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Sri Lanka, Plants
March 16, 2026

Sri Lanka: Resistant Species of Rice Against *Meloidogyne graminicola* in Rice Paddies

Introduction

The cultivation of rice(*Oryza sativa*) within the Democratic Socialist Republic of Sri Lanka is not merely a sector of the agricultural economy. Rather, it is the fundamental architectural framework upon which the nation's historical identity, socio-cultural cohesion, and macroeconomic stability are built. Rice paddies have allowed Sri Lanka to persevere through countless severe setbacks, including climate disasters, economic depressions, and a civil war. However, this backbone of the country faces a microscopic organism that is a gargantuan threat: the rice root knot nematode(*Meloidogyne graminicola*). By attacking the root of the rice crop, it destabilizes the root of the country's food security as well as its cultural and economic heritage.

Background on Country and Family

The agricultural and economic history of Sri Lanka is directly linked to the development of rice cultivation, which has flourished continuously for almost 3000 years. Historical records show that ancient Sinhalese civilization was fundamentally built upon remarkably advanced irrigation networks. Comprising canals and massive inland reservoirs called 'wewas', the paddies were designed specifically for capturing monsoon rains and sustaining farming across the island's dry zone.(Siriwardena, 2024) From approximately 161 BC, systematic paddy cultivation was centred in the capital city of Anuradhapura, establishing an agricultural golden age that persisted until 1017 AD.(Monara House, 2025)

Beyond the historical significance, rice has been deeply intertwined with the spiritual and religious culture of the nation. The processes of sowing the seeds, preparing the fields, and harvesting the grain are all significant ritualized events of profound cultural reverence.(Monara House, 2025) Within the Sinhalese caste system, rice farmers are of the highest possible societal esteem, seen as life-giving figures. Due to the highly arduous nature of the practice, it facilitated a deeply community based labor system, and created a powerful sense of community around the dish. It is a profound reflection of the diverse culture created by the Buddhist, Hindu, and Muslim populations of the island. A typical family celebrating the Sinhalese or Tamil New Year(Aluth Avurudda) would also place heavy significance on the crop. Kiri bath, or coconut milk rice, boiled over the edges of a clay pot to symbolize the overflowing of prosperity and abundance for the coming year. (Seneviratne, 2023)

This cultural reverence for rice translates into a quantifiable macroeconomic and dietary dependence in the modern era. Rice remains the most vital crop in Sri Lanka, dominating the island's geography. It now occupies approximately 1.1 million hectares of paddy fields, or around 34% of all agricultural land. (Kankanamge and Beillard, FAO, 2024) A whopping 1.8 million families also rely on the crop for their primary economic livelihood, creating a vast rural economy. (FAO, 2026) The grain also provides an astounding 45 percent of the total daily calories consumed by the average citizen. (FAO, 2026) Unfortunately, with a family being so dependent culturally, economically, and nutritionally on this staple crop, there are immense difficulties that are faced when they face a reduction in the crop.

Challenge and Impact

Currently residing within the family rice paddies of the island, multiplying exponentially, is a microscopic organism that threatens the economy, food security, heritage, and culture of the nation. This is the rice root-knot nematode, formally known as *Meloidogyne graminicola*. It is an obligate sedentary endoparasite and is recognized as the single most destructive and economically harmful organism threatening global rice production.(Gautam, Mantelin, 2025, 2017)

Originally identified and described in Louisiana in 1965, the pathogen has since aggressively expanded geographically, becoming heavily entrenched in Asia, the Americas, and Europe, with the European and Mediterranean Plant Protection Organization (EPPO) classifying it as such a severe threat that it was added to the Alert List.(Rusinque, 2024)

Unlike other common soil-dwelling nematodes, *M. graminicola* exhibits a highly specialized evolutionary adaptation: thriving actively in the flooded and hypoxic ecosystems characterized by paddy farming. Traditionally, nematodes and other agricultural pests are managed by continuously immersing the field in water or rotating crops with brief flooding, but this adaptation proves these methods to be largely ineffective. Phytosanitary studies indicate that these methods are only viable if a field is continuously submerged for periods longer than 18 months, which is impossible in Sri Lanka due to the nature of the seasonal agricultural cycles and the financial realities of farmers.(Gautam, Mantelin, Rusinque, 2025, 2017, 2024)

The nematode's pathology is insidious because it directly attacks the foundational architecture of the root system of the plant, damaging its water and nutrient acquisition system. The infection starts in the soil, where juveniles hatch from eggs and migrate through the soil matrix to locate a suitable host.(Wang, 2023) The nematodes then penetrate the root epidermis and congregate near root tips that are actively growing. They then migrate toward the vascular cylinder, become sedentary upon reaching the vascular tissue, and secrete effector proteins from their esophageal glands directly into the plant cells. These proteins hijack normal cell development to induce the formation of tumor-like feeding sites.(Gautam, Mantelin, Rusinque, Wang, 2025, 2017, 2024, 2023)

After these feeding sites are established, the nematode transitions through its subsequent stages of life and swells into a mature animal. The surrounding root tissue will then swell and go into hypertrophy and hyperplasia, creating hook shaped galls at the terminal ends of the roots. This intense swelling will lead to a cascading physiological failure of the entire plant. The galls will first physically split the root cortex, which will compromise the structural integrity of the root system. This will in turn render the plant susceptible to secondary fungal and bacterial infections. The galls also primarily cause a severe physical alteration of the root's vascular system, inhibiting the transport of essential macronutrients, starving the plant. (Gautam, Mantelin, Rusinque, Wang, 2025, 2017, 2024, 2023)

This immediately leads to a rapid and catastrophic reduction in Sri Lankan grain yield. Empirical agronomic studies also document that in highly susceptible rice varieties, uncontrolled infestations of *M. graminicola* can lead to yield losses reaching 70 percent. (Perera, 2023) Furthermore, the most widely cultivated rice strains are Bg 366 and Bg 251, which are incredibly susceptible to the nematode. This means that the juvenile nematodes can easily and rapidly penetrate the roots of these species without massive resistance, which can lead to severe structural root damage. (Gautam, Wang, 2025, 2023)

Exploring Solutions

However, some traditional varieties of rice from Thailand and some highly specific traditional Sri Lankan species have demonstrated near absolute immunity to *M.graminicola.* In these highly resistant traditional varieties, researchers observed an absolute absence of nematode penetration and zero gall formation through extensive evaluations. These resistant lines included Vandana, ZH11, Toga, HKG98, and SL 22-620, Khao Pahk Maw, and LD24 rice strains. (Gautam, Wang, Kumari, 2025, 2023, 2016)

Unfortunately, the vast majority of the 1.1 million hectares of Sri Lankan paddy land is sown exclusively with Bg varieties, which are highly susceptible. Because breeding programs to introduce resistance genes into these varieties would require continuous multi-generational effort, strategies have shifted towards pest management strategies. (Kankanamge and Beillard, 2024) Some of these strategies include the application of endophytic and rhizosphere fungi, to use as nematocides, and this resulted in a statistically significant reduction in the formation of root galls and preserved the weight of fresh roots. However, this requires successfully manufacturing, distributing, and effectively and continuously deploying living control agents at a national and macroeconomic scale, which is incredibly challenging for a developing economy. (Amarasinghe and Hemachandra, 2020) There has been agronomic experimentation with trap crops, using decoy plants to attract and destroy nematodes, and this has shown some preliminary efficacy, but this requires farmers to sacrifice windows that are critical for planting. (Amarasinghe and Hemachandra, 2020)

Recommendations

While the future of rice in Sri Lanka looks dim, the developing country's government must heavily invest in supporting the reduction of this parasite, as the future of not just rice, rather the entire nation, rests on it. The reclamation of the crop must be split into three phases, an immediate action, a medium term action, and a long term strategy. First, the most urgent vulnerability is the informational deficit at the farmer level. Many farmers unfortunately misdiagnose the nematode-induced miscoloring as standard nutrient deficiencies, which leads to the death of many crops due to the simple fact that a farmer didn't act quick enough. To remedy this, the department of agriculture must deploy rapid extension education programs to train farmers to uproot symptomatic plants and identify the root galls and splitting characterized by *M. graminicola*.(Perera, De Costa, 2023, 2023)

The next step until genetic solutions are viable is the management of the pathogen's reproduction factor within the soil matrix, using both pest management strategies and biological warfare. This means the government must heavily subsidize the production of proven endophytic and rhizosphere fungi in order to be used as nematicides across the country and preserve the root weight of the Bg varieties of the crop. Local farmers must also be incentivized to establish buffer zones around infested paddies, preferably around 100 metres. Other phytosanitary protocols must also be taken, including the deep cleaning of agricultural machinery and footwear between fields and trap crops. (Amarasinghe and Hemachandra, 2020) To facilitate the eventual transition to resistant varieties during early adoption stages, the agricultural department must implement phased programs. Government subsidies on seed starter kits will allow farmers to test resistant strains on a small fraction of their land. This minimizes their individual financial risk by allowing them to witness yield benefits without committing to a full scale transition.

However, the most reliable and long-term way to preserve the rice cultivation practices of Sri Lanka is the reclamation of genetic resilience of its ancient past. The mapping and introgression of resistance genes in ancient varieties of Sri Lankan rice into modern cultivars must be the focus of the nation's agricultural research and development apparatus. State and international funding must be violently and rapidly redirected towards profiling of Sri Lankan landraces like Khao Pahk Maw and other global resistant lines. Sustaining these complex genetics over time will require Sri Lanka to establish enduring partnerships

with international entities like the Food and Agriculture Organization and global agricultural research universities. By facilitating international knowledge exchange programs, the nation can guarantee the continuous financial and technical support needed for this project. The genes present in these varieties must then be introgressed into the modern cultivars of rice, engineering crops that can independently mount defense responses to neutralize any juveniles before any galls can form. (Wang, 2023)

Conclusion

Ultimately, the preservation of the great nation of Sri Lanka's culture, economy, and people rely on the mapping of its genetically resilient rice varieties. The biological dismantling of Sri Lanka's food security architecture must be remedied before the failure to do so will result in catastrophic issues of mass poverty and food hyperinflation. Only by physically restoring the plant at the molecular level can Sri Lanka permanently secure its caloric foundation, protect the fragile economic livelihoods of millions of rural families and farmers, and ensure that ceremonial pots of Kiri bath continue to boil over each Tamil and Sinhalese New Year to come.

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