__Review Article__

Sustainable Strategies for Managing Leaf Spot Disease in Castor Plants for Ericulutre: A Review

Abstract:

Cercospora leaf spot, caused by the fungal pathogen *Cercosporaricinella*, is a devastating disease affecting castor *(Ricinus communis* L.) plants, which are the primary food source for the eri silkworm (*Samia ricini* Donovan). This disease can lead to significant losses in leaf production, quality and quantity, ultimately impacting the growth and development of eri silkworms and silk production. This review discusses various sustainable approaches for managing Cercospora leaf spot in castor plants, including the use of phytoextracts, biocontrol agents like *Trichoderma viride* and their effects on silkworms. Additionally, it explores the impact of chemical fungicides on silkworms and the potential of integrated disease management strategies. By adopting eco-friendly and sustainable methods, the ericulture industry can effectively combat this disease while ensuring the safety and well-being of the eri silkworms and the environment.

Keywords: Cercospora leaf spot, castor plants, eri silkworm, phytoextracts, biocontrol agents, *Trichoderma viride,* integrated disease management

Introduction

Castor (*Ricinus communis* L.) plays an important role in the ericulture industry as its leaves are the primary food source for the eri silkworm *Samia ricini* Donovan. The eri silkworm is a domesticated insect that can feed on multiple host plants and produces multiple generations per year. It is responsible for producing eri silk, which is commonly known as poor man's silk or Ahimsa silk. Diseases are a major limiting factor in castor cultivation for producing high yields of quality leaves. A number of fungal pathogens can cause various diseases that affect the castor leaves, roots or stems from the time of planting. Of these, foliar pathogens (leaf diseases) are most significant. They can cause 15-20% loss in leaf production, as well as severe destruction of 20-25% of the leaf area, leading to leaf loss in both quality and quantity. Feeding silkworms with diseased leaves results in poor larval growth and makes them prone to bacterial, viral, and fungal diseases. The healthy and robust growth of silkworms depends on the quality of the castor leaves, which ultimately impacts the quality and quantity of the cocoons produced (Ramanamma, 2009).

Castor (*Ricinus communis* L.) is highly susceptible to various pathogens like *Phytopthoraparasitica* (causing seedling blight), *Alternaria ricini* (Alternaria blight), *Cercosporaricinella*(Cercospora leaf spot), *Leveillulataurica* (powdery mildew) and *Fusarium oxysporum* (wilt). Among the fungal diseases affecting this crop, Cercospora leaf spot is a serious problem, often leading to loss of foliage in castor plantations grown for ericulture (eri silk production). Cercospora leaf spot is a common disease in castor (Butler, 1918). It is a major issue in castor cultivation in India, causing substantial injury to the leaves intended as feed for eri silkworms. The disease is caused by the fungal pathogen *Cercosporaricinella*Sacc. &Berl. It is a seed-borne pathogen that can be transmitted by wind or rain splash (Chattopadhyay, 2000) and can survive in the soil for up to 2 years once established in fields.

Cercospora leaf spot is favoured by extreme temperatures and prolonged periods of high humidity or free moisture on the leaves. Optimal conditions for infection are daytime temperatures of 27-32°C, nighttime temperatures above 16°C and relative humidity above 60% for at least 15-18 hours each day. In Karnataka, it was reported that in severe cases, Cercospora leaf spot infection in castor reduced yield, production, and germination by 30-50% (Dange *et al.,* 2005). The leaf spot caused by Cercospora to mulberry is reported to cause 10-12% leaf yield loss, even up to 20-35% in severe conditions (Sikdar and Krishnaswamy, 1980).The disease appears as minute black or brown spots surrounded by a pale green ring (Gfiliata, 2005). These spots are visible on both leaf surfaces. As the spots enlarge, the center turns pale brown and then grayish-white, surrounded by a deep brown band that may be narrow and sharp or broad and diffused, causing defoliation with infected tissues often dropping off, showing shot-hole-like symptoms. When the spots are close together, the intervening leaf tissue withers, and large brown patches of dried leaf occur (Lobar, 1999). The fungus fructifications appear as tiny black dots in the white center. The diseased spots often occur in great numbers scattered over the leaf and are roundish when young but may become irregularly angular when mature.The disease severity completely depends on its first appearance and continuous progress throughout the growing season when weather conditions are favourable. Spraying copper fungicides may help control the disease, but spraying is not desirable where eri silkworm cultures are maintained on castor plants.Due to the limitations of chemical pesticides for managing seed/soil-borne pathogens, biological management has become a widely accepted alternative for mitigating these problems. Biological management is also a key component of Integrated Disease Management (IDM). It is regarded as an alternative, eco-friendly, and sustainable control measure for plant diseases.The successful application of antagonistic microorganisms for controlling seedling blight in castor caused by *Phytopthoraparasitica* has been reported by several workers. Seed dressing with the antagonistic fungus *Trichodermaviride* at 4 g/kg seed has been reported to reduce disease incidence. Nowadays, several commercial formulations have been developed by different agencies, such as Bioveer, Biozium, Ecofit, Funginil, Trichoguard, Bioguard, Biocon, Defense-SF, Bioderma, Ecoderma, Bioshield, Biotole, Kalisena-30, etc. *Trichoderma*-based formulation products account for about 60% of the biofungicide market.Despite using *Trichoderma*-based biofungicides as an alternative and additive to chemical fungicides, their applications are limited because their efficacy is lower than that of chemical fungicides. Unfortunately, many potent fungal antagonists are sensitive to agrochemicals.Plant extracts have been found effective against many plant pathogens and are increasingly used for controlling plant diseases in agricultural and sericultural crops. The use of biodegradable materials like fresh plant extracts has been prioritized during the last three decades for plant disease control, considering the high cost of chemical pesticides and their hazardous nature (Mitra*et al*., 1984).

Chemical control of diseases in castor involves the risk of residual toxicity to silkworms when the sprayed leaves are fed to them. Therefore, there is a need to find biodegradable, natural products or their non-toxic consortia for managing Cercospora leaf spot of castor caused by *Cercosporaricinella*.*Ocimum sanctum* Linn, also known as Tulsi or Holy basil, is an aromatic plant belonging to the Lamiaceae family. It is widely used in Ayurveda and Siddha systems of medicine to treat various ailments. Tulsi is known to possess antiseptic, analgesic, anti-inflammatory, antimicrobial, anti-stress, immune-modulatory, hypertensive, antioxidant, and hypoglycaemic properties (Hosdurga*et al.*, 2015).Most research on this disease has focused on technical aspects of fungicide development, with significantly less work done on understanding its basic ecology or epidemiology (Dange, 1997). This limits our ability to employ successful strategies for smart host plant disease management. Knowledge of the basic ecology of biocontrol agents, botanicals, or chemicals is necessary to include them in biological control or Integrated Disease Management (IDM).While various chemical fungicides have been used to control this disease, working with sensitive silkworms and feeding them treated castor leaves makes it important to understand the compatibility and residual effects of management approaches for efficient utilization. New research strategies should focus on alternate eco-friendly ways (Uma *et al.,* 2008), as agents incorporated in any management practice or control measure often have multiple effects on plant growth, soil microflora, and silkworm health besides managing the target organism.

Recently, the Pesticide Action Network (PAN), India, welcomed the Centre's draft order proposing to ban 27 pesticides, including fungicides like Captan and Mancozeb, recommended for controlling leaf spot in castor, and Carbendazin and Topsin, used in managing leaf spot of other crops like mungbean and chilli. Currently, no recommended organic package is available for managing Cercospora leaf spot in states like Assam.The success of eri silkworm rearing depends primarily on feeding the larvae with good quality and quantity of disease-free castor leaves. Thus, efficient management of this disease plays a crucial role in ericulture and good seed production. Good health of eri silkworms results in good quality and quantity of eri cocoons, leading to high-quality silk and ultimately helping to increase the country's economy through foreign exchange. Keeping all factors in mind, this review aims to focus on Sustainable Strategies for Managing Leaf Spot Disease in Castor Plants.

Cercospora Leaf Spot Disease

Cercospora leaf blight is a major fungal disease that reduces the productivity and quality of castor crops. This disease is characterized by the formation of small, circular or irregularly-shaped dark brown spots on the leaves of castor plants. These leaf spots are caused by the fungus *Cercosporaricinella*. As the disease progresses, the leaf spots enlarge and merge together. This leads to defoliation, decreased photosynthesis, and ultimately, reduced castor yields. To effectively manage Cercospora leaf blight, it is crucial to understand the epidemiological factors that influence the development and spread of this disease.

Disease cycle and epidemiology

The foliar disease affecting the castor plant (*Ricinus communis* L.) is caused by the fungal pathogen *Cercosporaricinella*. The asexual spores (conidia) of this fungus initiate infection by directly penetrating the leaf tissues or entering through the stomatal openings. The fungal mycelium then grows within the leaves, causing tissue damage that appears as circular or irregularly shaped brown lesions with lighter centres, resembling a "frogeye" pattern. The pathogen produces a toxin called cercosporin, which generates reactive oxygen species that disrupt plant cell membranes. Through this mechanism, Cercospora infects the plant and obtains nutrients for its growth and reproduction.

The germination process of the fungal conidia (spores) of *Cercosporaricinella*begins 9 hours after inoculation, with the formation of an appressorium (specialized infection structure) directly from the conidial apex or at the end of a short germ tube. Leaf lesions become visible 7 days after inoculation, and after 12 days, clusters of conidia emerge from the upper and lower leaf surfaces, breaching the epidermis or emerging through stomatal openings. Despite the multicellular nature of *C. ricinella* conidia, only a single germ tube is produced from each conidium, invariably originating from the terminal cell (Babu *et al.*, 2007). In contrast, the multicellular conidia of *C. moricola* (Gupta *et al.*, 1995) produce one or more germ tubes per conidium on mulberry leaves, facilitating direct entry into the leaf through stomata. On the other hand, in *C. henningsii* (Ayesu-Offei and Antwi-Boasiako, 1996), mature conidia undergo budding and fragmentation, generating numerous microconidia that subsequently germinate through germ tubes, some of which produce appressoria. In *C. ricinella*, leaf penetration is exclusively facilitated by appressoria, whereas the germ tubes of *C. moricola* (Gupta *et al.*, 1995) and *C. caricus* (Carlos *et al.*, 1998) penetrate host leaves directly through stomatal openings without the formation of appressoria.

Conventional Disease Management

Research indicates that the application of effective fungicides at the first appearance of symptoms, followed by subsequent applications based on the presence of leaf spots and favorable environmental conditions, consistently provides the most effective and economical control of Cercospora leaf spot disease (Ali *et al*., 2011). Spraying with Bordeaux mixture or other copper-based fungicides may help to manage the disease. Two applications of Mancozeb (2.5g/liter) or Carbendazim (1g/liter) at 10–15days intervals have been shown to reduce disease incidence. However, in cases where eri silkworm cultures are maintained on castor plants, spraying may not be desirable. Seed treatment with Thiram or Captan (3g/kg seed) can also aid in disease management. The use of resistant varieties is considered the most effective method for combating the disease (Altieri*et al.*, 2018).

Dey *et al.* (2017) found that spraying a 0.2% solution of bavistin (Carbendazim 50% WP) or 0.2% Karathane on mulberry leaves can help control Cercospora leaf spot, and the leaves can be used for silkworm rearing 7-10 days after the final spray. Pethybridge et al. (2020) reported that copper oxychloride + copper hydroxide and propiconazole significantly improved Cercospora leaf spot control in table beet if initiated prior to infection. Copper oxychloride is used for the control of fungal and bacterial diseases in fruit, vegetable crops, citrus, stone fruit, pome fruit, and ornamentals.In field trials conducted in Nigeria in 1981 and 1982, four systemic fungicide formulations (tridemorph, tridemorph plus maneb, carbendazim, and benomyl) and three non-systemic fungicides (captafol, mancozeb, and copper oxychloride) were evaluated for the control of early leaf spot (*Cercosporaarachidicola* Hori), late leaf spot (*Cercosporapersonatum* Berk. & Curt.), and rust (*Puccinia arachidis*Speg.) of groundnut (*Arachis hypogaea* L.). Plots receiving mancozeb and tridemorph plus maneb exhibited the best overall disease control and higher yields, followed by copper oxychloride (Salako, 1985).Bagwan (2010) reported that Thiram (0.2%), Copper oxychloride (0.2%), and Mancozeb (0.2%) are compatible with *Trichodermaharzianum* and *Trichodermaviride*. In the experiment, *Trichoderma* was found to be insensitive to blue copper and captaf but highly sensitive to dithane, bavistin, and ridomil.

Effect of chemical fungicides on silkworm

Researchers found that applying fungicides to mulberry plants, the sole food source for silkworms, increased caterpillar mortality up to threefold and significantly reduced the size of cocoons spun by surviving caterpillars, causing losses in silk production (Nicodemo, 2018). In the tests, mulberry leaves were offered to silkworm caterpillars 30 days after fungicide application. The researchers evaluated in vitro and in vivo mitochondrial bioenergetics of mitochondria from the caterpillars' heads and intestines, as well as their feed intake, mortality rate, and the weight of fresh cocoons and cocoon shells. At doses of 50 micromolar (in vitro) and 200 grams per hectare (in vivo), pyraclostrobin inhibited oxygen consumption, dissipated membrane potential, and inhibited ATP synthesis in the silkworms' mitochondria. Pyraclostrobin acted as a respiratory chain inhibitor, affecting mitochondrial bioenergetics, producing the expected effect on fungi in silkworm caterpillars. While the fungicide did not interfere with the silkworms' food consumption, it negatively affected mortality rate and cocoon weight at a dose of 100 grams per hectare.

The lethality of a substance is an important factor in determining its direct impact on a species' ability to survive due to exposure and dosage. However, non-lethality does not mean the substance is harmless, as damage can still occur. In this study, although caterpillar lethality was relatively low when exposed to pyraclostrobin-contaminated mulberry leaves, impairments occurred in the mitochondrial bioenergetics of the head and intestine, negatively influencing energy production and cocoon production.A study assessing the toxic effects of fungicides on silkworms (*Bombyx mori* L.) and cocoon and silk quality parameters revealed that carbendazim 50% WP and wettable sulfur 80% WP at 0.1% concentration showed no toxic effect, with zero larval mortality three days after treatment. Larval weight and length were higher in these treatments compared to others. Cocoon characters like cocoon weight, pupal weight, shell weight, shell ratio, and cocoon yield were also higher with carbendazim 50% WP and wettable sulfur 80% WP at 0.1%. Additionally, silk quality traits like filament length, filament weight, and denier were higher in these treatments (Manjunatha, 2017).Another study analyzed the effect of fungicides on silkworm larvae, finding that daily feeding on 1 and 2g/liter of carbendazim, a systemic fungicide, did not significantly affect larval and pupal mortality. However, the weight of treated larvae showed a considerable decrease of up to 37%. While economic traits of male and female adults treated with the fungicide decreased, the decrease was not significant for cocoon shell weight and hatching percentage (Etebari and Bizhannia, 2005).

Sustainable Disease Management Approaches

Gupta (2022) and Anuradha (2023) both emphasize the importance of integrated disease management (IDM) strategies for fungal diseases, including Cercospora leaf spot caused by *Cercosporaricinella*in castor. These IDM strategies typically involve a combination of cultural, chemical, and biological control methods. Gupta specifically mentions the use of systemic fungicides and protectant fungicides, while Anuradha highlights the potential of biotechnological techniques for developing resistant castor cultivars. Additionally, Awad (2012) supports the use of biological control agents and resistance-inducing chemicals for managing fungal diseases, which could be applicable to Cercospora leaf spot. This suggests that long-term sustainability should be a key consideration in the development of disease management strategies for *Cercosporaricinella*in castor.

Phytoextracts

Plants produce many bioactive compounds such as phenols, phenolic acids, quinones, flavones, flavonoids, flavonols, tannins, and coumarins. These compounds exhibit antimicrobial properties and serve as defense mechanisms for plants against pathogenic microorganisms (Das*et al.*, 2010). Vahunia et al. (2017) evaluated the efficacy of antagonists and botanical extracts against *Fusarium oxysporum* f. sp. ricini, which causes wilt disease in castor plants. Plant extracts from turmeric (*Curcuma longa* L.) and marigold (*Tegeteserecta*) demonstrated effectiveness against this fungal pathogen. Reddy *et al*. (2009) investigated the efficacy of plant extracts and essential oils from certain medicinal plants against *Cercosporamoricola* Cooke, the causative agent of leaf spot disease in mulberry (*Morus alba* L.). *Eucalyptus globulus* extract exhibited the highest mycelial growth inhibition (72.59%) at a 10% concentration. Other effective plant extracts included *Oscimum sanctum* (49.08%), *Phyllanthus emblica* (46.75%), *Aloe barbedensis* (45.75%), *Allium sativum* L. (41.08%), and *Azadirachta indica* (35.25%). Plant oils such as *Madhuca indica* oil (75.73% inhibition), *Cymbopogon citratus* oil (73.22%), and neem oil (24.44%) also inhibited the fungal mycelial growth compared to the control.

Effect of Phytoextracts on silkworm

Tulsi (*Ocimum sanctum* L.), known as the "Queen of Herbs," is a highly valued medicinal herb used in Ayurveda, Siddha, Unani, Greek, and Roman medicine for preventing and curing various illnesses. Vth instar *Bombyx mori* L. larvae were fed mulberry leaves enriched with different concentrations (1%, 2%, and 3%) of Tulsi leaf extract, and its effect on larval weight, cocoon weight, pupal weight, shell weight, shell ratio, and silk characteristics was studied. Among the different concentrations, 2% Tulsi extract was found to be the most effective compared to the control. Tulsi extract has a growth-promoting effect on silkworms, which helps enhance the commercial qualities of silk and can be used in sericulture for yield improvement (Padma Sree and Ramani Bai, 2015).

Sujatha et al. (2015) reported that when silkworms were fed mulberry leaves fortified with aqueous Tulsi leaf extract at the second instar, a positive response was observed in larval and economic parameters. The highest larval weight in three instars (third, fourth, and fifth) was noted at a 3% concentration. Post-cocoon characters also increased with increasing concentrations. At 3% leaf extract concentration, the maximum Effective Rate of Rearing (ERR %), total weight of 100 cocoons, average cocoon weight, average shell weight, average silk ratio, and average filament length were observed. The overall performance of *B. mori* in response to the treatment showed an improvement in commercial parameters.Saritha Kumari et al. (2010) studied that feeding mulberry leaves treated with aqueous leaf extracts of*Adhotodavasica*, *Phyllanthus niruri*, and *Terminalia arjuna* to first instar larvae of PM × CSR2 resulted in a positive response regarding rearing parameters. The highest larval weight in all instars was recorded with *P. niruri*.Pachiappan (2009) evaluated the antibacterial efficiency of certain plant extracts, including turmeric rhizome, amla fruit, asparagus, bael, boerhavia, garlic bulb, and basil. Among these, asparagus and basil showed effective growth inhibition against *Staphylococcus* sp. at various concentrations.

Manjunath *et al*. (2020) revealed significant results regarding the inhibition zone of *Bacillus* sp. by botanicals in vitro. For 1:1 and 1:3 proportions, *Adathodavasica* had a considerable zone of inhibition. *Agelemarmelos*, *Ocimum sanctum*, *Phyllanthus niruri*, *Solanum nigrum*, and *T. indica* were also found to be significant compared to the control.Gahukar (2014) reported that silkworms reared on mulberry leaves smeared with *Terminalia chebula*, *Coleus aromaticus*, and *Ocimum sanctum* exhibited increased larval weight, ERR, shell weight, silk productivity, and reduced fifth instar larval duration and mortality. Positive effects were observed compared to the control, suggesting that these botanicals at higher concentrations could enhance the economic and rearing parameters of silk.

Trichodermaviride

Trichodermaviride is a mold that reproduces asexually through mitosis, producing spores. It is the anamorph (asexual stage) of *Hypocrearufa*, which is the teleomorph (sexual stage) that produces a typical fungal fruiting body. The mycelium of *T. viride* can secrete various enzymes, including cellulases and chitinases, which can degrade cellulose and chitin, respectively. This allows the mold to grow directly on wood (composed of cellulose) and fungi (with cell walls made of chitin). *T. viride* is a parasite of other fungi's mycelia and fruiting bodies, including cultivated mushrooms, causing distortion and reduced crop yield, a condition known as "green molddisease."In a study on the efficacy of bioagents and botanicals against leaf spot (*Cercosporaarachidicola*) of groundnut (*Arachis hypogaea* L.), *Trichodermaviride* was found to be the best treatment for managing the disease. Based on the cost-benefit ratio, *T. viride* treatment was statistically the most economical method after chemical treatment, and the yield from *T. viride*-treated plots was comparable to chemical-treated plots. As chemicals can have harmful effects on the environment and human health, *T. viride* is considered a better option as it is eco-friendly (Ramesh and Zacharia, 2017).

The AESA-based IPM package for castor recommends using biopesticides containing bioagents like *Trichodermaviride*/*harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment, and soil application against Cercospora leaf spot.In an experiment to manage early blight of tomato caused by *Alternaria solani* and improve growth parameters and yield, various treatments, including essential oils, bioagents, and their combinations, were evaluated. Among all treatments, a combination of neem oil + *T. viride* (2.5% + 2.5%) was most effective in reducing early blight infection and increasing growth parameters, followed by neem oil (5%) and *T. viride* (5%) alone (Madhuri*et al.*, 2021). *T. viride* combined with essential oils was more effective and economical than single treatments.A *Trichodermaviride* strain, CZTV-1, was screened against 15 fungal plant pathogens isolated from groundnut, cumin, and castor. In dual culture assays, *T. viride* (CZTV-1) significantly reduced the mycelial growth of pathogenic fungi, with the least inhibition (29.0%) observed against *Fusarium* sp. (CZC-3) and the maximum inhibition (82.2%) against *Aspergillus niger* (CZGN-12), statistically on par with *Fusarium solani* CZGN-9 (80.7%) (Singh and Jadon, 2019).

Effect of *Trichoderma*on silkworm

A study assessed the residual toxic effect of fungal and bacterial bioagents used against powdery mildew of mulberry on silkworms. The results revealed that *Trichodermaharzianum* had a positive effect on larval weight and length, increasing them to 21.46g and 5.18cm, respectively. Similarly, cocoon, pupal, and shell weights of 14.99g, 11.86g, and 3.17g, respectively, as well as a shell ratio of 21.17% and cocoon yield of 524.66g/dfl, were higher compared to other treatments. The filament length of 769.05m, filament weight of 0.16g, and denier of 1.80% fineness were found superior when silkworms were fed mulberry leaves treated with *T. harzianum*. The investigation revealed that bioagents effective against mulberry powdery mildew, including *T. harzianum*, *T. viride* at 15% concentration, *Bacillus subtilis*, and *Pseudomonas fluorescens* at 10-15% concentration, were safe for silkworms when leaves were fed three days after treatment with the bioagents' culture filtrate (Manjunatha *et al.*, 2017).

Berini*et al.* (2015) biochemically characterized a commercial chitinolytic enzyme mixture from *Trichodermaviride* and analyzedit’s in vitro and in vivo effects on the peritrophic matrix (PM) of the silkworm *Bombyx mori* L. The PM lines the insect midgut, forming a physical barrier involved in digestion and protection. The enzymes had significant in vitro effects on the PM's structure and permeability. A bioassay supported these results, showing that oral administration of the mixture caused PM alterations, adversely affecting larval growth, development, pupal weight, and inducing mortality. Ahmad and Ahmad (2020) studied the antagonistic potential of four *Trichoderma* isolates against *Beauveria bassiana*, which causes white muscardine disease in silkworms (*Bombyx mori* L.). In vitro mycelial interaction and the effect of biocontrol agents' culture filtrate on pathogen sporulation and spore germination were examined. *T. viride* isolates A and M produced the maximum inhibition zones, followed by *T. harzianum* isolates L and C. In dual culture, all *Trichoderma* isolates overgrew the pathogen, coiled around its hyphae, and disintegrated it. *T. harzianum* isolate L's culture filtrate inhibited mycelial growth by 55.35%. *T. viride* isolate A inhibited spore production and germination by 63.65% and 83.70%, respectively. The antagonism mechanisms were hyperparasitism and antibiosis. The study revealed that all tested biocontrol agents possessed antagonistic properties against *B. bassiana* in vitro and could be used to control white muscardine disease.

Challenges and Future Prospects

The management of Cercospora leaf spot disease in castor plants caused by *Cercosporaricinella* presents several challenges and future prospects. A key challenge is developing effective and sustainable strategies that minimize the use of chemical pesticides and promote eco-friendly approaches. This involves identifying and characterizing potent biocontrol agents and plant extracts with broad-spectrum antifungal activity against the pathogen. Additionally, evaluating the compatibility and residual effects of various management approaches on eri silkworm health and silk production is crucial, as castor leaves are the primary food source for these silkworms. Integrating cultural practices, biological control agents and botanicals into a holistic integrated disease management (IDM) program is a promising avenue.Crous (1994) and Hesami (2011) identified new species and host records within the Cercospora genus. Their findings suggest that there is potential for further diversity and spread of the pathogenic fungus *C. ricinella*, which causes *Cercospora* leaf spot disease in castor plants. The discovery of new Cercospora species and their ability to infect different host plants highlights the potential risk of this fungal genus adapting and expanding its host range. Continuous research and monitoring are necessary to understand the evolving diversity within the Cercospora genus and its implications for the management of Cercospora leaf spot disease in castor cultivation. Breeding and developing castor cultivars with enhanced resistance or tolerance to Cercospora leaf spot is another area of focus.

Braun (2007) and Conway (1976) emphasized the potential for biological control of *Cercospora* species. Their findings indicate that future research could focus on developing sustainable management strategies for *C. ricinella*, the causal agent of Cercospora leaf spot disease in castor plants. Exploring biological control methods, such as the use of antagonistic microorganisms or natural compounds, could provide eco-friendly alternatives to chemical fungicides. Sustainable approaches like these could effectively manage *C. ricinella* while minimizing the negative impacts on the environment and human health. Further investigations in this direction could contribute to the development of integrated disease management strategies for *Cercospora* leaf spot in castor cultivation.Promoting awareness and adoption of sustainable disease management strategies among eri silkworm rearers remains a crucial step towards widespread implementation of these approaches.

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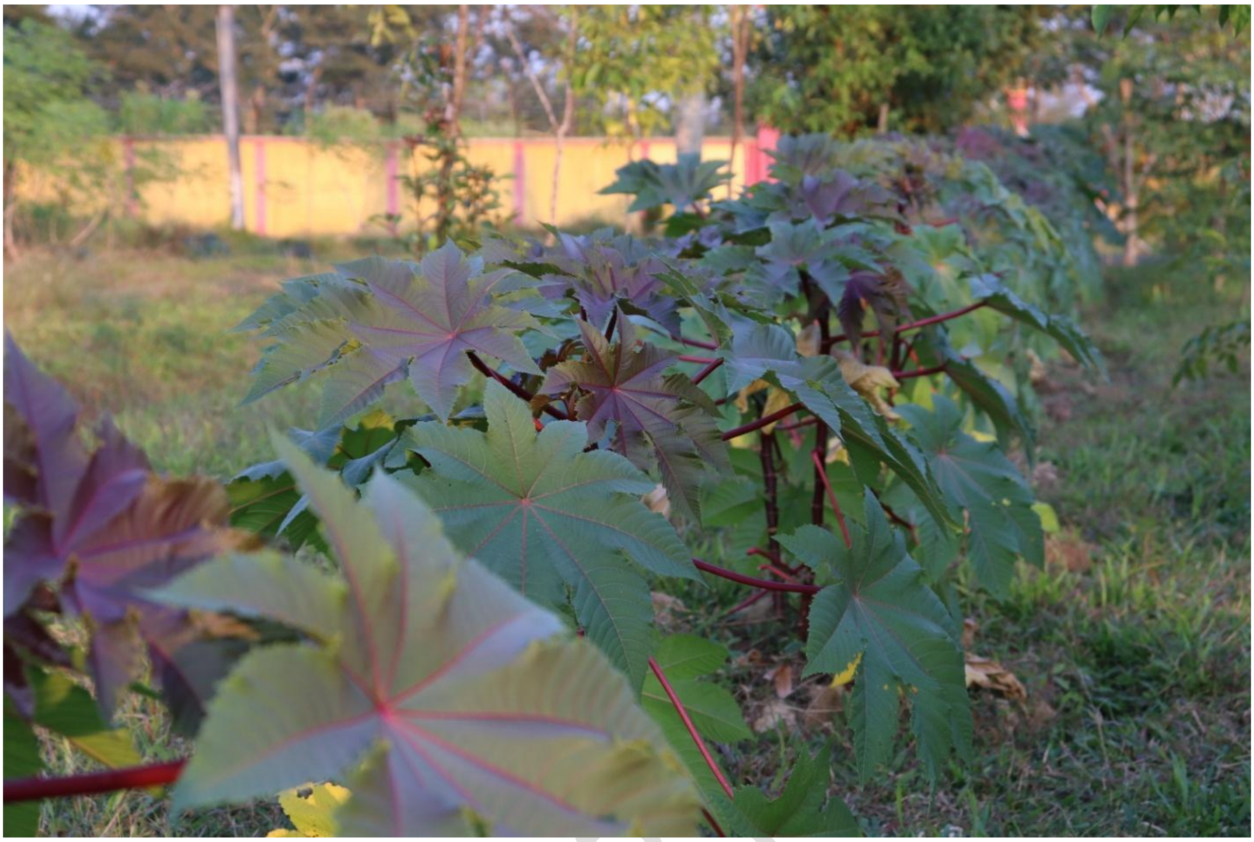

Figure 1. Castor cultivation at Germplasm Conservation Centre, Chenijan, Central Muga Eri Research and Training Institute (CMER&TI), Lahdoigarh

Figure 2Cercospora leaf spot on castor leaf

Figure 3 Infected castor fields

Figure 4. Eri silkworm (Samia ricini Donovan) feeding on castor leaves