

Review Article

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Integrated Management of Fungal Diseases in Potato

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ABSTRACT

Among major food crops, potato occupies fourth position following rice, wheat and maize across the globe. There are several factors affecting the crop yield and quality in potato of which disease is one of the most important factors. Potato diseases are caused by fungi resulting in the immense economic loss, posing the threat to food security and sustainable agriculture. Therefore, effective disease management is essential to overcome these risks. In this review, the objective is to discuss the disease causing pathogen, symptoms, factors favouring disease and integrated management of early blight, late blight, black scurf and wart diseases. The famous Irish famine disease *i.e.* late blight is a major challenge in potato, which can be controlled with the help of intercropping. In addition to late blight, other major complex diseases mentioned above can cause significant potato yield loss. Pathogen survival in soil prohibits the sustainable potato production in same field. However, as new strain develops, no management practice is effective when used alone. Therefore, integrated disease management approach *i.e.* chemical control in combination with bio-control agents, is the most efficient, cost effective and eco-friendly way to effectively combat pathogens. For complex diseases, the common control measures employed worldwide include the use of tolerant cultivars, crop rotation and other practices; singly or collectively have met limited success. Therefore, there is a dire need of extending research for disease management in potato for better food quality.

Keywords

Potato, Integrated disease management, Bio-control

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Introduction

Potato (*Solanum tuberosum* L.) ranks fourth following wheat, rice and maize worldwide. Population growth in this world possesses a serious concern with regard to natural resources *i.e.* land, air and water. Following this, potato holds guarantee aimed at nourishment to a great many individuals particularly in developing nations. Maximum capacity of the yield can be acknowledged just if pests and diseases are monitored.

Potato yield can be influenced by roughly 160 diseases and disorders of which 50, 10 and 40 are caused by fungi, bacterial and viral infections, respectively and others by non-parasitic, or because of obscure causes. These may influence potato at any phase of harvest development or not withstanding amid capacity. They may influence foliage, tubers or both. Condition favouring pathogens can demolish the harvest. The aftermaths of verifiable potato starvation in Europe especially in Ireland caused by late blight

have been all around recorded (Woodham-Smith, 1962). Tuber illnesses like scab, black scurf may not wreck the harvest but rather can incredibly decrease quality and market value of the product. With the introduction of resistant cultivars and enhanced cultural practices, the disease infection situation may change now and again which require periodic observation. Diseases may likewise be influenced by any environmental change such as global warming (Kankoranta, 1996). The present review focuses up-to-date information on improvements that have occurred worldwide. Information is arranged under the following headings: symptoms, pathogen, epidemiology and control for each of important fungal diseases. This might be utilized as a part of better administration of the harvest and enhancement in food quality. Some important diseases caused by fungus with regard to food quality are considered under, for the effective management strategies.

Early blight

Alternaria solani requires free water in order to germinate on leaf surface referring to high humidity requirement. The ideal temperature for its growth is 26.6-29.4 °C.

Symptoms: Ellis and Martin (1882) firstly described the disease symptoms. Older leaves are affected primarily (Jones, 1893). Black lesions encircled by concentric rings on leaves, creating 'target spot' effect are the key symptoms contrary to greenhouse-inoculated plants, due to difference in moisture, temperature etc. (Waals *et al.*, 2001). The pathogen enlarges lesions surrounded by a narrow chlorotic halo, which further moves to uninfected epidermal cells and eventually cause death of the leaf, stem or petiole (Rands, 1917). Tuber infection illustrated via rotting of tubers, sunken surface lesions.

Control: Cultural practices can effectively control early blight, such as crop rotation for 3-5 years using the site selection methodology, non-preferable host crop plants, nourishing crops, sanitation of fields, escaping prevailing water stress or popularly known as drought conditions and using disease-free seed tubers for sowing (Madden *et al.*, 1978). Usually, grain and fodder crops, like maize (*Zea mays* L.) are best for rotation, including maize (*Zea mays* L.). Large area under potato or tomato or both, results in favour of occurrence of disease (Shtienberg and Fry, 1990). Planting early blight tolerant cultivars may also help in minimizing the pathogen attack. However, Shtienberg and Fry (1990) demonstrated that effect of early blight is not associated with host resistance. Before harvesting maturation of tubers reduces tuber infection, escaping extreme wounding during or after the potato tuber harvesting, especially while storage (Waals *et al.*, 2001). However, spraying protectant fungicide on vine during early days of the growing season is a good chemical control (Jones, 1912; Douglas and Groskopp, 1974). Also, plots treated with contact fungicides yielded 20–40 % more than in untreated plots on experimenting in Colorado (Harrison and Venette, 1970), whereas chemical control of early blight with captafol, triphenyltin hydroxide resulted in approximately 90 % yield increase in Minnesota on comparing it with the unsprayed controls of the treatments in the conducted experiment by Teng and Bissonnette (1985). Applications of fungicides at appropriate decreases number of sprays and also help sustaining the tuber yield and quality. Additionally, covering the entire foliage via aerial fungicidal application to prevent disease spreading is of utmost importance. Therefore, combination of practices, that is, crop rotations, chemical application and good storage facilities ably manage the prevailing threat from early blight occurrence.

Late blight

The development of fungus *Phytophthora infestans* famous for Irish famine occurs at 16-24°C (Vowinkel, 1925) and 90-100% relative humidity. Younger plants are more susceptible (Lowings and Acha, 1959), whereas water stress increases resistance in potato crop (Carnegie and Colhoun, 1980).

Symptoms: Water-soaked irregular pale green lesions appeared commonly close to the leaves tip and margins, resulting in necrotic spots. A white mildew, comprising of pathogen sporangia and spores, appears on infected leaves lower surface especially around the necrotic lesions' edges. Infected parts of the potato crop frail and may end up. Crop is destroyed in week after blackish appearance occurs. During storage, rotting of the infected tubers occur.

Management: Soil remediation and roughing (Flier and Turkensteen, 1999) should be done for reducing the disease epidemic. Also, infected plants on dumps, as experiments conducted under the stewardship of Zwankhuizen *et al.*, (2000), covered with black plastic sheet (Cooke *et al.*, 2011) provides relief from infection. Crop rotation, early-maturing cultivars, early planting, Avoiding excess nitrogen, use of systemic fungicides during the early days of the season can be useful to succeeding managing the seed infected late blight occurrence. Roy *et al.*, (2001) revealed that higher phosphorus and potassium doses give the greater potato tuber yield during severely pathogen attacked crop year. Crop rotations for three or more years are most effective in the gap of potato growing crop years as demonstrated by the Hannukkala *et al.*, (2007) and also independently by the another scientist Bodker *et al.*, (2006). For tuber infection reduction, ridge sowing, maximum number of hoeings, proper maturity harvesting time and avoiding

long potato harvest products transportation is recommended (Arora *et al.*, 2014). However, resistant cultivars development using *Solanum demissum* (Niederhauser *et al.*, 1996) and screening methodology has played significantly the finest role towards disease management (Tiwari *et al.*, 2013). Fungicidal application reduces as foliage and tubers resist to late blight. Mixing and growing susceptible and resistant cultivars yield better than grown solo (Garrett and Mundt, 2000). Application of boron concentration with reduced fungicide propineb + iprovalicarbate was significantly effective than fungicide alone treated plants (Frenkel *et al.*, 2010).

Late blight can also be suppressed by phosphorus acid spray (Tsai *et al.*, 2009). Substantial reliance towards fungicides poses danger for the entire biodiversity (Bradshaw *et al.*, 2000). In addition, Biocontrol agents (BCAs) and biopesticides might upsurge as protected alternative for utilization of synthetic fungicides. Threat to late blight pathogen by some naturally occurring microorganisms such as *Pythium ultimum* (Kuznetsova *et al.*, 1995), *Penicillium aurantiogriseum* (Roy *et al.*, 2001), *Trichoderma spp.*, *Pseudomonas syringae* and *Fusarium graminearum* (Gupta *et al.*, 2004) etc. positively significant tested under various scientists and various studies. Also in organic production, Bounes and Finckh (2008) stated, strip cropping fundamentally diminished late blight severity in potato, when the harvest was planted opposite to the wind along with the grass clover. Also, potato is garden crop in Ethiopia's central highland and intercropping with brassica at a lower population being an ordinary practice but crop like garlic is also grown as a sole crop in the same garden. Of the different alternatives accessible in the zenith, cropping systems, other than such a large number of advantages identified with intercropping, disease problem is low in an intercropping generation systems

than traditional one (Rajputt *et al.*, 2017). In Ethiopia, the research for evaluating intercropping effect on potato yield against late blight. The result demonstrated that superiority of potato-garlic ratios in comparison to unsprayed treatment. Among the proportions, high tuber yield and low disease incidence was found in garlic: potato (3:1) intercropped plots. Moreover, at 3:1 (garlic: potato) combination the land equivalent ratio (LER) was >1 and greater monetary values resulted. The study concluded that intercropping helps in managing potato against late blight.

Black scurf

Rhizoctonia solani is a seed-borne or soil-borne pathogen. The development of *Rhizoctonia solani* in potato occurs at low temperatures due to hampered emergence rate, high soil moisture as fungus grows at a faster rate compared to plantlets and neutral to acid soil (<pH 7).

Symptoms: Pre-emerging sprouts die, cankers develop on the underground stem parts and stolons of the potato, potato progeny tubers provide shelter for sclerotia to develop constituting towards the key symptoms of black scurf.

Management: To occasionally escape black scurf the potato crop should be harvested early, after destructing haulm (Mulder *et al.*, 1992). Combined green harvesting and hyperparasite *Verticillium biguttatum* use helps in controlling disease better (van den Boogert *et al.*, 2005). Under greenhouse conditions, attack of pathogen *R. solani* was controlled via usage of *Trichoderma harzianum* (Schroth and Hancock, 1981). Combining *T. harzianum* with soil solarization decreased disease infection (Elad *et al.*, 1980). *R. Solani* infection was decreased upon soil treatment with *Laetisaria*

arvalis (Murdoch and Leach, 1993). Application of the organic matter not only progresses soil structure but also increases soil water holding capacity and promotes plant growth. Soil-borne plant pathogens attack is inhibited by the use of composts. *R. solani* propagation reduction occurred due to cattle manure application in the soil (Kuter *et al.*, 1983), reason being approved antagonistic microorganisms for the biological control against various diseases, such as *T. harzianum*, *Pseudomonas yuorescens*, *Enterobacter cloacae* etc. (Kleifeld *et al.*, 1996) activities were enhanced.

Wart

The fungus *Synchytrium endobioticum* is responsible for causing wart disease of potato. This obligate parasite mostly develops in warm temperatures (up to 20 °C) with more relative humidity. Sporangia remain active for many years and can survive up to 50 cm soil depth.

Symptoms: Tubers, flowers, leaves and stems, produce warty exudations, therefore, the disease is known as potato wart, (Hooker, 1981). Different sized, green or brown coloured gall formation are principle symptoms. Tubers distort in younger stages and hence, become spongy. However, unlike roots stolons in older tubers are infected and give warty appearance. The leaves become pulpy and soft in nature, if attacked. Morphologically, the hyperplastic tissue mass mixed along with the proliferated leaves and branches can be noticed. This pathogen reduces plant vigour but does not kill it.

Management: The European and Mediterranean Plant Protection Organization (EPPO) consider *S. endobioticum* A2 quarantine pest resulting in the policing making to hamper pathogen spread across the globe. The European Union (EU) has enacted

preferable requirements in Dec. 8th 1969's 'Council Directive 69/464/EEC for controlling Potato Wart Disease' and May 8th 2000's 'Council Directive 2000/29/EC on protective measures to safeguard their community from disastrous pathogens (Obidiegwu *et al.*, 2014) by various quarantine measures against infected products. 'EPPO specific quarantine requirements' mentions that in *S. endobioticum* infected fields, the potato trials are not allowed. Also, ban on trade and seed production of diseased potato is imposed. If during field diagnoses *S. endobioticum* prevails, potato production on that particular site or location is not allowed for 20 years followed by Union members. After that period soil tests have to be passed to initiate again. Council Directive 69/464/EEC says, that Union Members have the right to follow stricter rules as per their choice as chemical controls are ineffective till date to exudates sporangia from soil. Hampson (1977) discovered 120 chemicals, inorganic or organic, singly or in combination have not given significant results except few. Chemically treated soils became barren (De Boer 2005) and hence, none recommendation of chemical (Hampson, 1993) exist to control this. (Obidiegwu *et al.*, 2014) tried to minimise wart effect from 97 to 25% using biological control solution along with potato slices culture with actinomycetes, diluting them in sand and including it in infested pot soil mixes. Simultaneous soil treatment proved better resulting in 3-year treatment program proposal to discard soil borne pathogen. The biological control *Thiobacillus thiooxydans* proposed by Roach *et al.*, (1925) was significantly effective while repeated trials proved it to be insignificant to control potato wart. In addition, crop rotation and intercropping with maize effectively minimized *S. endobioticum* population (Singh and Shekhawat, 2000).

Summary and conclusion of the study are as follows:

The important food crop of the world, potato (*Solanum tuberosum*) used in household and industrial purposes. The properties of potato are greatly affected by the attack of various pathogens leading to the economic and quality loss to everyone producers, processors and consumers. Therefore, the effective disease management is necessary. Although efforts via single management approaches are made with little affect but integrated management of fungal diseases is necessary to feed the future and sustainable agriculture.

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