with mosquito bugs, the fungi Colletotrichum gloeosporioides and Phomopsis anacardii are responsible for the sickness.
- The wilting of flower branches is a symptom of the disease. On the primary and secondary rachis, tiny, reddish-brown, glossy lesions that are submerged in water appear. The sores expand, turn pinkish-brown, and quickly develop scabs.
- The afflicted areas exhibit gummy exudation. The adjacent lesions combine, causing the inflorescence to dry up and take on a burned appearance. The apples and nuts exhibit decay and shrinkage. When it is cloudy outside, the sickness spreads more frequently.

Control

It is advised to use a combination spray of the pesticide monocrotophos 36 WSC 0.05% @ 1.5 ml per liter and the fungicide copper oxychloride 0.2%.

Pink Disease or Die-Back

- Pellicularia salmonicolor, which causes pink illness, is of minimal consequence (Berk and Brown). During the South-West monsoon season, it is common.
- The sickness is more common when it rains. Initially, affected branches have white patches on their bark, and

during the monsoon season, a silky thread-like mycelium layer forms on the branches. The fungus enters deeper tissues and prevents nutrients from being transported. The word "die-back" comes from the way that this causes the shoots and branches to droop and dry up from the tip down. Later, a pink growth that depicts the poromas appears on the fungus. In later phases, the leaves become yellow and drop off while the bark breaks and peels off.

- The disease can be controlled by cutting off and destroying the affected branches and shoots below the infection site, applying Bordeaux paste (10%) to cut surfaces, and spraying prophylactic doses of Bordeaux mixture (1%) or any other copper fungicide during the months of October and November.

Powdery Mildew

i). Oidium sp. (Erysiphales: Ascomycotina) is a fungus that causes powdery mildew. The pathogen, an obligate parasite, generates a large number of hyaline, one-celled spores with thin walls that are primarily spread by wind.

ii). The illness manifests as a greyish-white growth on young nuts, flowers, and fragile leaves. When a tree is badly impacted, the leaves wilt and dry, the flower buds and blooms wilt, and the fruits drop off early.

iii). The illness typically manifests between December and January. During the flowering seasons, high humidity and cool nights encourage the fungus's rapid reproduction and, as a result, the spread of the disease.

iv). Rainfall during the flowering season increases the disease's spread.

v). Spray the trees twice with wettable sulfur @ 0.2% at pre-bloom and full-bloom to control the illness. Dust fine sulfur on young trees once before flower blooming and once more at fruit setting. Another efficient way to control the disease is to

vi). Spray carbendazim at a concentration of 1g per liter of water. *Source:https://www.ikisan.com/tn-cashew-disease-management.html#top*

T.N. Ravi Prasad et al. (2020) [26]. One of the main pests of cashews, Helopeltis spp. (Hemiptera: Miridae), affects its delicate shoots, panicles, nuts, and apples. Nymphs and adults both eat by sucking plant components and injecting salivary enzymes called polyphenol oxidase. Each insect has the potential to severely reduce the output by damaging three or four shoots or panicles. Damage of between 25 and 30 percent and perhaps 100 percent may be anticipated in outbreak scenarios. (Ravi Prasad & Vanitha, 2020) [26]. In order to characterize and synthesize the sex pheromone components for the development of sex-pheromone traps that may be used to monitor and catch the insect population during the cropping season, collaborative trials are now being conducted. This method eliminates the potential for environmental degradation and lessens the reliance on insecticides, which can cause residue-related problems.

Fani Ardiani et al. (2020) [4]. Farmers execute treatments including weeding, fertilizing, insect management, and pruning as part of crop maintenance activities. Typically, cashews are harvested from September to November. In the past, cashew crop growing was the national industry of Indonesia. 2.86% of the world's cashew production comes from Indonesia. (Ardiani *et al*., 2020) [4]. An example of optimal land use is choosing an intercropping cropping pattern. In order for cashew plants to produce well, proper cultivation techniques are used for everything from plant maintenance to post-harvest procedures.

Filipa Monteiro et al. (2022) [20]. Establishing a standardized identification process is crucial for accurately identifying the disease-causing agent and determining the incidence and/or spread of a certain pathogen. Across the areas that produce cashews. (Monteiro *et al*., 2022) [20]. Cashews may grow in well-drained soils with little to no inputs in tropical areas that alternate between seasonal wet and dry conditions. Information on the state of cashew diseases is essential for the stakeholders to improve the cashew value chain and serves as a starting point for the development of effective control methods. (Monteiro *et al*., 2022) [20]. According to the information that is currently available, gummosis is the most common and destructive disease of cashews, affecting more than 90% of the total planted areas throughout the Pantropics, while anthracnose has a relatively low incidence and only becomes economically significant when it affects inflorescences and fruits. *(C. gloeosporioides).*

Fitra Parlindo et al. (2023) [23]. Rigidoporus sp. is the main cause of the serious cashew disease known as white root disease. Five endophytic fungal isolates were evaluated as the bio control agents against Rigidoporus sp. *in vitro* and in planta, including AR31D (Fusarium proliferatum), AR42D (Penicillium citrinum), BR32C (Trichoderma asperellum), VNTB1 (Chaetomium sp.), and EAGS14 (Curvularia lunata). (Parlindo *et al*., 2023) [23]. Only four isolates, however, were able to solubilize phosphate with low to moderate solubilization efficiency. In 10-65% of the cases, the isolates successfully colonized the roots of cashew saplings. Farmers in Bali continued to use eradication techniques to manage the illness in the cashew crop. In the meantime, synthetic fungicides were typically used to treat rubber plants for this fungus (sprinkled on the soil around the root neck) (*Yulia et al. 2017*).

F Parlindo et al. (2022). Field research revealed that white root disease, which primarily manifests as wilting and the presence of rhizomorph on the basal stem in cashew trees between the ages of 8 and 23, affects cashew plantations. The development of wilting symptoms and the presence of rhizomorph on the basal stem occurred 51-76 days after an artificial inoculation on nine-month-old saplings. Finally, the vaccinated seedlings perished. Rigidoporus sp. (Parlindo *et al*., 2023) [23]. Because farmers know little about this illness, there is still room for improvement in terms of disease prevention and control. Low yields were endured by farmers as a result of a decrease in the quantity of producing plants. (Parlindo *et al*., 2023) [23]. Similar symptoms to those of the infected productive plants in the field were present in infected saplings, including the presence of fungal rhizomorphs in the roots and stem base. The afflicted plants' roots rot and turn black after the disease has evolved to this stage. (Parlindo *et al*., 2023) [23].

Methodology of the Proposed System

The proposed model for identifying cashew leaf disease is described in this section. The main objective of disease detection is to identify the type of ailment that the cashew crop is suffering. Predicting how a disease will develop is the goal of disease management. Accuracy is one of several factors that go into classifying and recognizing plant leaf diseases. (Sudha & Kumaran, 2023) [28]. The gathering of Cashew Leaf image datasets, image preprocessing, segmentation, and classification are all steps in the image

classification process. The suggested model for identifying cashew leaf disease is shown in Figure 1.

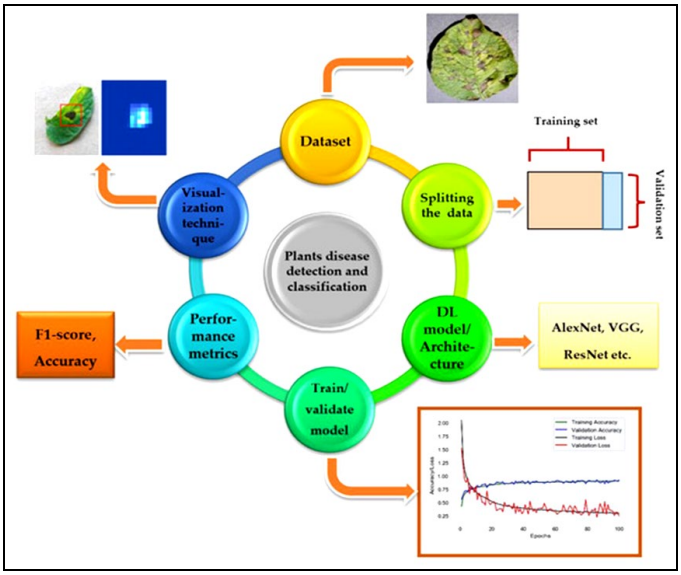

Fig 1: proposed model for cashew leaf disease detection.

History, Effect, and Conditions Favoring Cashew Disease and Their Management in Tamil Nadu

- **Cashew Powdery Mildew Disease:** Although powdery mildew has been around since the 1950s, Tanzania did not see its economic impact until the middle of the 1970s (Casulli, 1979; Castellani and Casulli, 1981; Sijaona, 1984; Sijaona and Shomari, 1987; Shomari, 1988). Old and mature leaves are rarely affected by the illness (Sijaona *et al*., 2006). On the afflicted fruit-bearing stems and flowers, a white, powdery growth develops. After two to three weeks, the lesions on the infected areas start to progressively fade, dry out, and shed, which causes a large number of blooms and sensitive fruits to dry up and fall off *(Sijaona and Shomari, 1987).* Although at varying degrees, powdery mildew illness can affect any kind of cashew. Compared to improved varieties, which have a specific amount of resistance or tolerance, most unimproved Cashew types die more quickly from the illness (Masawe 2006; Sijaona, 2013). Cold nights, mild days, and misty or foggy weather in the mornings create an atmosphere that is favorable for PMD. (Manjusha *et al*., 2023). The ideal temperature is between 25 and 28 C, with 26 C being the best. The optimal relative humidity for a healthy environment is 95% *(Noak 1898; Ohler 1979; Casulli 1979; Chacko et al. 1990; Sijaona 2013)*, with a range of 80 to 100%.
- **Cashew Pestalotia Leaf Spot Disease:** In mature leaves, the fungus causes angular to irregular leaf lesions that are reddish brown on the upper surface and pale grey to whitish on the underside. Wind and free-flowing water are the pathogen's principal means of dispersion. The disease can be best treated by applying copper-based fungicides, such as Kocide, at rates of 3-5 gm per liter of water at intervals of two weeks *(Zhongrun and Masawe, 2014).*
- **Cashew Damping off Disease:** Several fungi, the majority of which are found mostly in nurseries, cause the damping off cashew disease, including Fusarium spp., Pythium spp., Phytophthora palmivora Butler, Cylindrocladium scoparium Morgan, Sclerotium rolfsii Sacc, and Pythium ultimum trow. To prevent waterlogging, the nursery or the land where young plants are kept in containers needs to have good drainage.
- **Cashew Anthracnose Disease:** According to Casali (1981), anthracnose first appeared in Tamil Nadu in 1978. Colletotrichum gloeosporoides Penzis, the fungus that causes this disease, affects not only cashew trees but also mango, citrus, avocado, and papaya plants in tropical climates (Sijaona, 2013). The illness targets all young and delicate vegetative organs, along with nuts and fake fruits/apples.
  Lesions produced by *C. gloeosporioides* on young leaves of cashew seedlings or adult plants are initially water-soaked and become orange-brown to light reddish with age and sporulation of the fungus. The pathogen can attack leaves, twigs, inflorescences, young apples, and fruits. In severe cases leaves and fruitlets become totally blighted and drop. Under suitable conditions, the disease can reduce yield by up to 50%, drastically affecting apple and kernel quality (*Cardoso et al., 1994*). The fungus life cycle is highly dependent upon free water and humidity. During the rainy period in the Tamil Nadu southern region (*from January to June*) and during "cashew rain", in August and September, the disease reaches its highest severity, spreading quickly inside and between plants. Temperatures range from 22ºC to 28 ºC and at least 10 h of saturation are excellent conditions for the infection.
  Spraying tall cashew trees is not an easy task. Dwarf cashews, on the other hand, facilitate cultural practices such as pruning, spraying, and the careful harvesting of apples. However, a number of barriers prevent the adoption the chemical control by the farmers. The extensive area planted, low productivity, and fungicide cost, make disease control economically unviable. (Majune *et al*., 2018) [17]. Reddish brown shiny lesions that are absorbed in water and resin exudation on the affected areas are the early indications. "Hanging nuts" are the appearance of infected shoots. During the next season, hanging nuts could serve as a source of disease infection (*Zhongrun and Masawe, 2014*).
- **Cashew Dieback Disease:** *Intini and Sijaona (1983)* state that Tamil Nadu received a report of the cashew dieback disease in 1980. According to *Zhongrun and Masawe (2014)*, damage to the cashew plant caused by mirid (Helopeltis spp.) or coconut bug (Pseudotheraptus way) may have promoted the spread of this fungal disease caused by Phomopsis anacardii early and Punithalingam. (Majune *et al*., 2018) [17]. Panicle withering is one of the disease's signs, which is followed by the gradual dieback of little flower stalks. Intini and Sijaona (1983) state that this starts from the tips and moves down to the main flower shoots. The healthy branches' natural greenish tint gradually changes to brown, which causes the loss of blooms. Young, infected nuts and apples turn black and fluffy and stay affixed to the flower stems. Heavy infection resembles fire damage in appearance (Sijaona, 2013). (Majune *et al*., 2018) [17].
- **Black Mould:** After anthracnose, black mold is considered the most important foliar disease of cashew plants in Tamil Nadu. Although the disease was first recorded on the common cashew type, the damage is most severe on the dwarf cashew clones. The disease was named black mold by Aquino and Melo (1974). *Pilgeriella anacardii* (Batista *et al*., 1964) Arx & Miller, 1975, the causal agent, is an obligate parasite and has been found infecting only cashew plants. The taxonomic position of

the pathogen has been discussed by Freire (1998). The initial symptoms are chlorotic spots on the upper surface of the leaves, the pathogen forms dark brown to almost black colonies. Severely infected leaves become shriveled and fall prematurely. Young leaves are not susceptible to the pathogens.

Attempts to control the disease by spraying protective and cultivating fungicides have been successfully carried out in Tamil Nadu (Freire, 1991b; Cardoso *et al*., 1995). None of the commercially grown dwarf cashew clones in Tamil Nadu has shown resistance against the black mold, although five clones of the germplasm collection of the Brazilian Enterprise for Agricultural Research (BMBRAPA) have shown resistance to this disease (Cardoso *et al*., 1999).

- **Angular Leaf Spot:** Another widespread foliar disease of cashews in Tamil Nadu is angular leaf spot, caused by the fungus *Septoria anacardii* Freire. Initially, confused only recently (Freire, 1997). This fungus can infect seedlings in the nursery as well as adult plants in the field. On seedlings, leaf spots are conspicuous, with dark brown margins and light brown or nearly cream-colored necrotic tissues in the center, visible on both surfaces.

  Severe infection may cause some defoliation mostly of seedlings. Adult plants are more resistant to this disease. No control measures have been used against angular leaf spots in cashews. However, spraying of experimental plots with protective and systemic fungicides has successfully controlled the disease. Resistance to angular leaf spot was detected in 11 clones of dwarf cashew clones in Tamil Nadu (Cardoso *et al*., 1999).
- **Powdery Mildew:** This disease is considered of secondary importance in Tamil Nadu cashew plantations so control measures are not used. Experimental trials, however, revealed that control can be obtained by fortnightly dusting or spraying with sulfur products or with benomyl (Cardoso *et al*., 1997). In some African countries such as Tanzania crop, losses of 50% and 70% were recorded from experimental blocks (Sijaona and Shomari, 1987).
- **Gummosis:** In India, an inflorescence and young shoot blight are presumed to be caused by the combined attack by the tea mosquito (*Helopeltis antonii*) and fungi have been shown to be primarily caused by the tea mosquito. The fungi were only saprophytic colonizers (Nambiar and Brahma, 1979). Spraying of endosulfan 0.05% at the time of emergence of new shoots and inflorescences and at the fruit set helps bring down the pest population and the incidence of the disease. There are no records on the *Helopeltis* spp. Attack on cashew plants in Tamil Nadu.
- **Diseases Affecting Seedlings:** Cashew seedlings are subjected to serious nursery infections in Tamil Nadu. The most common is anthracnose *(C.gloeosporioides)*, which appears mainly during the rainy period. Symptoms are similar to those on adult plants, with severe leaf and shoot blight. Weekly spraying with copper oxychloride (3 g c.p./1) or with benomyl (1 g c.p./1) can efficiently control the disease. Sometimes a dipterous insect (*Contarinia* sp.) can simultaneously attack the seedling leaves, increasing the severity of the anthracnose. Insecticides must be used in order to keep nurseries insect-free. The second most common infection is foot and root rot caused by *Pythium splendens* Braun. Seedlings show yellowish leaves, followed by wilt and death 2-5 days later. As the seedlings get older they become more resistant. The rate of infection is usually<1%, and good nursery management (i.e. shading, water supply, etc.) is sufficient to keep the disease under control.

  Blight caused by P*hytophthora heveae* and P. *nicotiana* is a recently observed disease of cashew seedlings in Tamil Nadu. During the rainy season, this disease can devastate a nursery in a few days if chemical control is not used. Initial symptoms are water-soaked leaf spots, which progress to necrotic brown to dark-brown color spots. The infection reaches the whole seedling quickly causing its death. Preventive or curative weekly spraying with metalaxyl (1 g c.p./1) is sufficient to control the infection. Foliar blight caused by C*ylindrocladium scoparium* Morgan is another disease of seedlings occurring only during the rainy season and affecting a few plants in nurseries. No control measures have been prescribed. Root and foot rot caused by *Sclerotium rolfsii* Sacc. Is a sporadic disease of cashew seedlings in Tamil Nadu. Characteristic symptoms of infection are wilting withering, and rotting of underground parts. On the stem, near the soil level, many white sclerotia appear, which turn brown or dark-brown color. No control measures are used.

  Grafted cashew seedlings can be affected by the fungus L. *theobromae* during the healing of graft unions. The pathogen can be either endophytic in cashew root stocks or scions, or be disseminated to seedlings through the nurserymen knives. This infection has been controlled by periodically cleaning the knives with a 1.0% sodium hypochlorite solution and by immersing the scions in a 1.0% benomyl solution for 15 min (Almeida *et al*., 1979; Freire, 1996, 2001).
- **Other Minor Foliar Diseases:** Several other fungi have been reported that are associated with foliar infections of cashew plants in Tamil Nadu, namely *Corynespora hansfordii,* P*estalotia dichaeta,* P.*paeoniae, Phyllosticta brasiliensis,* P*homopsis anacardii*, and other species associated with dark mildew and sooty molds such as C*apnodium brasiliensis*, C*apnodium citri*, C*apnodium* sp., fumago sp., Micro xyphium sp. And Cladosporium sp. The alga Cephaleuros virescens is also widespread in Tamil Nadu cashew plantations (Batista *et al*., 1964; Urben and Mattos, 1974; Ponte, 1984; Menezes, 1997). (Gardens, 2022) [14].

Plant Parasitic Nematodes

To date, there has been no conclusive report of any damage caused by plant parasitic nematodes to cashew plants. Nematodes do survive in this plant rhizosphere but without causing any apparent damage. In the Indian State, of Tamil Nadu, nematodes such as *criconemodes* sp., *Scutellonema* sp., and *Xiphinema* sp. Have been found around the roots of cashew trees (Lima *et al*., 1975). (Gardens, 2022) [14], Cashew seedlings inoculated with root-knot species (M*eloidogyne arenaria*, M. *halpa*, M. *incognita*, and M. *javanica*) did not show any infection symptoms (Ponte and Saraiva, 1973). In India, the nematode B*asirotyleptus caudatus* was also detected in the rhizosphere of adult plants. (Bhattacharya *et al*., 2012) [9]. However, the pathogenic association was proven (Jairajpuri, 1966). The same has been reported for Trophurus sp. and an unidentified reniform nematode in Jamaica (Ohler, 1979). If it is. Potted plants from the nursery are often transplanted during the months of June and July. (Asogwa *et al*., 2008) [5]. The stages of phenological development of cashew nuts' leaf, stalk, inflorescence, blooming, and fruit that are most vulnerable to PMD attack are these stages (Chávez-mejía *et al*., 2019) [10]. These stages of development

take place in Tamil Nadu from April to September. The vegetative leaf development stage is the cashew's primary growth stage from late December to early April. (Chávez-mejía *et al*., 2019) [10].

Fungal Deterioration of Cashew Kernels

Dwarf cashew kernels showed the highest rates of infection, with Aspergillus and Penicillium being the most prevalent fungi. Brazilian exporters claim that fungal kernel degradation can result in losses of up to $20 million per year. (Adebajo & Diyaolu, 2003) [1].

(Amiri & Tibuhwa, 2021). As a result of their widespread distribution and higher survivability during the final stages of decomposition, Alternaria species, Aspergillus niger, Cladosporium species, Curvularia lunata, Fusarium solani, Mucor racemosus, Nigrospora spherical, Penicillium species, Phoma species, and Trichoderma koningii are considered essential for litter degradation in the study forests. (Venkatesan & Muthuchelian, 2008) [30]. An extensive survey of fungal flora in Tamil Nadu revealed the presence of 65 different taxa associated with kernel deterioration. The highest rates of infection were observed in kernels of dwarf cashews, and the most common fungal species were those of A*spergillus* and P*enicillium*. According to Tamil Nadu cashew exporters, fungal kernel deterioration can cause losses as high as 20 million dollars yearly. Two fresh cashew fruits were washed with 10% sodium hypochlorite, rinsed in distilled water, and allowed to dry in order to prove that the fungal isolate is responsible for the disease condition (i.e., cashew fruit degeneration). On healthy cashew fruits, a cork borer was used to drill holes 8-10 mm in diameter, and each isolate was then injected into each one. The samples were cultured to see if the distinctive symptoms would appear. After five days of inoculation, illness symptoms started to appear on the fresh fruits (cashews). Re-isolating and re-identifying the isolate were done. (Bahu *et al*., 2020) [8]. When compared to other fungal isolates in the same sites, this investigation showed that Aspergillus flavus was more common in various places. Additionally, the absence of fluorescence in an Aspergillus versicolor-infected sample suggests that the sample does not contain any mycotoxins. (Bahu *et al*., 2020) [8]. Following Adebajo (2000), this investigation was carried out to ascertain the involvement of isolates in the rotting of the nuts. Fresh, healthy cotyledons were dry-milled, weight-controlled oven-dried at 900 C, well mixed, and portioned in 25g portions into 250 ml conical flasks. The flasks were aluminum foil-wrapped, cotton-stoppered, and autoclaved twice in a 24-hour period for 15 minutes at 1210 C. A 6-day-old culture of a test fungus cultured on PDA slants was aseptically injected (using an atomizer) into the substrate in each flask using six ml of an aqueous conidial suspension (106/ml). Throughout the procedure, the latter was turned to achieve a uniform distribution of the conidia-bearing mist. Five copies of each experiment were performed. After inoculation, the substrates' approximate moisture content was 21.2%. (Adebajo & Diyaolu, 2003) [1]. After 30 days of incubation at 280 C, the contents of each flask were oven-dried for 48 hours at 900 C, cooled in a desiccator over anhydrous CaCl2, and then weighed. Fungal deterioration was the cause of the weight difference between the beginning and end of the trial. Cashew trees were shown to survive for more than three years without contracting any diseases in biofield-treated fields, resulting in totally organic trees. The biofield-treated farms' cashew trees had lustrous green leaves, and healthy nuts, and were free of illnesses. (Kumar Trivedi *et al*., 2015).

He suggested that insects of the genus A*topomyrmex were* not only agents of dissemination of those fungi but also effective agents of inoculation. Studies conducted in Tamil Nadu have demonstrated that fungi associated with kernel infection are endophytic to cashew plants or can invade ovaries through flowers or be introduced into the young kernels by insects (Freire, 1999) [13]. In India, the presence of C*ladosporium* sp., A.*niger*, F*usarium* sp., P*enicillium* sp., and R*hizopus* sp. is associated with kernel rot in immature and mature nuts was confirmed by Nambiar (1978) in Thailand. The presence of cashew kernels of fungi potentially toxigenic such as A*lternaria alternate*, A*spergillus flavus*, A. ochraceus, A. *parasiticus*, C*haetomium funicola*, C. *globosum,* P*enicillium citrinum*, and P. *oxalicum* is of concern to the exporters of all producing countries since foreign buyers have now severe limits for mycotoxins, mainly for aflatoxins.Indeed, recent studies conducted on the microflora and mycotoxins in Tamil Nadu cashew kernels revealed, for the first time, the presence of some fungal metabolites, including traces of aflatoxin G_2 (Freire *et al*., 1999) [13]. The field fungi may have continued to flourish and perhaps even produced mycotoxin due to the high humidity and storage temperatures. (Freire *et al*., 1999) [13]. Despite the fact that direct plating is thought to show a better picture of fungal counts in a commodity, fungi that do not sporulate frequently or may be slow growers tend to be supplanted by their more vivacious counterparts. We commonly saw two or three different species developing from the same kernel fragment in this study. (Freire *et al*., 1999) [13].

Expected Yield Return on Diseased Cashew

It was estimated that L. diplodialis infestations reduced average yields by 40-50%. The disease is classified as dangerous since it has the potential to reduce nut yields by 70-80% and kill vegetative shoots by more than half. (Adeniyi *et al*., 2020) [20].

For those involved in Tamil Nadu's cashew value chain, knowledge of the state of illnesses that impact cashews and their prevention methods is essential. Plant breeders and pathologists should work together to produce resistant crop varieties and integrated pest management strategies, respectively, to battle diseases, to alleviate cashew disease issues. Understanding the season about the stage of growth and damaged plant portions is necessary for managing cashew diseases, and quick response is crucial for limiting production losses. (Adeniyi *et al*., 2020) [20].

Importance of Pollinators in Cashew

Pollinator activity has a major impact on the cashew plant's ability to bear fruit. Inflorescences in cashews grow on lateral branches from the current growing season. Both staminate (male) and hermaphrodite (bisexual) flowers can be found in each inflorescence. (Vanitha & Raviprasad, 2020) [29]. because pollen grains are naturally sticky, wind pollination is challenging, and self-pollination is challenging because of the arrangement of styles in hermaphrodite flowers. A wide variety of insects, including ants, thrips, butterflies, flies, wasps, and bees, frequently visit cashew blooms. At the ICAR-DCR, 40 species from 13 families and three insect orders have been identified as visiting cashew blooms. Many dipterans are not pollinators but only guests at cashew blooms. Wasps like sphecids and vespids frequently wander among cashew blooms, possibly in search of nectar as well as

insect prey. Like how many ant species swarm over cashew inflorescences throughout the day, EFN at the base of flowers and buds and honeydew from certain sucking pests attacking cashew inflorescences are needed most.

Conclusions and Recommendations

This study provides a thorough profile of economically significant cashew insect pests and illnesses, opening the door for additional research on cashew cultivation and enhancing the body of literature. The illnesses anthracnose, gummosis, die-back, Pestalotia, algal leaf spots, and branch pruning rot have all been linked to these fungus and algae. (Muntala *et al*., 2021) [21]. The TARI at Naliendele Centre has suggested various management techniques, including using fungicides to combat the disease that affects cashew leaves and nuts. Tebuconazole, trifloxystrobin, or chlorothalonil are among the active compounds in most recommended chemical brands (NARI 2018). (Nene *et al*., 2022) [22]. From the above studies, it is confirmed that spraying with the Triazoles group of fungicides like Hexaconazole, Propiconazole, and Difenoconazole 25% Ec@ 0.1% twice@ 25 days intervals recorded the lowest percent disease incidence and highest percent disease reduction over the control.

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