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Management Tactics for Early Blight of Tomato Caused by Alternaria Solani: A Review

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Abstract

Tomato is belonging to *Solanaceae* family. Tomato is known as poor man's apple. It is one of the most widely grown vegetable in the world. Among the processing crops, tomato is 1st rank in the world. Tomato products are important part of human diets. It is rich source of amino acids, sugars, minerals and vitamins (A, C & K). There are so many factors involved in low yield of tomato crop. Fungi, bacteria, nematodes or viruses are those factor, which causes heavy loss in tomato production. Among those, fungal pathogen mostly causes diseases in tomato like Anthracnose fruit rot, early blight, septoria leaf spot, late blight, and Buckeye rot. In this Early blight (*Alternaria solani*) is one of foliar diseases of tomato is the most destructive and widespread in temperate, tropical and subtropical regions of the world. Early blight symptoms appearance as brown to black spots, 1 ⁄4 to 1 ⁄2 inch in diameter with dark edges, appears on lower leaves. Spots frequently merge, forming irregular blotches. Dark, concentric rings often appear in leaf spots. Every plant part of the tomato can be infected by *Alternaria solani*. The most cost-effective and ecologically well-disposed technique being the Integrated Disease Management (IDM) which are the safe method for environment as well as human life also. Management practices use to manage early blight of tomato are Cultural management, Use of resistant varieties, Biological management including chemical management.

Introduction

Tomato is belonging to family *Solanaceae*. Tomato is known as poor man's apple. It is the most important fruit and vegetable crop consumed in the world and it is estimated that 124.4 million tons fresh tomato fruits are produced every year in all over the world [1]. It is one of the most widely grown vegetable in the world. Among the processing crops, tomato is 1st rank in the world. Tomato crop is growing over an area of 4815.71 million ha, with 163029.7 million tones production and 33.9 tones/ha productivity. In India tomato is cultivated over 8.82 million ha, with the 18735.9 metric tons production and 21.2 metric tons/ha productivity [2]. Tomato products are important part of human diets. Currently, in developed countries tomato has a higher consumption rate and is often referred to as a luxury crop [3].

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Tomato consumed fresh in salad or cooked within sauces, meat and soup dishes. Dried and canned tomatoes are economically important processed products [4]. It is rich source of amino acids, sugars, dietary fibers, minerals like Ca, P & Fe and vitamins (A, C & K). Because of its wide use and nutritional value have increased the demand for both fresh market and processed tomato varieties, therefore higher production of tomato is required to fulfill the ever-increasing demand [5]. For the low productivity of tomato the most important factors are diseases and insect pests. Among those diseases, early blight (*Alternaria solani*) is one of foliar diseases of tomato is the most destructive and widespread in temperate, tropical and subtropical regions of the world, ehich causes reduction in tomato yield [6]. *Alternaria solani* can infect each part of the plant like leaf, fruit and stem and can damage during all stages of plant development. It causing foliage blight, fruit lesions and stem collar rot [7].

Symptoms of early blight

The primary symptoms are the appearance of small dark brown spots on the lowest and oldest leaves. The entire leaves may become necrosis and chlorotic. The spots get enlarged; they develop concentric rings which give them a bull's eye. In favorable weather conditions, disease develop, lesions can become numerous and plants defoliate, which damage the tomato fruits [8]. The early blight causes severe epidemics in tomato plants grown in warm and humid regions. Under favorable conditions to the disease progress, many secondary cycles of the pathogen may occur during the crop cycle leading to epidemics [9]. According to morphological characters and physiologic analysis of the pathogen, early blight pathogen belongs to large, long beaked and concatenated spores [10]. It needs to develop new effective fungicide and bioagents with mode of action, which will be helpful for increase in quality and quantity of tomato production [11].

Pathogen

Early blight is caused by the fungus pathogen, *Alternaria solani*. *Alternaria solani* survives in infected leaf or stem tissues on or in the soil. Spores form on infected plant debris at the soil surface or on active lesion over a fairly wide range of temperature, especially under alternating wet and dry condition. Pathogens are easily carried by windblown soil, air currents, splashing rain, and irrigation water. Infection occurs in warm, humid weather with heavy dews or rain. Early blight can develop quite rapidly in mid to late season and is more severe when plants natural openings on the skin or through injuries [12].

Alternaria solani produce asexual spores, which are dark to black color. Not produce sexual spores. The main hosts of *Alternaria solani* are potato and tomato. Other wild cabbage, cucumber and zinniz are also known hosts of *Alternaria solani* [12]. *Alternaria solani* have dark-colored mycelium, and in older diseased tissue they produce short, simple, erect conidiophores that single or branched chains of conidia. Conidia are large, dark, long or pear shaped and multicellular, with both transverse and longitudinal cross walls. Alternaria occurs on many plant species throughout the world. Alternaria spores are present in the air and dust. Mostly Alternaria is saprophytic. Many species of Alternaria produce toxins. Some Alternaria toxins affect many different plants, whereas others are host specific [13].

Host range

A wide range of Alternaria species were recorded infecting several crops causing economic loss. Due to evolution, this pathogen has wide range of host and infects of plant of diverse origin. Early blight of potato, leaf spot disease in *Withania somnifera* is caused by *Alternaria alternata*. Alternaria species have high host range like stem canker of tomato, leaf lesions on Asian pear and lesions on Blumea aurita caused by *Alternaria arborescens*, *Alternaria arbusti*, and *Alternaria blumeae*, respectively. A. brassicae infect many vegetable crops, Alternaria brassicicola invade on cole crops). Similarly, cumin blight, leaf blight on carrot are caused by A. brunsii, A. carotiincultae, respectively. *A. carthami*, *A. cinerariae*, *A. citri*, *A. conjuncta* all found to infect parsnip. *A. dauci* grows on carrot; crucifers are also infected by other species such as *A. dianthi*, *A. dianthicola*, *A. euphorbiicola*. This wide range of host of Alternaria has attracted the attention of pathologist towards it and various studies are still going on its variability and characterization.

Symptoms of early blight disease on tomato

Early blight symptoms appearance as brown to black spots, 1/4 to 1/2 inch in diameter with dark edges, appears on lower leaves. Spots frequently merge, forming irregular blotches. Dark, concentric rings often appear in leaf spots, resulting in the "target" appearance. Tomato leaves turn yellow and dry up when only a few spots are present. The fungus occasionally attacks fruit at the stem end, causing large, sunken areas with concentric rings and a black, velvety appearance [14].

Early blight symptoms include small to irregular brown spots that give ''bull eye'' appearance on older tomato leaves. Seedling, stem, blossom blight and fruit drop symptoms also produced by *Alternaria solani* [13]. Every part of the tomato plant can be infected by *Alternaria solani* and can be affected at all stages of plant growth [7].

The tissue around the primary lesions will turn yellow and the entire leaves can become necrosis and chlorotic if the lenions are multiple [8].

Alternaria solani can cause less economically important symptoms on tomato, including collar rot, stem lesions on the adult plant, and fruit rot [15].

Disease cycle and epidemiology

Alternaria solani is a polycyclic pathogen. It reproduces asexually by means of conidia. It overwinters primarily on infected tomato crop debris. Extends the survival time in the soil to several years the dark pigmentation of the mycelium increases resistance to lysis. Thick-walled chlamydospores have been reported, but they are found infrequently.

For infection, warm, humid environmental condition requires. Conidia will germinate in approximately 40 min. Desiccated germ tubes are able to renew growth when re-wetted, and, hence, infection can occur under conditions of alternating wet and dry periods. Germ tubes penetrate the leaf epidermis directly or enter through stomata. Wet conditions at harvest provide a favorable environment for spore germination.

Time from initial infection to appearance of foliar symptoms is dependent on environmental conditions, leaf age, and cultivar susceptibility. Lesions generally appear quickly under warm, moist conditions on older foliage and are usually visible within 5-7 days after infection.

For sporulation, a long wet period is required but it can also occur under condition of alternating wet and dry periods.

Conidiophores are produced during wet nights and the following day light and dryness induce them to produce spores, which emerge on the second wet night.

Secondary spread of the disease mainly be wind and occasionally by splashing rain or overhead irrigation Kemmitt, G [16].

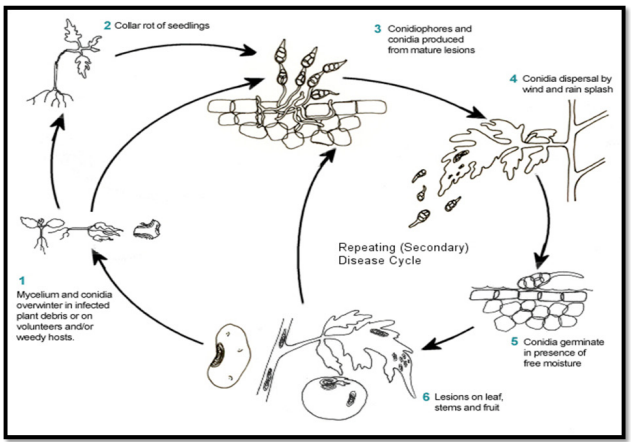

Figure 1: Disease cycle of *Alternaria solani* [16].

Dissemination

Conidia produced in the spring act as primary inoculum, which are dispersed by splash- or wind- to the lower leaves where they germinate and cause infection.

Management

For the control and better management of the early blight different methods have been used. In this include cultural, use of resistant varieties, biological control, chemical control and disease free planting material [17].

The use of fungicide is considered as effective method for control early blight of tomato. Use of resistant varieties is also an important method to management of early blight. Different type of fungicides is available in market use for controlling the disease like ziram, azoxystrobin, pyraclostrobin and mancozeb etc.

The worldwide trend towards safe environment methods for controlling plant diseases in sustainable agriculture practice needs reduced usage of synthetic chemicals [18]. The use of bio-control agent's safe method for environment as well as human health.

Cultural control

Cultural methods have been successful tools in reducing disease severity caused by various pathogens for centuries [19]. Cultural control includes altering farming practices to make the environment unfavorable for the growth of disease pathogens and pest [20].

Cultivating different types of crops in the same area in sequential seasons, it is known as crop rotation. It is one of the most effective strategies in reducing levels of early blight on tomato. A crop rotation including members of different families' crops has been found to reduce the initial inoculum of early blight [21].

In cultural control crop rotation, mainly help to reduce the population of the pathogens in the soil. It is effectively control a soil borne pathogen, the pathogen must be completely eliminated along with the plant residues from the field [22].

Mulching also important cultural practice to control weed, optimize soil moisture and keep the soil cool. This helps create unfavourable conditions for soil borne pathogens thereby controlling diseases.

Mulching also avoid splashing of soil borne disease on tomato leaves during watering.

Using disease free seed is one way of managing early blight disease on tomatoes. There are currently no known resistant cultivars available to farmers in the market. However, partial resistance cultivar has been present in wild species of tomato crop[23].

Biological control

Bacteria for biological control were effective against early blight [24]. Pseudomonas gladioli b25 used as control of early blight of tomato [25]. *Trichoderma* viride with Pseudomonas strains is another effective bio-control strategy used for disease management. Owing to strong mycoparasitism of fungal pathogens and rapid growth potential, *Trichoderma* species are considered as effective control agent [26]. Use of biocontrol agent is the effective and ecological alternative approach for managing early blight. Several researchers have shown the use of biological agents as a best alternative method for the control of early blight on tomato. *Trichoderma virens* show better inhibitory effect on radial growth and sporulation of mycelium [27]. Early blight disease was reduced significantly by 67-83% by foliar application of *B. subtilis* either alone or in combination with the plant nutrients [28]. *Trichoderma* isolates reduced mycelial growth of *Alternaria solani* [29].

Chemical control

The use of chemical fungicides is considered as the most effective approach for controlling early blight [30]. The fungicide mancozeb has been widely used to control early blight, reducing the effect of the disease and enhances yield of tomato [18].

Table 1: List of some common fungicide used for controlling early blight disease caused by *Alternaria solani*.

Fungicide	Type of fungicide	Reference
Copper oxychloride	Protectant	Sahu et al. [11]
Mancozeb	Protectant	Sarkar and Chowdhary [36]
Azoxystrobin	Curative	Bartlett et al.[35]
Iprodione	Translaminar	Sarkar and Chowdhary [36]

Use of plant extract

The natural products are considered as a best alternative to synthetic chemicals due to less hazardous to environment as well as human life [31]. There are number of plants species with natural constituents, which are harmful to several plant pathogen [32]. Plant extracts have antimicrobial activity for controlling early blight disease [33]. *A. sativum* showed promising results against *Alternaria solani* causing early blight of tomato [31]. Coumarins, flavonols, tannins, quinones, phenolics and saponins secondary toxic metabolites are produced by plant [17].

Garlic bulb extract (10%) was observed most effective against mycelial growth (35.16%) in controlling disease intensity followed by neem leaf extract (35.68%), datura leaf extract (36.25%) and onion bulb extract (36.71%) [34].

Conclusion

Tomato is one of the most important vegetable crops economically produced and consumed worldwide. Many fungal pathogen causes disease in tomato plant among them early blight disease of tomato caused by *Alternaria solani* is one of the most important and widespread disease of the cultivated tomato. To control early blight various strategies and management practices use to control the disease in tomato. Several management practices used to control early blight of tomato such as cultural, biological, chemicals and use of plant extract. Regular use of chemical fungicide hazardous to human life as well as to environment. In recent years, research is focused more on using biological control method because it is safe method.

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