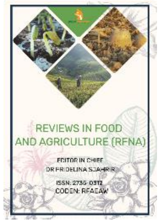
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2735-0312 (Online)
CODEN: RFAEAW

Reviews In Food And Agriculture (RFNA)

DOI: http://doi.org/10.26480/rfna.02.2023.50.53



CrossMark

RESEARCH ARTICLE

A COMPREHENSIVE STRATEGY FOR LATE BLIGHT MANAGEMENT IN POTATO AND TOMATO

Samarth Bista, Anjela Adhikari*

College of Natural Resource Management, Pakhribas, Dhankuta, Nepal
****Corresponding Author Email: anjelaadhikari82@gmail.com***

ARTICLE DETAILS

Article History:

Received 04 June 2023
Revised 08 July 2023
Accepted 11 August 2023
Available online 16 August 2023

ABSTRACT

Late blight is a highly destructive disease primarily affecting potato (*Solanum tuberosum)* and tomato *(Solanum lycopersicum)* and some other closely related crops such as aubergine, pepper, solanaceous weeds such as nightshade species, wild tomato etc. This disease is caused by fungus-like organism oomycetes also known as water mold called *Phytophthora infestans.* Whereas early blight of potato and tomato are caused by fungus *Alternaria solani* and *Alternaria tomatophila* respectively. Heinrich Anton De Bary, the father of modern plant pathology studied the epidemics of Late Blight in 1863 and renamed the causal organism *Phytophthora infestans* (infectious plant destroyer). The disease is severe in areas with high humidity and rainfall and spreads through wind, rain, or contaminated plant material capable of causing entire crop failure if left uncontrolled. Late blight affects foliage, fruit, and tuber and its symptoms include dark, water-soaked lesions on the stem, leaves, and fruit which can rapidly develop into brown, necrotic areas ultimately leading to plant death. Control measures for late blight includes crop rotation, the use of resistant varieties and the application of fungicides. However, the emergence of more virulent strains of *Phytophthora infestans* and the development of resistance to fungicide application pose ongoing challenges to effective disease management. This paper reviews the current knowledge on management strategies for late blight focusing on integrated disease management approaches. Furthermore, the challenges and prospects of integrated management strategies are discussed.

KEYWORDS

Potato, tomato, late blight, *Phytophthora infestans*, management, strategies.

1. Introduction

The potato is the third most important food crop in the world in terms of human consumption. More than a billion people worldwide eat potatoes and global total crop production exceeds 300 million metric tons (CIP). Similarly, tomato is also an important crop globally with an introduction of over 189.1 million metric tonnes in 2021 (Tomato news, 2022). Both potatoes and tomatoes are rich in essential nutrients and are packed with minerals and vitamins. The food value per 100g of edible potato is 85 calories of energy, 2g of protein and 13mg calcium, 40mg vitamin A, 12mg ascorbic acid, 0.11mg thiamine, 0.06mg riboflavin and 1.18mg niacin. And a 100g serving of tomato contains 22 kcal energy, 10mg calcium, and 8.1mg potassium (USDA, Nutrient database). Potatoes and tomatoes are both widely cultivated crops all around the world, originating in the South American Andes. The cultivated potato and tomato were brought to Europe by the Spanish in the 16th century and later introduced from Europe to Southern, Eastern Asia, Africa, and The Middle East. Potato is a cool season crop whereas tomato is grown during the summer season and both flourish well in loam to sandy loam soil.

The potato and tomato plants are affected by many insects, pests and disease causing microorganisms which causes devastating losses to farmers around the globe. Fungi, bacteria, virus, nematode, MLOs, PLOs causes serious constraints. Some major diseases are common scab, early blight, late blight, fusarium rot for potatoes and anthracnose, late blight, fusarium wilt, and powdery mildew for tomatoes. Late blight has emerged as a huge threat among all diseases.

Phytophthora infestans survive in potato tubers and soil that didn't freeze during the winter. The pathogen doesn't overwinter in tomatoes and is not seed-borne (University of Massachusetts Amherst, 2017). To overcome this issue, farmers need to adopt a comprehensive strategy for late blight management. Given the ongoing struggles of farmers, it is highly necessary to implement extension programs that address late blight management.

2. Spread and Symptoms

Late blight pathogen is favoured by excessive humidity more than 90% coupled with suitable temperature 10-25°c for germination of sporangia by germ tube or by zoospore. Below 90% relative humidity, the sporangia production is halted. The infection is caused by the zoospores found in the soil or that fall onto the tubers from infected foliage during harvest. *Phytophthora infestans* overwinters similarly in plant debris as mycelia, a filamentous thread-like growth of the pathogen. The pathogen can also produce a soil-persistent spore also known as oospore. The pathogen spreads by movement of asexual spores; sporangia (air-borne spores) and zoospores (water-swimming spores) (Gevens and Wilbur, 2014).

The symptoms appear at first as water-soaked spots, usually at the edges of lower leaves. In moist weather, the spots enlarge rapidly and form brown, blighted areas with indefinite borders. In dry weather, the activities of the pathogen are slowed. Infected tubers may be subsequently covered with sporangiospores and spores of the pathogen or become invaded by two fungi and bacteria, causing soft rots and giving rotting potatoes a putrid offensive odor. Tomato leaves, stems and fruit are also attacked. Fruits may rot rapidly in the field or storage (Agrios, 2017).

Quick Response Code	Access this article online	
	Website: www.rfna.com.my	**DOI:** 10.26480/rfna.02.2023.50.53

Cite The Article: Samarth Bista, Anjela Adhikari (2023). A Comprehensive Strategy for Late Blight Management in Potato and Tomato. *Reviews In Food and Agriculture, 4(2): 50-53.*

2.1 The Pathogen: *Phytophthora infestans*

The mycelium is endophytic, coenocytic, hyaline, branched, and intercellular that produces lemon–shaped sporangia with distinct papilla at the apex. The two types of germination are observed;

a. Direct = at 18°C (Spores germinate directly forming hyphae).

b. Indirect = at 10 – 12°C (Sporangia produces zoospores which get encysted in the host cell wall).

3. Disease Development and Life Cycle

The pathogen strains belonging to mating type A1 reproduced asexually in the absence of its compatible mating type A2. The compatible mating type spread from Mexico to around the world. *Phytophthora infestans* has a well-defined life cycle affecting potato and tomato plants. Late blight pathogen overwinters in infected plant debris/tubers left in the soil. Under favorable environmental condition, the pathogen produces spores called sporangia, which are released into the environment through rain/wind. The sporangia germinate when they come in contact with a susceptible host plant such as potato or tomato. Upon germination, the sporangia develop into hyphae, which are thread-like structures that penetrate the plant tissues. The fungal hyphae form a network of mycelium inside the plant tissues, which causes wilting and decay of the plant. As the mycelium grows, it produces stalks called sporangiospores that extend out of the plant and form sporangia at their tips. The sporangia release spores infecting nearby plants or be carried by wind or water to infect other plants. The cycle continues as the infected plant produces more spores which spread disease to neighboring plants.

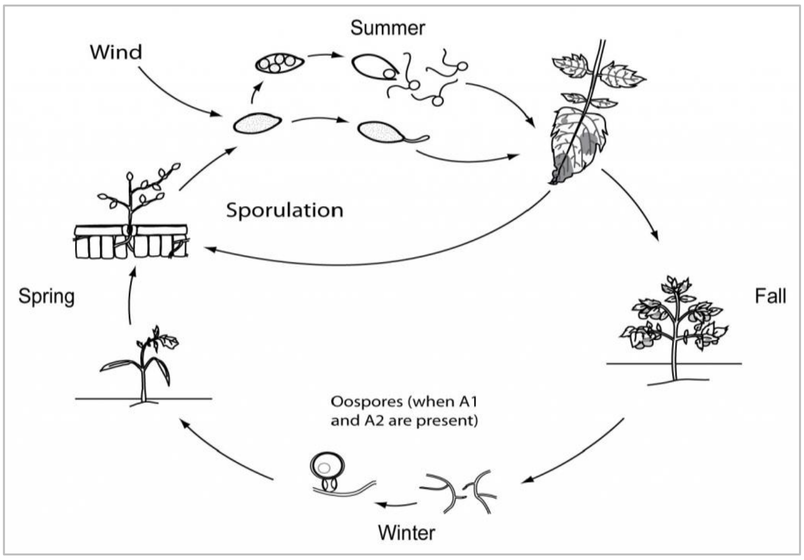


Figure 1: Disease cycle of late blight of tomato Source: https://vegpath.plantpath.wisc.edu/diseases/tomato-late-blight/

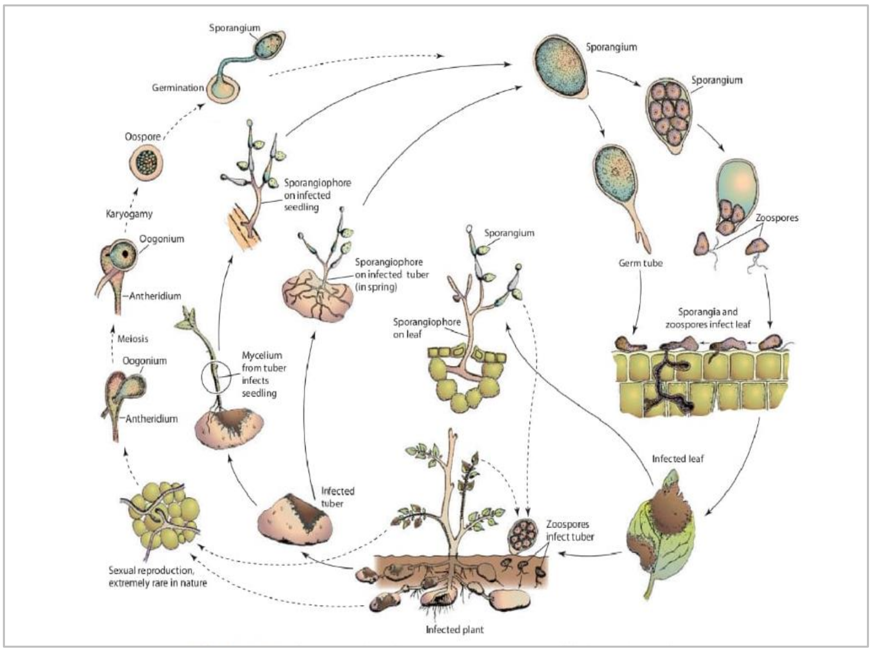


Figure 2: Disease cycle of late blight of potato
Source : Agrios, 2017

4. Management of Late Blight

I. Cultural control methods

The cultural methods include;

a. Crop Rotation and Field Sanitation

Crop rotation and field sanitation practices disrupt the lifecycle of the pathogen and reduce inoculum levels and minimize disease occurrence.

b. Planting resistant cultivar

Breeding for resistance to *Phytophthora infestans* has been a primary approach for late blight management. Developing resistant cultivars through conventional breeding and the integration of molecular techniques.

c. Seed tuber management

Seed tuber management including certified seed production and diseasefree seed tuber selection plays a crucial role in disease prevention reducing the spread of *Phytophthora infestans*.

II. Genetic Control Methods

a. Resistance breeding and MAS (Marker Assisted Selection)

Resistance breeding strategies including classical breeding and MAS to develop potato and tomato varieties using spray-induced gene silencing has been found to control late blight in potato with enhanced resistance to *Phytophthora infestans* (Kalyandurg, et al., 2021).

b. Transgenic approaches for *Phytophthora infestans* resistance

Genetic engineering techniques have been employed to introduce novel genes conferred resistance to *Phytophthora infestans*.

c. Gene editing technologies for targeted resistance

Recent advancements in gene editing technologies such as CRISPR/CAS 9 offer new possibilities for precise modifications in plant genomes. Daniel Monino Lopez , WUR researcher has found a way to use gene editing technology CRISPR/CAS 9 to make potato plants resistant to late blight disease without putting foreign DNA in the plant genome (Carmelli-Peslak, 2023)

III. Biological Control Agents

a. Antagonistic Microorganisms and Biocontrol Agents

Biological control agents including antagonistic microorganisms and biological products offer an environmentally friendly approach to suppress *Phytophthora infestans.*

b. Induced Systemic Resistance and Plant Defense Activators

Stimulating plants defense mechanisms through ISR and use of plant defense activators helps in managing *P. infestans*.

IV. Chemical Control Measures

a. Fungicide Applications and Resistance Management

Chemical control although challenging due to resistance development remains an important component in integrated management strategies. In practice, the traditional management of late blight depends highly on preventive fungicides application on a regular calendar basis during growing season (Liu, et al., 2017). Spraying fungicides is the most effective to prevent late blight. For conventional gardeners and commercial producers, protectant fungicides such as chlorothalonil and mancozeb can be used.

b. Decision Support System and Forecasting Models

To optimize chemical control measures, Decision Support Systems and Forecasting Models are valuable tools. The Blight Pros DSS is an internet-based platform developed by Cornell University Researchers to improve late blight disease suppression and fungicide use efficiency by providing real-time support for late blight management. (Liu, et al., 2017).

4.1 Integrated Management Approaches

a. IPM Principles

The main principle of the IPM is to provide a holistic framework combining multiple control methods. IPM involves an integrated approach to the prevention and or suppression of organisms harmful to plants through the use of all available information, tools, and methods (European Commission, Food and Safety). It aims to keep the use of pesticides and other forms of intervention only to levels that are economically justified and which reduce or minimize risk to human health and the environment.

b. Combining Cultural, Genetic, Biological, And Chemical Control Methods

Implementation of IPM programs almost always employs a combination of management techniques instead of dependence on only one method. (UC Sustainable Agriculture Research and Education Program, 2017).

V. Challenges and Future Perspectives

a. **Pathogen Variability**

The late blight pathogen exhibits high variability leading to the emergence of new strains with different virulence profiles.. The late blight disease caused by *Phytophthora infestans* is regarded as one of the most devastating plant diseases and certainly the most devastating disease of potato (Agrios, 2005).

b. Sustainable and Environment-friendly Strategies

The sustainability of Integrated management strategies is crucial to minimize environmental impact and its harsh consequences to the ecosystem.

c. Advances in Technology and Data-Driven Management

Rapid technological advancements such as high throughput genotyping and remote sensing offer opportunities for data-driven disease management. Spray-induced gene silencing is an alternative option for pest control by RNA delivery into plants through the leaves and roots.

5. Conclusions

In conclusion, this review provides an in-depth analysis of the comprehensive strategies employed for the management of *Phytophthora infestans* in potato and tomato crops by combining cultural, genetic, biological, and chemical control methods. IPM strategies offer effective and sustainable approaches to mitigate the devastating impacts of late blight. Nonetheless, continued research, collaboration, and implementation efforts are necessary to overcome challenges and further enhance the management of *Phytophthora infestans*.

Conflict of Interest

We thus, declare that there is no conflict of interest.

References

Phytophthora infestans, 2012. Phytophthora Blight, n,d. n.d. Retrieved from UC IPM: https://ipm.ucanr.edu/

AHDB, 2020. Agriculture and Horticulture Development Board. Retrieved from Potato variety database.: https://varieties.ahdb.org.uk/varieties/view

Agrios, 2017. Guidelines for Integrated Pome Cultivation

Agrios, G., 2005. Plant Pathology (Vol. 5). Florida, USA: Elsevier Academic Press.

AHDB, 2020. Potato variety database. Retrieved from https://varieties.ahdb.org.uk/varieties/view

Alberta, 2023. Retrieved from https://www.alberta.ca/late-blight-of-potatoes-and-tomatoes.aspx#:~:text=Late%20blight%20was%20responsible%2C%20in,in%20potato%20tubers%20in%20storage

Arora, R., Sharma, S., Singh, B., 2014. Late Blight Disease of Potato and Its Management. Potato Journal.

Bekele, K., Yaynu, H., 1996. Tuber yield loss assessment of potato cultivars with different levels of resistance to late blight. In: Proceedings of the 3rd Annual Conference of Crop Protection Society of Ethiopia.

Board(NHB), N. H., 2013. Ministry of agriculture and farmer welfare, Potato varieties. Retrieved from http://nhb.gov.in/pdf/vegetable/potato/pot013.pdf

Carmelli-Peslak, R., 2023. New Research Finds Gene Editing Can Aid Fight Against Late Blight. SPUDSMART.

Cooke, D., Cano, L., Raffaele, S., 2012. Genome analysis of an aggressive and invasive lineage of the Irish potato famine pathogen. PLoSPathogens, 8.

DEFRA, 2012. Department for Environment, F. a. Green Food Project Conclusions. London, UK.

Dutt, B., 1979. Bacterial and fungal disease of potato.

El-Naggar, M., Abouleid, H., El-Deeb, H., Abd-El-Kareem, F., Elshahawy, I., 2016. Biological control of potato late blight by means of induction systemic resistance and antagonism.

European Commission, 2023. Food and Safety. (n.d.).

Conway, G., 1997. The Doubly Green Revolution. London: penguin.

Garrity D.P., A. F., 2010. Evergreen Agriculture: A robust approach to sustainable food security in Africa, Perennial grains: Food security for the future. . Google Scholar.

Gevens, A., Wilbur, J., 2014. Retrieved from University of Vegetable Pathology: https://vegpath.plantpath.wisc.edu/diseases/tomato-late-blight/

Hannukkala, A. O., Kaukoranta, T., Lehtinen, A., Rahkonen, A. 2007. Late-blight epidemics on potato in Finland 1933–2002; increased and earlier occurrence of epidemics associated with climate change and lack of rotation.

Hardy, B., Trognit, Z., Forbes, G., 1995. Late blight breeding at CIP.

IAD, 2011. Agriculture 2050 Starts Here and Now. Paris, France.

Ivanov, A. A., Ukladov, E. O., Golubeva, T. S., 2021. Phytophthora infestans: An Overview of Methods and Attempts to Combat Late Blight. Journal of fungi.

Kalyandurg, P., Sundararajan, P., Dubey, M., Ghadamgahi, F., whisson, S., Vetukuri, R., 2021. Spray-Induced Gene Silencing as a Potential Tool to Control Potato Late Blight Disease. Phytopathology.

Krause, R., Massie, L., Hyre, R., 1975. Blitecast: A computerized forecast of potato late blight. Plant Disease Reporter, 59.

Krishi Diary, 2013. Retrieved from Ministry of Agriculture and Livestock Development: https://aitc.gov.np/english/downloadsdetail/2/2019/19794382/

Kromann, P., Miethbauer, T., Ortiz, O., Forbes G. A., 2014.

Lal, M., Sharma, S., Yadav, S., Kumar, S., 2018. Management of Late Blight of Potato. Retrieved from https://doi.org/10.5772/intechopen.72472

Large, 1958.

Liu, Y., Langemeier, M., Small, M., Joseph, L., Fry, W., Ristiano, J., Preckel, P., 2017. A Risk Analysis of Precision Agriculture Technology to Manage Tomato Late Blight.

Swaminathan, M. S., 2000. An evergreen revolution. Pubmed.

Majeed, A., Chaudhry, Z., Muhammad, Z., 2017. Changes in Foliar Glycoalkaloids levels of Potato .Solanum tubersom. Triggered by Late Blight Disease Severity. International Journal Agriculture Biology.

Mekonen, S., Tadesse, T., 2018. Effect of Varieties and Fungicides on Potato Late Blight Management.

Milder J.C., Garbach, K., DeClerck, F.A.J., Driscoll, L., Montenegro, M., 2019. An Assessment of the Multi-Functionality of Agroecological Intensification.

Modi, B., 2023.Retrieved from Research gate.

NHB, N. H., 2013. Ministry of agriculture and farmer welfare, Potato varieties. Retrieved from http://nhb.gov.in/pdf/vegetable/potato/pot013.pdf

NIVAA, N. C., 2007. Etherlands Catalogue of Potato Varieties. 5(2), 288.

Nowicki, M., Foolad, M., Nowakowska, M., & Kozik, E. (2012). Potato and tomato late blight caused by phytohphthora infestans: an overview of pathology and resistance breeding. plant disease, 96 .

Nyankanga, R., Wien, H., Olanya, O., & Ojiambo, P. (2004). Farmers' cultural practices and management of potato late blight in Kenya Highlands: implications for development of integrated disease management. Retrieved from https://doi.org/10.1080/09670870410001691812

Olanya, O. M., Ojiambo, P. S., Nyankanga, R. O., Honeycutt, C. W., & Kirk, W. W. (2009). Recent developments in managing tuber blight of potato (Solanum tuberosum) caused by Phytophthora infestans. Canadian Journal of Plant Pathology.

Selvaraj., 2013.

Sharma, H., KC, H., 2004. Participatory IDM research on potato late blight through farmers field school, in Advances of horticulture research in Nepal. In proceeedings of the Fourth National Workshop on Horticulture.

Snapp S.S., B. M.-K.-P., 2010. Biodiversity can support a greener revolution in Africa. USA: pubmed, google scholar.

Teng, P., Bissonnette, H., 1985, November. Estimating potato yield responses from chemical control of early blight in Minnesota.

Tiwari, I., Shah, K., Tripathi, S., Modi, B., Subedi, S., Shrestha, J., 2021. Late blight of potato and its management through the application of different fungicides and organic amendments. Journal of Agriculture and Natural Resources.

tomato news, 2022. tomato news.

Tomato-Potato Late Blight in the Home Garden. (n.d). Penn State Extension. (2020, November 24).

Towards Sustainable Agricultural Systems in the 21st Century, 2010. Committee on Twenty-First Century Systems Agriculture.

Tripathi, S., Shah, K., Tiwari, I., J., S., 2020. Indonesian Journal of Agriculture Research.UC Sustainable Agriculture Research and Education Program. 2017.

University of Massachusetts Amherst, 2017. Retrieved from https://ag.umass.edu/vegetable/fact-sheets/solanaceous-late-blightUSDA, Nutrient database. (n.d.).

Xin, C., Li, N., Guo, J., 2012. Potato Late Blight Control Using R-Gene Polyculture by GMO.

Cite The Article: Samarth Bista, Anjela Adhikari (2023). A Comprehensive Strategy for Late Blight Management in Potato and Tomato. *Reviews In Food and Agriculture, 4(2): 50-53.*