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REVIEW ARTICLE

Organic and Natural Farming Based Disease Management Strategies in Pulse Crops

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ABSTRACT

Pulses are vital sources of protein, soil fertility enhancement, and sustainable cropping systems but their productivity is severely constrained by diseases such as Fusarium wilt, dry root rot, foliar diseases like cercospora leaf spot, anthracnose, ascochyta blight, powdery mildew, bacterial blight and some viral diseases. In recent years, organic and natural farming approaches have become popular as environmentally friendly alternatives to chemical-based disease control. The integration of eco-friendly practices such as biological control agents, botanical extracts and ecological cultural practices is emphasized in recent developments in plant disease management in pulses. Beneficial microorganisms such as *Trichoderma*, *Pseudomonas*, and *Bacillus* spp. have demonstrated significant potential in suppressing soil-borne pathogens through antagonism, competition, and induction of systemic resistance and botanical extracts such as neem and garlic, enhances plant immunity and suppresses pathogens naturally. Proper nutrition, water management, and the cultivation of disease-resistant varieties further strengthen crop resilience. Overall, this holistic approach promotes sustainable disease management, environmental protection, and long-term productivity in pulses.

KEYWORDS

• Organic • Diseases • Pulses • Environmental protection

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INTRODUCTION

In the case of grain legumes, the impact of biotic threats can cause an estimated yield loss of 35–70%. Despite having a significant impact on animal and human nutrition, studies on pathosystems including grain legumes have been relatively neglected when compared to other crops such as cereals. This highlights the urgent need to increase our knowledge of the defence responses in these crop species to successfully tackle the main biotic threats to their production. Grain legumes, such as pigeonpea, mungbean, urdbean, lentils, and chickpeas, are susceptible to various diseases that can lead to huge yield losses. Here are some common diseases of grain legumes, along with brief descriptions and management strategies:

Fusarium wilt

The wilt caused by different *Fusarium* sp. is one of the most serious and oldest known diseases of pigeonpea, chickpea and lentil and is known to cause heavy losses every year in India (Kannaiyan *et al*., 1981, Siti *et al*., 2019). In India, Fusarium wilt is the most important disease of pigeonpea resulting in yield losses up to 67 per cent when it appears at maturity and 100 per cent in case of infection at pre-pod stage (Kannaiyan and Nene, 1981). The annual yield loss to pigeonpea due to wilt in India has been estimated worth of US$ 36 million (Pathak *et al*., 2012, Kannaiyan *et al*., 1984).

In addition to soil inhibiting nature, the fungus has also been found to be seed-borne (3-5%). The fungus produces micro and macroconidia; chlamydospores are formed under unfavourable environmental conditions, both in parasitic and saprophytic phases from the hyphae and conidial cells. The chlamydospores survive during prolonged absence of the host and at the advent of favourable conditions they act as an initial inoculum of the fungus (Mariyappa *et al*., 2025) Being an internal pathogen, initially, no symptom appears. At the advanced stage of disease when symptoms appear it becomes difficult to control the disease. This has necessitated implementing management module that prevents infection by the pathogen at the initial stage as well as sustains its effectiveness for a longer period. Several management tools are available in the market but have some limitations. Only Fungicides based management strategies were not effective but expensive and created numerous environmental hazards (Pimentel and Burgess, 2014, Kassam *et al*., 2019). Biological control is another option for disease management. Above all, cultivation of disease-resistant cultivars like GT 101, GT 108 of pigeonpea is the best option; thus breeding for resistance or tolerance germplasm to Fusarium wilt is necessary (Revanappa *et al*., 2025, Chugh and Mishra, 2025).

Dry Root Rot

Dry root rot is a complex disease and caused by *Macrophomina phaseolina*. It is endemic in both tropical and temperate regions of the world and causes the disease in over 500 different crops including chickpea, pigeponpea, mungbean, urdbean, mothbean, cowpea, clusterbean, etc. Dry root rot causes up to 100% yield losses under favourable conditions, normally when the day temperature is high (above 30ºC) and under dry conditions (Sohaliya *et al*., 2025). Although, this disease was not of much significance in grain legumes earlier; however, it become a significant threat to pulse production nowadays due to altered weather conditions, i.e., capricious rainfall with longer drought spells. Furthermore, this disease becomes very difficult to manage due to the formidable nature of its pathogen. Pathogen produces numerous sclerotial bodies on host tissues, which measure about 110-130μm in diameter. Often the conidial or pycnidial stage is produced on the infected host tissues. The fungus is mainly a soil inhibitor in its sclerotial form and spreads from plant to plant through irrigation water and implements and cultural operations (Rangaswami and Mahadevan, 2008). Management of this disease includes a large range of options but farmers largely depend on fungicides, like Carboxin 37.5% + Thiram 37.5% WS @ 3 g/kg, Captan 50% WP @ 2 g/kg, etc due to their prompt and high control efficiency over other methods (Sharma D., 2025). However, indiscriminate use of fungicides can cause hazards to human health and is known to increase environmental pollution. Therefore, to overcome this negative impact, alternative eco-friendly approaches based on the cultivation of resistant varieties and the application of bioagents like *Trichoderma harzianum*, *Pseudomonas fluorescens* for managing root rot of grain legumes are needed along with crop rotation, field sanitation, etc to break the disease cycle and reduce the pathogen's population in the soil (Kamal *et al*., 2015). Already we have proposed that farmer should treat their seeds with a combination of seed treatment (4+4 gm/kg seed) along with soil application of *Trichoderma harzianum* +*Pseudomonas fluorescens* (1.25 +1.25 kg in 50 kg FYM for each / ha) for effective management of root rot in cluster bean including other pulses. Further exploration of the rhizospheric microbiome is necessary for finding better microbial consortia to root rot complex (Choudhary, S. 2019, Sitamarhi, 2012).

Mosaic disease complex

Yellow mosaic disease is a complex virus disease that affects various leguminous crops, including mungbean, urdbean, cowpea, pigeonpea, and other beans, The disease is caused by different species of begomoviruses, which are transmitted by whiteflies (*Bemisia tabaci*). The most characteristic symptom is the yellowing and mottling of leaves. This gives the affected plants a mosaic-like appearance with serious pod infection, which ultimately manifests as a severe yield penalty (Malathi and John, 2009). The overall crop yield loss may range between 10 and 100%, depending on the mungbean genotype and stage of crop infection. It is very difficult to manage this disease in field conditions due to the rapid evolution of virus pathogens. Thus, farmers need to adopt an integrated pest management (IPM) approach that combines various strategies to effectively manage yellow mosaic disease in legumes. This may involve a combination of resistant varieties, vector control, and cultural practices tailored to the specific leguminous crop being grown. The YMD management using insecticides like imidacloprid, and thiomethoxam (to control whiteflies) has been considered effective, but due to the development of insecticide resistance in the vector population, the disease is on the rise. In addition, excessive use of chemicals resulted in detrimental impacts on both the environment and human health (Mishra *et al*., 2017, Swapna and Prema, 2025, Jain *et al*., 2022). To avoid this, planting resistant varieties is an effective strategy to manage yellow mosaic disease. Nowadays, many YMV-resistant cultivars like GC 3 of cowpea, GAM 5, GM 6 in mugbean and GU 3 and GU 4 in urdbean are available. Additionally, local agricultural extension services can provide guidance on best practices for disease management in a particular region.

Foliar disease complex

Foliar diseases such as *Cercospora* leaf spot, anthracnose, powdery mildew, *Ascochyta* blight, and bacterial blight caused by different fungal and bacterial pathogens become a serious concern nowadays. These foliar diseases are highly tragic due to their rapid epiphytotic nature and the occurrence of yield loss has been highly varying from 10-15% to 40-67 percent (Vandana *et al*., 2020, Altieri *et al*., 1999). Foliar disease complexes in legumes involve the simultaneous or sequential occurrence of multiple foliar diseases, often caused by different pathogens. Effective management of foliar disease complexes requires an integrated approach that combines cultural, chemical, and biological control strategies. We are recommending the farmers to apply two sprays of tebuconazole/hexaconazole @ 0.005%, or carbendazim @ 0.025% at 15-day intervals for effective control of foliar disease complex like powdery mildew, Cercospora leaf spot and anthracnose diseases of greengram and other pulses under North Gujarat condition. However, planting certified, disease-free seeds and regular monitoring with early detection is required, before applying management of options in field condition (Kaur M., 2023, Altieri *et al*., 1999).

Scope of natural farming in pulse production:

Natural farming in pulse production involves adopting practices that minimize the use of synthetic inputs, promote sustainability, and enhance the overall health of the soil and ecosystem. Adopting natural farming practices in pulse production not only contributes to environmental sustainability but also enhances the nutritional quality of the produce. It promotes a holistic approach to farming that considers the long-term health of the soil, the ecosystem, and the well-being of the farmers. Natural farming practices can play a significant role in managing plant diseases in pulses, which include crops like lentils, chickpeas, peas, and beans. Here are some strategies commonly employed in natural farming for disease management in pulses (Khan *et al*., 2024, Pooniya *et al*., 2014).

Crop Rotation: Rotating pulse crops with non-host crops, especially sorghum, bajara, and millets can help break disease cycles by disrupting the buildup of pathogens in the soil (Kumari and Katoch, 2020). This reduces the risk of diseases like wilt, root rot that thrive on specific pulse species.

Companion Planting: Planting pulses alongside companion plants like *Tagetes* sp. that repel pests or suppress diseases can enhance disease management. For example, planting marigolds alongside pulses can deter nematodes, which are common pests in pulse crops (Parihar *et al*., 2025).

Cover Cropping: Growing cover crops, such as legumes or grasses, during fallow periods can improve soil health, suppress weeds, and reduce disease pressure by promoting beneficial microorganisms and enhancing soil structure (Sharma *et al*., 2018).

Mulching: Mulching with organic materials like straw or compost can help suppress weed growth, conserve soil moisture, and prevent soil-borne diseases by acting as a barrier between pathogens and plant roots (Panth *et al*., 2020).

Biocontrol Agents: Introducing beneficial microorganisms like *Trichoderma* sp., and *Pseudomonas fluorescence* on plant pathogens can help suppress disease development. Examples include using beneficial nematodes to control nematode populations or applying microbial biopesticides to target fungal pathogens like *Fusarium*, *Macrophomina*, *etc* (Khan *et al*., 2024, Kloepper and Schroth., 1978).

Organic Amendments: Applying organic amendments such as compost, manure, biochar, etc can improve soil fertility and promote a healthy soil microbiome, which in turn can enhance plant resilience to diseases (Singh *et al*., 2024). These organic amendments contribute to disease management in pulses by promoting soil health, enhancing plant immunity, and suppressing pathogens through various mechanisms. Incorporating these amendments into organic farming practices can help sustainably manage diseases while promoting overall soil fertility and crop productivity (Tariq-Khan *et al*., 2019).

Biostimulants: Some organic amendments, such as seaweed extracts or fish emulsions, are considered biostimulants due to their ability to enhance plant growth and vigour. While not directly targeting pathogens, biostimulants can improve plant health, potentially reducing the impact of pathogens infections (Mader *et al*., 2002).

Natural Extracts and Botanicals: Some natural extracts and botanicals have been found to possess antimicrobial properties that can help control plant diseases. Examples include neem oil, garlic extract, and plant-derived biofungicides (Nagamma *et al*., 2019, Singh and Singh, 2014).

Proper Plant Nutrition: Ensuring adequate nutrition for pulse crops through balanced organic fertilization can help strengthen plant immunity and reduce susceptibility to many viral diseases in pulses (Kumar *et al*., 2023).

Water Management: Proper irrigation management, such as avoiding overhead watering to minimize foliar diseases, and maintaining proper drainage to prevent waterlogging, can reduce the incidence of *Phytophthora* blight in pigeonpea (Krishnamoorthy and Subramaniam, 2023).

Genetic Diversity: Selecting and planting diverse varieties of pulses with inherent disease resistance or tolerance traits can reduce the risk of widespread disease outbreaks and improve overall crop resilience (Mondal *et al.*, 2016).

By integrating these natural farming practices into pulse crop management, farmers can effectively manage plant diseases while promoting soil health and sustainability in agricultural systems.

Future thrust in disease and pest management option in pulses:

The future thrust in disease management in pulses will likely involve a combination of traditional and innovative approaches to address existing challenges and emerging threats. Here are key areas of focus for disease management in pulses in the future:

Resistant Varieties and Breeding:

Emphasizing breeding programs to develop pulse varieties with inherent resistance to common diseases like wilt, SMD, mosaics, etc. This involves identifying and incorporating resistance genes to enhance the crop's ability to withstand infections.

Genomic Technologies:

Utilizing advanced genomic technologies for rapid identification of disease-resistant traits.

These technologies, such as marker-assisted breeding and CRISPR-Cas9 based gene editing, can accelerate the development of resistant varieties.

Integrated Pest Management (IPM):

Implementing integrated pest management strategies that combine biological, cultural, and chemical control methods. Encouraging crop rotation and diversification to break disease cycles. Growing pulses in a rotation with other crops can disrupt the buildup of soil-borne pathogens and reduce the risk of disease outbreaks.This holistic approach minimizes the reliance on chemical pesticides and promotes sustainable disease management, especially for root rot and other soil borne diseases.

Biopesticides and Biological Controls:

Increasing the use of biopesticides derived from natural sources, as well as deploying biological control agents such as beneficial insects and microorganisms. These methods are environmentally friendly and target specific pests and diseases.

Disease Surveillance and Early Detection:

Implementing advanced monitoring systems and technologies, including remote sensing and sensor networks, for early detection of diseases. Timely identification allows for prompt and targeted intervention to prevent the spread of diseases.

Climate-Resilient Practices:

Developing and promoting climate-resilient agricultural practices to mitigate the impact of changing climatic conditions on the prevalence of diseases. Climate-smart agriculture can enhance the overall resilience of pulse crops.

Data Analytics and Predictive Modeling:

Leveraging data analytics and predictive modelling to assess disease risk factors and anticipate potential outbreaks. This allows for proactive disease management strategies and resource allocation.

Farm-Level Biosecurity:

Promoting biosecurity measures at the farm level to prevent the introduction and spread of diseases. This includes proper sanitation practices, quarantine measures for incoming plant material, and controlled movement of farm equipment.

Extension Services and Farmer Education:

Strengthening extension services to educate farmers about effective disease management practices. Providing farmers with information on disease symptoms, prevention measures, and sustainable farming practices is crucial for successful disease management.

Public-Private Collaboration:

Encouraging collaboration between public institutions, private companies, and research organizations to pool resources and expertise for effective disease management. Public-private partnerships can accelerate the development and dissemination of disease-resistant technologies.

Global Collaboration and Knowledge Sharing:

Facilitating global collaboration and knowledge sharing on disease management in pulses. International cooperation can help address diseases that cross borders and facilitate the exchange of best practices and research findings.

By focusing on these future thrust areas, the goal is to create a more resilient and sustainable pulse production system that is better equipped to manage diseases while minimizing environmental impact and ensuring food security.

CONCLUSION

Pulses are indispensable to nutritional security, soil health, and sustainable agricultural systems, yet their productivity continues to be constrained by a complex array of soil-borne, foliar, and viral diseases. The present review highlights that conventional chemical-dependent approaches alone are neither economically sustainable nor environmentally desirable in the long term. Instead, a paradigm shift toward organic and natural farming-based disease management is both timely and essential.Evidence indicates that integration of resistant cultivars, crop rotation, biological control agents (such as *Trichoderma sp. Pseudomonas sp.*, and *Bacillus* sp.), botanicals, organic amendments, and sound agronomic practices can effectively suppress major diseases including Fusarium wilt, dry root rot, yellow mosaic disease, and foliar disease complexes. These strategies not only reduce pathogen load but also enhance plant immunity, improve soil microbial diversity, and strengthen agroecosystem resilience. Moreover, combining traditional knowledge with emerging tools such as genomic-assisted breeding, microbial consortia development, disease surveillance systems, and predictive modelling will further enhance the precision and sustainability of disease management in pulses. Future pulse protection strategies must therefore adopt a holistic, climate-resilient, and farmer-centric framework that integrates ecological principles with scientific innovation. Strengthening extension services, promoting public–private collaboration, and encouraging participatory research will accelerate the adoption of sustainable technologies at the field level.

In conclusion, organic and natural farming-based disease management offers a viable, eco-friendly, and economically sound pathway for safeguarding pulse crops against evolving disease threats, ensuring long-term productivity, environmental protection, and .food and nutritional security

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