

Alternaria leaf and fruit spot in apple: Symptoms, cause and management

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Abstract

Apples are most predominantly produced fruits, cultivated in all temperate regions across the globe. Over the last decade, Alternaria leaf and fruit spot disease caused by *Alternaria* species complex has created epidemic like condition all over the world. The infection begins in spring when overwintering mycelium produces conidia and infects young emerging apple leaves. Increase in temperature in combination with high rainfall and relative humidity after 90 days of blooming increases secondary infection in leaves and fruits. Various disease management strategies are available including cultural, chemical, resistance and biological approach for its control. Here we review the cause, symptoms and management of the disease.

Keywords: alternaria, apple, fungicide, conidia

Introduction

Apples are most predominantly and commercially grown fruits, cultivated in all temperate regions of the globe with a production of around 81 million tonnes with productivity of nearly 18 tonnes/hectare per annum (FAOSTAT, 2018). These are subject to more than 70 plant diseases, of which the vast majority is caused by pathogenic fungi (Nabi *et al.*, 2020) ^[1]. Several diseases such as apple scab, Alternaria blotch, cankers etc are distributed throughout the world (Muneer *et al.*, 2017) ^[19]. Alternaria leaf and fruit spot (ALFS) disease caused by *Alternaria* spp., poses a severe threat to the apple production and productivity. Over the last decade, *Alternaria* disease in apple causes severe losses to the apple industry in most of apple growing regions of the world (Filajdic *et al.*, 1991) ^[10]. In India apple is largely grown in Union territory Jammu and Kashmir (J &K) and state of Himachal Pradesh, Uttarakhand which account for about 90% of the total production of country. The ALFS has emerged as an important disease causing economic losses to the farmers and industry. Alternaria leaf blotch was first reported in the USA in 1924 (Roberts, 1924) ^[2], and now has been reported from most apple producing countries. The occurrence of the disease (*Alternaria mali*) in Indian was reported in 2002 in Kashmir valley of J and K (Shahzad *et al.*, 2002) ^[3]. The ALFS is considered as disease of minor

importance compared to apple scab. The ALFS has been observed in most cultivars; however Delicious group is highly susceptible (Bhat *et al.*, 2015) ^[3].

Symptomatology

During late spring or early summer a small, round, purplish or blackish spots appear on leaves, later they gradually enlarging to ¼ inch in diameter to have purplish border (Figure 1a). Most lesions undergo secondary enlargement and become irregular, darker and appearing frog eye like symptoms or crescent-shaped rings (Figure 1b). Frog eye leaf spot usually appears early in the season and are present nearby fruit mummies or dead wood. When infection occurs in petioles, the leaves turn yellow and premature defoliation may occur. Severe defoliation may leads to the premature fruit drop. Defoliation is more severe when severe mite infestation is present (Filajdic *et al.*, 1995) ^[11]. Fruit symptoms are characterized by Small, dark, slightly sunken spots are associated with the lenticels (Figure 1c). Round, sunken, blackish spots border by cracks observed in twigs of susceptible cultivars. Presence of moisture increases abundant light-grey mycelium on the surface of apple fruit under storage condition. When fungus infects damaged fruits it also causes soft rot (Peter, 2017) ^[6].



Figure 1a-c

Causal organism

The ALFS of apple caused by *Alternaria* species belong to Phylum Ascomycota, Subphylum Pezizomycotina, Class Dothideomycetes, Order Pleosporales, Family Pleosporaceae, and Genus *Alternaria*. The genus *Alternaria* is differentiated from other fungal genera by conidia

morphology, which are large and dark, multi-celled, catenate or single, ovoid or obclavate, often beaked, brown, with transverse and longitudinal septa. *Alternaria mali*, most reported and serious pathogen of apple and is currently identified from America (USA, Canada, Chile), Europe (Netherlands, France, Turkey, Serbia, Slovenia) Asia (India,

China, Japan, Taiwan Korea), and Australia (EPPO Global Database 2020). In addition to *A. mali*, several other *Alternaria* species complex are associated with the ALFS viz., *A. alternata*, *A. arborescens*, *A. longipes* and *A. tenuissima* (Harteveld *et al.*, 2013) [8]. However, different isolates exhibited variable pathogenicity and virulence (both within and between species complexes) (Harteveld *et al.*, 2014) [9].

Disease cycle

The fungus can overwinter as mycelium mainly in leaf residues on the orchard floor and also in twigs or dormant buds. During spring, spore production increase on dormant leaves due to increased temperature and rainfall. Presence of wind or rain splashes increases the upward movement of spores into the canopy of the tree. Primary infection takes

place one month after petal fall (Harteveld *et al.*, 2013) [8]. The disease progress rapidly in the optimum temperature ranging from 25-31°C and 5.1 hours of wetting and symptoms can start appear two days after infection (Filajdic *et al.*, 1992) [10]. The freshly emerging shoots get infected from about 20 days after bloom. Disease incidence and secondary infection increases during growing season, where peak temperature in combination with high rainfall and relative humidity 90 days after blooming leads to fruit infections. Disease progress on leaves and fruit continues to increase until end of summer/ beginning of autumn when defoliation occurs (Figure 2). The pathogen *A. alternata* f. sp. *mali*, is known to produce host specific AM toxin, which increases the severity of the disease on susceptible cultivars (Peter. 2017) [6].

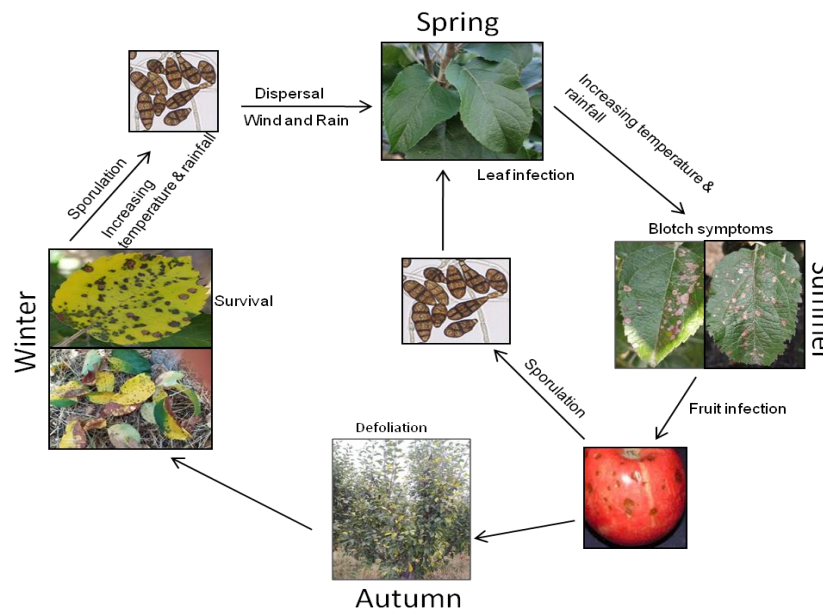


Figure 2

Disease management

Effective control of diseases is possible by using resistant cultivars. To date, no resistance gene has been identified. Few studies have investigated resistance to *Alternaria* leaf blotch (Filajdic *et al.*, 1991; Abe *et al.*, 2010; Li *et al.*, 2011) [11, 12, 13]. The ALFS outbreak could be controlled by combination of fungicidal spray, mite treatments and proper cultural practices. Main source of inoculums is leaf residue on the orchard floor and spores resides on twigs and buds during winter. Therefore it is crucial to reduce the leaf residue from the orchard floor. Maintenance of hygiene in orchards and chop or degradation of fallen apple leaves and other debris to minimize *Alternaria* leaf blotch fungi and mite eggs from overwintering in the debris. Application of urea on fallen leaves, mulching, removal of weeds, discarding fallen apple litter from orchards, application of

lime sulphur, covering the plastic foil, manual removal of leaf residues could reduce the source of inoculums in orchards. Spores also resided on twigs and buds during the winter season. Protective spray of copper based fungicide is recommended prior to development of new leaves during the end of autumn or early spring. Selective pruning of canopy also reduces inoculum present in twigs and buds in the orchards. Fungicide sprays could aid in the reduction of infections with correct timing of the application. Leaf blotch incidence should be monitored and if by 70-90 DAB (2 months before harvest) the incidence is more than 15%, fungicide application may need to be applied to prevent fruit spot infection (Gomez *et al.*, 2007; Holb *et al.*, 2006; Sutton *et al.*, 2000; Cooley *et al.*, 2011) [14, 15, 5, 17]. List of chemicals recommended and registered for control of apple leaf and fruit blotch (Table 1) (Peter, 2020) [6]

Table 1: List of chemicals recommended and registered for control of *Alternaria* leaf and fruit spot in apple

S. No.	Fungicide	S. No.	Fungicide	S. No.	Fungicide
1 ^a	Fluxapyroxad 250 G/L + Pyraclostrobin 250 G/L SC	6 ^a	Kresoxim methyl	11 ^c	Ziram
2 ^a	Difenoconazole 8.4% + Cyprodinil 24.1%	7 ^b	Fluxapyroxad 75g/L + Difenoconazole 50g/L SC	12 ^c	Sulfur
3 ^a	Pyraclostrobin 12.8% + Boscalid 25.2%	8 ^b	Mancozeb	13 ^c	Ferbam
4 ^a	Metiram 55% + Pyraclostrobin 5% WG	9 ^c	Benzovindiflupyr 10.27%	14 ^c	Potassium bicarbonate
5 ^a	Zineb 68% + Hexaconazole 4%	10 ^c	Fluazinam 40%	15 ^c	Polyoxin D zinc salt

a= Best, b= Good, c= Pair

Conclusion

The ALFS disease caused by *Alternaria* species complex has created epidemic all over the world. Control options are limited, due to lack of understanding of the time and process of infection and epidemiological aspects of the diseases. Improved disease management strategy based on orchard hygiene and better timing of fungicide applications. Further research should focus on developing and improving selection methods to enable breeding of resistant cultivars to *Alternaria* leaf blotch and fruit spot.

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