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A REVIEW ON EARLY BLIGHT AND LATE BLIGHT DISEASE OF POTATO

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ABSTRACT

Edible potatoes, *Solanum tuberosum* L., are classified fourth among staple food crops and fifth for human consumption. Given that it's a crop that grows vegetatively, a lot of pests and disease can be inherited by subsequent generations. Pathogens, including fungi, bacteria, viruses, and nematodes, considerably decreased yields in both field and storage conditions. Blights are caused by *Alternaria solani*, *Phoma* spp., and *Phytophthora infestans*. The two most deadly potato diseases are late and early blight. For timely prophylaxis, it is important to identify disease and the extent of infection on potato leaves. This study looked into a precise recognition technique for identifying the kind of disease and level of infection in potato leaf photos. The early blight was first identified in 1882 and is a regular occurrence wherever potatoes are produced worldwide. Early in the growing season, when the plants are just 3–4 weeks old, disease first appears, coinciding with the tuber production phase. The pathogen targets numerous different Solanum species with significant economic significance, indicating its broad host range. One of the most dreaded potato diseases globally, late blight produced by *Phytophthora infestans* results in a large loss of yield. Because of its extreme variability, the pathogen can adapt to fungicides and newly developed kinds. The need to create an effective information technology-based disease management strategy is indicated by the growing severity of late blight in many potato-growing regions, a shift in pathogen population toward increased specific virulence, and an increasing resistance to the most effective late blight specific fungicides.

Keywords: Early Blight, Late Blight, Potato, *Alternaria Solani, Phytophthora Infestans,* Disease Forecasters.

I. INTRODUCTION

One of the most valuable food crops for humankind is the potato (*Solanum tuberosum* L.) (FAO, 2004). In terms of production and consumption, it is the most significant vegetable crop globally (FAO, 2005). It comes in fourth place globally in terms of production volume, behind rice (*Oryza sativa* L.), maize (*Zea mays* L.), and wheat (*Triticum aestivum* L.) (Bowen, 2003). Potato yields are remarkably high per hectare (Talburt, 1987; Feustel, 1987). From 30 million tonnes in the 1960s to 165 million tonnes in 2007, the world produced more potatoes than ever before (FAO, 2008). There are many different environments in which potatoes are grown: from heavily farmed tropical highland zones in Eastern and Central Africa, where they are primarily a small farmer's crop, to irrigated commercial farms in Egypt and South Africa. Of all the African countries, Ethiopia may have the greatest potential for potato production. It is predicted that 70% of the arable land in the nation may be used for potato farming (FAO, 2008). A highly recommended crop for food security, potatoes can help low-income nations avoid the hazards associated with rising global food costs (FAO, 2008). Numerous tables, processed, livestock feed, and industrial applications are among its many uses (Feustel, 1987; Talburt, 1987). In various settings, potatoes offer wholesome meals. With their ability to include more protein and vitamin C, potatoes can be a vital diet for the growing global population (Pereira and Shock, Undated). For low-income farm households, potatoes are becoming a more valuable source of monetary revenue (FAO, 2008).

More than a hundred diseases that can be brought on by bacteria, fungus, viruses, or mycoplasmas can affect potatoes. On the other hand, Alternaria blight, often known as early blight, is a major leaf disease in regions with suitable meteorological conditions and is found all over the world (CIP, 1996). The two species of Alternaria (A.solani and A.alternata) that cause early blight on potato crops are found all over the world. They are most common in areas with high temperatures, high humidity, and periods of alternating dry weather and/or irrigation. They also affect potato soils that are light-textured, sandy, and low in organic matter (Gudmestad and Pasche, 2007). The early blight's causative agents, A. alternata and A. solani, are becoming more and more risk-important diseases affecting potato crops. All places where potatoes are produced are affected by early blight, but only in warm, humid weather early in the growing season does it have a major effect on tuber yield and quality. The amount of each species varies and is influenced by weather and environment (Hausladen and Leiminger 2007, Kapsa 2007). A relatively prevalent disease that affects both potatoes and tomatoes is early blight. On potatoes, it results in leaf spots and tuber blight; on tomatoes, it produces leaf spots, fruit rot, and stem lesions. If left unchecked, the disease can be extremely damaging and frequently causes total defoliation of plants. It can occur in a variety of climatic circumstances. Contrary to the name, it typically emerges on mature foliage and is rarely developed early (Rowe et al., Undated). The measured crop losses attributed to early blight in the literature range widely from 5 to 78% (Waals et al. 2004; Pasche et al. 2004, 2005). Plants that are young or middle-aged are less vulnerable to disease, which is regulated by crop age. Mature plants are most vulnerable to the disease; young plants are reasonably resistant, but from the beginning of tuber development onward, vulnerability grows gradually and consistently (Campo et al., 2001; Johnson and Teng, 1990; Rotem, 1981; Shtienberg et al., 1996). Because early blight can create massive volumes of secondary inoculum, it is challenging to control (Campo Arana et al., 2007; Pasche et al., 2004). The majority of methods for managing foliar early blight have relied on applying protectant fungicides in warm, humid weather. However, the standards for determining the ideal timing of the first fungicide application have varied greatly, leading to needless spraying (Christ and Maczuga, 1989; Christ, 1991; Easton and Nagle, 1985; Reis et al., 1999). This analysis aims to examine the management options for early blight of potato crop disease and its economic significance.

The first reports of late potato blight date back to South America's Andes Mountains, and the disease is now found almost everywhere in the world that grows potatoes. The disease, which was first identified in 1845 and spread quickly throughout Halland, Northern France, and Eastern Germany, finished off the potato crops throughout Europe, particularly in Ireland, between 1845 and 1846, resulting in a significant loss of tubers. Therefore, the Great Famine or the Irish Famine were caused by the disease. [Elansky and others, 2001]. Midway through the 1800s, late blight devastated crops across Northern Europe, including Ireland, resulting in the Irish famine.

The names Irish Potato Famine, Great Irish Famine, and Famine of 1845–1849 are other names for the Great Famine. The potato harvest failed in the years that followed the famine of 1845–1849. Potato tubers, roots, and leaves were destroyed due to crop failures caused by late blight disease. *Phytophthora infestation* is the late blight's causative agent.

The sickness was initially discovered in the Nilgiri hills of India between 1870 and 1880. In 1880, shortly after European potatoes were introduced to India, the disease was initially identified in Darjeeling (Assam). Due of previous famine, Oomycetes *Phytophthora infestans* (Mont.: de Bary) is the causal agent of Late Blight, a significant potato disease.

Fungi not only affects potatoes but also tomatoes.

1. Early blight of potato:

Symptoms:

- Shortly before tuberization begins, early blight patches begin to form on the potato crop. The disease keeps getting worse until the plant dies (Dutt, 1979). When the crop is maturing, the disease could be severe.
- The disease mostly affects leaves, though it can also sporadically harm stems and tubers. The symptoms initially appear as dark brown, angular, oval, or circular necrotic spots dispersed across the leaf surface on the lower leaves.
- The leaf may eventually dry out and drop off as the diseased areas grow larger and merge together. Usually, the dots appear in between the veins.
- The lesions may develop concentric rings that give them a target board appearance. Senescence and dropping occur when a single leaf has a large number of spots on it.
- The spots may also appear on the stem later in the plant's growth cycle, which could result in the plants dying too soon.
- The presence of the pathogen-produced toxin "alternaric acid" causes the spots to be surrounded by a chlorotic zone that may extend much beyond the lesion.
- On tubers, lesions have a dark, sunken, rounded to uneven shape, elevated borders, and underlying flesh that gives the appearance of being dry and leathery.

- The afflicted tubers have a dark brown lesion on their surface and could infect the following crop. In India, tuber early blight infection is uncommon.

Fig. 1: Early Blight symptoms on foliage.

Causal organism:

Early blight is caused by the dematiaceous *Alternaria solani* (Ellis & Mart.) Jones & Grout. Conidiophores can be either single or in small groups, with a maximum length of 110 µm and a diameter of 6–10 µm. They have thick walls, are straight to flexuous, septate, and dark or olivaceous brown in colour (Neergaard 1945; Ellis & Gibson 1975). According to Neergaard 1945 and Ellis & Gibson 1975, cnidogenesis is thetic. Conidia have two walls, measuring 75–350 µm in length and 20–30 µm in diameter in the broadest part. They are typically pale to olivaceous-brown, produced singly or infrequently in short chains, straight or slightly flexuous, obclavate to elongate, and double walled with 0–8 longitudinal or oblique and 6–19 transverse septa (Ellis & Martin 1882; Rao 1964, 1969). The diameter of the beaks ranges from 5 to 9 µm, and they are filiform, straight and flexuous, septate, hyaline to pale brown, and roughly half to one-third the length of the conidium (Ellis & Martin 1882; Rao 1964, 1969). There is no known ideal stage of the fungus.

Scientific classification (Kirk et al., 2008)

Phylum: Ascomycota
Class: Dothideomycetes
Order: Pleosporales
Family: Pleosporaceae
Genus: *Alternaria*

Disease cycle:

Though they could be contaminated, tubers almost never act as the main source of infection. The principal source of inoculum is plant debris that has been infected and left in the fields after harvest. Even after a year in damp conditions, the pathogen can continue to grow and produce new conidia and conidiophores in dried infected leaf fragments in the soil. In addition, the pathogen infects weeds like Solanum nigrum and other hosts like tomatoes and capsicum, which may be crucial to its survival (Singh and Nagaich, 1977). Early in the season, the lower, older leaves become infected first. This results in a huge number of conidia, which are then transported by wind, water, and rain splashes, leading to secondary disease dissemination. When moisture is present, the conidia germinate and produce five to ten germ tubes, which either directly or through stomata enter the host tissue. Three to four days after the infection, dark brown blotches start to form.

Management:

- Effective cultural techniques, such as a three- to five-year crop rotation with non-host crops, site selection, field sanitation, correct plant nutrition, minimising water stress, and planting disease-free seed, can effectively manage early blight (Madden et al. 1978).
- According to Workman et al. (1983), tuber infection can be reduced by letting tubers mature before harvesting, minimising injuring during harvest, and creating storage conditions that promote wound healing.
- Potato early blight can be effectively managed using fungicidal sprays. This disease can be successfully controlled by spraying crops with 0.20 percent chlorothalonil, 0.20 percent mancozeb, 0.05 percent hexaconazole, or 0.20 percent propineb at intervals of 15 days. (Sharma, 2015)

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2. Late blight of potato:

Symptoms:

- Potato stems, leaves, and tubers are the main areas where symptoms manifest.
- Generally, pale green, water-soaked patches (2–10 mm) form on the tips and margins of leaves (Arora et al., 2014). When the weather is favourable, that is, damp, the spot grows larger and eventually covers the entire leaf, which quickly turns necrotic. White fungal growth with lots of sporangia formed on the underside of the leaves around the necrotic area (Sharma et al., 2015).
- Lesions ranging from light to dark brown weaken the petioles and stem, which may cause them to fall later (Arora et al., 2014).
- The crop appears completely blighted and black throughout the disease development stage, and it may be destroyed in a matter of weeks.
- A reddish-brown to purplish splotch that first appeared on an infected tuber subsequently migrated internally. These tubers are typically dry and rigid, but during fieldwork or storage, bacterial invasion causes them to become soft and rotting (Arora et al., 2014).

Fig 2: (a) Symptoms on potato crops (b) Necrotic surface with whitish fungal growth on lower side of the leaves.

Fig 3: Symptoms on tuber **Courtesy:** Dr. Steve Johnson, University of Maine Cooperative Extension

Causal organism: *Phytophthora infestans* (Mont.) de Bary

Pathogen:

Phytophthora infestans (Mont.) the late blight is caused by De Bary. The mycelium has haustoria that range in form from simple to club-like, is branching, hyaline, and coenocytic. Sporangiophores appear through stomata on leaves and tubers and are derived from the inner mycelium. These are septate, thin, hyaline, sympodial, indeterminate branches with swelling bases on their lateral branches. Sporangia are crystalline, oval-shaped, thin-walled papillates with up to 30 nuclei that measure 21–28 x 12–24 µm. They originate at the apex of sporangiophores. As the sporangium reaches maturity, sporangiophores continue to grow and develop their distinctive enlarged nodules. Due to the heterothallic nature of this fungus, two mating types—A1 and A2—are required for sexual reproduction. While type A2 mating was expanded in the Shimla hills after 1984, type A1

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mating is significantly more widespread in India (Singh et al., 1994). Singh et al. (2015) state that in temperate uplands, A1 type replaces A2 type, whereas A1 always predominates in subtropical levels. Antheridia and oogonia are formed following intimate contact between coupling types A1 and A2. Antheridia have an amphygynous shape, while oogonis have a rounded form. Oospores that have grown after fertilisation have thick walls and measure 24 to 26 µm in diameter. The genotypes of the infected potatoes and certain A1 and A2 combinations affect how oospores form (Cohen et al., 1997), On the other hand, reports also exist of oospore self-production in the Al population. Simple 0 and 4 race P. infestans gave way to complex 4–8 gene breeds in India after 1965. Varieties and environmental conditions are the primary concerns for complicated breed performance. Arora (1990) asserts that good atmospheric conditions and planted varieties are necessary for the establishment of diverse races.

Taxonomy: (Kirk *et al.*, 2008)

Phylum: Oomycota
Class: Oomycetes
Order: Peronosporales
Family: Peronosporaceae
Genus: *Phytophthora*
Species: *infestans*

Disease cycle and Epidemiology:

As an asexual organism, *Phytopthora infestans* requires a living host to sustain itself throughout time. Asexual reproduction produces sporangia that only exist for a few days or weeks, whereas sexual reproduction produces oospores that live for several days to a month in the absence of a living host (Drenth et al., 1995). In an asexual life cycle, the infection can begin through a zoospore (which germinates after swimming for a few minutes before encystinging) or a germ tube (which germinates directly from sporangia).

In the event of an incompatible interaction on a live host, hypersensitive reaction occurs. For the first few days during a compatible interaction, a germ tube establishes a biotrophic association following penetration in the living host.

In fewer than three days, infection can be seen in a suitable interaction with favourable environmental conditions (i.e., 18–24°C and RH: >90%) (Crosier, 1934). The fungus can sporulate in moderate temperatures (10–25°C) and humid conditions (RH–100%), and the lesion appears in one or two days. Under ideal circumstances, sporangiophores generate sporangia in 8–12 hours. As the relative humidity changes, sporangia split from the sporangiophore and spread via splashing and air currents. Sporangia can persist for hours in unsaturated climate conditions when exposed to shielded sun radiation (Minogue and Fry, 1981). Sporangia can disperse hundreds of metres to kilometres before landing on a living host in suitable conditions, when they germinate and penetrate within two hours (Van der Zaag, 1956). More than 100,000 sporangia formed from single lesion (Legard *et al*., 1995).

P. infestans' asexual stage survival is mostly dependent on disease-infested potato tubers that are surviving in the earth, heap, and storage. When conditions are right, the fungus can sporulate from plants that were generated from infected tubers once more, initiating a new asexual generation succession.

Each thallus forms oogonia and antheridia during the sexual life cycle as a result of physical contact between individuals of the opposing mating type (i.e. A1 and A2). Gametangial is meiosis. Following fertilisation, the oospore grows and survives in adverse weather conditions. Only after a few weeks to months of slumber does the oospore begin to germinate. In a lab setting, germination occurs on water agar at 18°C under blue light. Through a germ sporangium, oospores proliferate. This sporangium can proliferate via a germtube or zoospore. The asexual phase may begin if the fungus interacts with the host plant.

Epidemiology:

- Cool, humid conditions;
- Temperature range of 12-240 C; relative humidity of greater than 90%.

Dutch rules:

- A minimum of four hours of below-dew point temperatures at night.
- Low temperature at night, no less than 10°C;

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- Overcast the following day.
- Pour at least 0.1 millimetres the next day.

Management:

Use of Healthy Seeds:

Only disease-free seed tubers were used. Disease control should target many polluted sources, such as diseased neighbouring fields, trash heaps, volunteer plants, infected tuberculosis, and regrowth following foliage destruction (Turkensteen and Mulder, 1999).

Resistant cultivars:

In the sub-tropical plains, K. arun, K. Anand, K. chipsona-1, K. Badshah, K. Pukhraj, K. Sutlej, K. Himsona, K. Sadabahar, K. Chipsona-2, and K. Chipsona-3 should be planted. Varieties of late blight resistance ranging from moderate to high should be planted, including Kufri Himalini, K. Shailja, and K. Girdhari for the northwestern hills, K. Megha, K. Kanchan, K. Girdhari, and K. Himalini for the north eastern hills, and K. muthu, K. Neela, K. Neelima, and K. swarna for the southern hills.

Cultural methods:

- Only well-drained soil should be used for potato cultivation;
- High ridging should be used to limit the exposure of infected seed tubers as they are the main source of inoculum.
- Regular inspections are necessary to identify primary infection foci, and the affected plants should be destroyed after being soaked in the suggested fungicides.
- If only light irrigation is needed, stop watering the potato field once the weather is comfortable.
- When the disease severity reaches more than 80%, remove the foliage from the field in order to lessen the tuber infection (Sharma et al., 2015).

Chemical control:

- It is advised to apply four fungicide applications at minimum. Depending on the severity of the sickness, it may be raised or lowered.
- In accordance with Chakraborty and Banerjee (2016), a preventive spray of mancozeb at a rate of 0.2% should be applied at the time of canopy closure. This should be followed by a second spray at the onset of the disease using fenamidone + mancozeb at a rate of 0.3%, a third spray at a rate of 0.2% after seven days of the second spray, and a fourth spray at a rate of fenamidone + mancozeb @ 0.3% after seven days of the third spray.
- In accordance with Lalet et al. (2017), Amectoctradin 27% + Dimethomorth 20.27% SC @ 0.08 & 0.1% is an effective late blight spray management strategy.

II. CONCLUSION

Potatoes, a vital staple crop globally, face significant threats from diseases such as early and late blight caused by pathogens like Alternaria solani and Phytophthora infestans, respectively. These diseases can result in substantial yield losses, impacting food security and economic stability in regions reliant on potato cultivation. Effective disease management strategies, including cultural practices, use of disease-resistant cultivars, and chemical controls, are crucial for mitigating these threats. Additionally, advancements in information technology-based disease recognition techniques can aid in timely diagnosis and management. Given the increasing severity of late blight in many potato-growing regions and the evolving nature of pathogen populations, a proactive approach to disease management is essential for ensuring the sustainability of potato production and global food security.

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