ECRONICON OPEN ACCESS

EC MICROBIOLOGY
Mini Review

An Overview of Apple Scab, its Cause and Management Strategies

Sheikh Mansoor Shafi[1]*, Muneer Ahmad Sheikh[2], Sajad Un Nabi[2], Mudasir A Mir[3], Nazeer Ahmad[3], Javid Iqbal Mir[2], Wasim Hassan Raja[2], Rifat Rasool[2] and KZ Masoodi[3]

[1]*Division of Biochemistry, (SKUAST-J) Jammu, Jammu and Kashmir, India*

[2]*ICAR- Central Institute of Temperate Horticulture, Srinagar, Jammu and Kashmir, India.*

[3]*Division of Plant Biotechnology, (SKUAST-K), Shalimar, Srinagar, Jammu and Kashmir, India*

***Corresponding Author:** Sheikh Mansoor Shafi, Ph.D, Scholar, Division of Biochemistry, (SKUAST-J) Jammu, Jammu and Kashmir, India..

Received: January 16, 2019; **Published:** March 25, 2019

Abstract

Apple scab is the most important disease of apple (*Malus × domestica*) throughout the temperate regions of world. This disease results in 70% yield loss and even complete loss is also possible, if it is not managed in orchards properly. The infection begins in spring when ascospores are released and infect young emerging apple leaves. Conidia are then produced from these infections and continue the cycle of secondary infection in leaves and fruits. Different management strategies like cultural, biological, resistance and chemical approach has been adopted for its control. However, development of scab resistant apple cultivars carrying the *Vf* resistance gene could be a step toward a more ecological-based production system for producing high quality apples with reduced fungicide input.

Keywords: *Apple; Scab; Conidia; Infection; Management; Fungicides*

Introduction

Apple is most widely cultivated and grown species in the genus *Malus* worldwide. Apple is the one of the most important fruit of J&K. Directly or indirectly half of population of Jammu and Kashmir is involved in apple production and trade business in the state and provides means of employment generation [1]. Apples are affected by a number of diseases caused by fungi, bacteria, viruses, viroids and phytoplasmas [2]. In India it was first reported from Kashmir valley on the native cultivar Ambri in 1935. The large scale damage and spread of apple scab created an alarming situation and the problem managed to engage the attention of the Indian Council of Agricultural Research (ICAR), Directorate of Plant Protection, Quarantine and Storage (DPPQS) and the Govt. of India (GOI) and it was promptly declared as one of the five main problems of national importance in India [2]. Apple scab is the major disease affecting apples grown in temperate climates throughout the world [3]. This disease can have a significant economic impact as diseased fruit are not marketable. The disease negatively affects fruit size and quality (due to blemishes and poor ripening). Over time, repeated defoliation from the disease reduces tree vigor, growth and yield. This outrageous disease leads to premature leaf/fruit fall that results in 70% yield loss and even complete loss is also possible, if steps are not taken in the orchard to reduce infection [4].

Symptoms of apple scab

Symptoms which are visible and are severe occur on leaves as well as fruits. The early lesions of scab are defined with dark green velvety spots, seen on lower surfaces of leaves. Leaves and fruits are highly susceptible to apple scab when they are young and growing. Mature leaves and fruits gain resistance as they age. During the main growth period in early spring, there is more susceptible tissue available for infection and therefore, greater risk of disease than later in the season. Apple scab generally does not kill the trees but it can cause defoliation, which will weaken the tree and influence its survival during winter conditions. On leaves, young scab lesions are pale, irregular, and small. As they age, they become circular and olive-colored with a velvety texture. Lesions in a more advanced stage become black and slightly raised. Heavily scabbed leaves can desiccate, become deformed and fall (Figure 1a). Early infections can lead to abnormal growth (fruit deformation) and fruit drop. The lesions on the fruits are similar to those on the leaves, but as they age, they will produce cracks (Figure 1b). If the fruit is infected late in the summer or just before harvest, black, circular, very small (0.1 – 4 mm diameter) lesions called 'pin-point scab' will appear during storage [5].

Figure 1

Causal organism

Causal agent of apple scab *Venturia inaequalis* (Cke) belongs to subdivision Ascomycota, class Loculoascomycetes, order Pleosporales and family Venturiaceae and genus Venturia. Saprophytic (sexual state *Venturia inaequalis* (Cke) and parasitic (asexual state *Spilocaea pomi* Fr) are the two states of this fungus [6]. *Venturia inaequalis* overwinters mostly on dead leaves, in which small microscopic flask-formed black fruiting bodies, called pseudothecia, are developed. Ascospores start maturing in early spring and when temperature and moisture are suitable these spores are released forcibly in air. In the spring during the rainy season, fungal spores are released from the infected leaves that remain from the previous year and are carried by the wind to newly emerging leaves and fruits of healthy trees. Once primary infection occurs, secondary spores (conidia) are formed, allowing a tree to continually reinfect it or neighbouring trees as long as environmental conditions are favourable (Figure 2). The disease progresses rapidly and causes severe infections if plants remain continuously wet for at least a six-hour period with temperatures around 20 - 25°C [7].

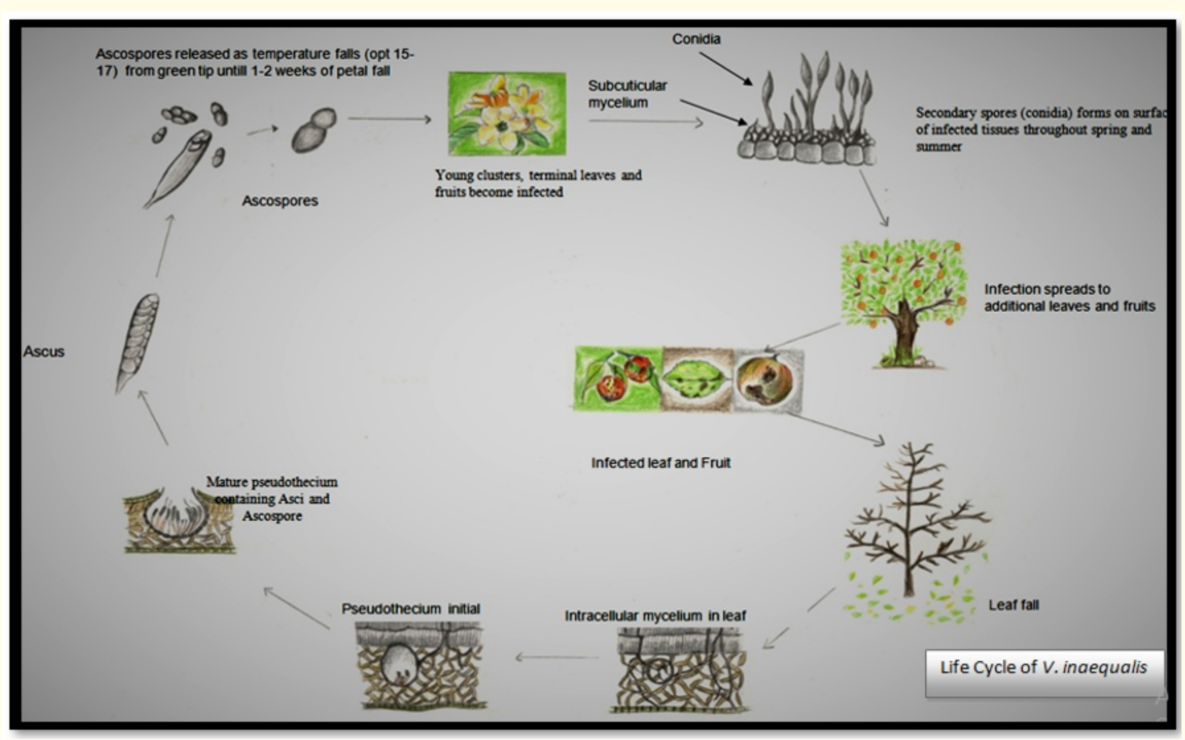

Figure 2

Disease management

Successful apple scab disease management requires an integrated approach that depends on the grower's goals and such approach combines resistant cultivars, cultural practices, biological agents and fungicides. Through cultural practices, disease can be minimized, or even prevented, by good horticultural practices like selecting sites that provide more than six hours of sunlight per day, spacing trees adequately following proper pruning practices to open the tree canopy, sanitation in orchards to prevent pseudothecial formation in overwintering apple leaves, applications of 5 percent urea to autumn foliage to increase leaf decomposition, thereby reducing the amount of fungus that will survive the winter [8]. The scab-resistant cultivars, including Freedom, Shireen, Firdous, Jonafree, Liberty, Prima and Redfree is essential if growers wish to produce organically grown fruit, as most organic fungicides will not provide adequate control against this disease in most years [9]. Biological control is often seen as a strategy that recently emerged from microbial biotechnology, but, in fact, research on biological control of apple scab has been conducted for per 50 yr. The nature of life cycle of *V. inaequalis* has lent itself to studies that aim to interrupt overwintering of the perfect stage or else to control infection of leaves during the spring and summer [8,10]. Regardless of a cultivar's susceptibility, fungicide applications are an essential component of effective scab management. For disease-resistant cultivars in particular, the most critical step of the process is controlling primary infection by ascospores in the spring [10]. These spores are the "offspring" of the previous year's infection and have the potential to infect even scab resistant cultivars if they contain the right combination of genes. Using fungicides on scab-resistant cultivars can help prevent infection by any newly virulent strain of the fungus, protecting the tree from primary scab and any successful secondary scab. Throughout the season different fungicides (10 - 15 Times) are used to control apple scab (Table 1). Generally apple growers apply curative and preventive fungicides altogether to prevent its development. In J&K, various sprays at important growth stages of apple as per recommended schedule are shown in table 2 [11]. Spray of any Protectant/systemic fungicide should continue after walnut size fruit if secondary infection is still anticipating.

S. No	Fungicide	Chemical composition	Molecular formula
1	Bitertanol	Bitertanol 1-(biphenyl-4-yloxy)-3,3-dimethyl-1-(1,2,4-triazol-1-yl)butan-2-ol	$C_{20}H_{23}O_2N_3$
2	Captan	Ethanethiol *or* ethyl mercaptan, Trichloromethyl)sulfanyl]-3a,4,7,7a-tetrahydro-1*H*-isoindole-1,3 (2*H*)-dione	$C_9H_8Cl_3NO_2S$
3	Captan 70% + Hexaconazole 5%	Ethanethiol + 2(2,4dichlorophenyl) -1-(1,2,4-triazol-1-yl) hexan-2-ol	$C_9H_8Cl_3NO_2S$ $C_{14}H_{17}Cl_2N_3O$
4	Carbendazim 12% + Mancozeb 63%	Carbendazim methyl N-(1H-benzimidazol-2-yl) carbamate + ethylenebisdithiocarbamate manganese-zinc	$C_9H_9N_3O_2$ $C_8H_{12}MnN_4S_8Zn$
5	Chlorothalonil	Tetrachloroisophthalonitrile	$C_8Cl_4N_2$
6	Difenaconazole	Difenoconazole	$C_{19}H_{17}Cl_2N_3O_3$
7	Dodine	Dodecylguanidine acetate or N-Dodecylguanidine acetate	$C_{15}H_{33}N_3O_2$
8	Flusilazole	Bis(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	$C_{16}H_{15}F_2N_3Si$
9	Hexaconazole	2(2,4dichlorophenyl) -1-(1,2,4-triazol-1-yl) hexan-2-ol	$C_{14}H_{17}Cl_2N_3O$
10	Kresoxim methyl	(alpha E)-alpha-(Methoxyimino)-2-[(2-methylphenoxy)methyl]benzeneacetic acid methyl ester	$C_{18}H_{19}NO_4$
11	Mancozeb	Ethylenebisdithiocarbamate manganese-zinc	$C_8H_{12}MnN_4S_8Zn$
12	Metiram55% + Pyraclostrobin 5%	Zinc ethylenebisthiocarbamate + Methyl (2-(((1-(4-chlorophenyl)-1H-pyrazol-3-yl)oxy)methyl)phenyl) (methoxy)carbamate	$C_4H_6N_2S_4Zn$ + $C_{19}H_{18}ClN_3O_4$
13	Myclobutanil	2-(4-chlorophenyl)-2-(1,2,4-triazol-1-ylmethyl)hexanenitrile	$C_{15}H_{17}ClN_4$
14	Penconazole 10 EC	1-(2,4-dichloro-beta-propylphenethyl)-1H-1,2,4-triazole	$C_{13}H_{15}Cl_2N_3$
15	Propineb	Propylenebis(dithiocarbamato)zinc	$C_5H_8N_2S_4Zn$
16	Trifloxystrobin 25% + Tebuconcazole 50%	(E,E)-methoxyimino-(2-(1-(3-trifluoromethylphenyl)ethylideneaminooxymethyl)phenyl)acetic acid methyl ester + N-[5-chloro-2-(4-methylpiperazin-1-yl)phenyl]cyclobutanecarboxamide	$C_{20}H_{19}F_3N_2O_4$ $C_{16}H_{22}ClN_3O$
17	Ziram	Zinc Dimethyldithiocarbamate	$C_6H_{12}N_2S_4Zn$
18	Zineb	Zinc ethylenebisthiocarbamate	$C_4H_6N_2S_4Zn$

Table 1: *Plant protection schedule for the management of insects and apple scab.*

Stage picture	Chemical spray
Green Tip 	Mancozeb 75WP@3 gm/L of water or Captan50WP @3 gm/L of water
Pink Bud 	Dodine 65wp@ 0.5 gm/L of water, Mancozeb 63% + Carbendazim12% @2.5 gm/L of water
Petal Fall 	Bitertanol10EC @ 0.5 ml/L of water or Kresoxim methyl 44.3SC @ 0.4 ml/L of water or Difenconazole 25EC @0.3 ml/L of water
Pea Shaped fruit 	Protectant fungicides like Hexaconazole5%+ Captan70% @ 0.5 gm/L of water
Walnut shaped fruit 	Mancozeb63%+ Carbendazim12% @2.5 gm/L of water or Myclobutanil10WP @0.5 gm/L of water

Table 2: *Spray schedule for management of Apple Scab disease in J&K.*

Conclusion

Apple scab causes huge losses to apple industry throughout the world, hence there is a need to develop an ideal system that prevents these losses and is eventually acceptable to consumers. In order to control such menace caused by scab, proper prediction and forecasting systems are need of the hour to prevent apple scab disease well in advance and also understanding the host pathogen interaction, which can provide new insights for effective management of this disease. Cisgenesis can be one of the approaches for introgression of resistance gene through biotechnological intervention under control of its own regulatory sequences from same species or related species which can also maintain the original cultivar characteristics.

Bibliography

1. Bhat TA and Lone TA. "Potential and Prospects of J&K Economy". Educreation Publishing (2017).
2. Abrol DP. "Pest Problems in Fruit Crops". Pollination Biology, Volume 1: Springer (2015): 59-90.
3. Sheikh MA., *et al*. "Phenotypic and molecular screening for diseases resistance of apple cultivars and selections against apple scab (Venturia inaequalis)". *International Journal of Chemical Studies* 5.4 (2017): 1107-1113.
4. Ogawa JM and English H. "Diseases of temperate zone tree fruit and nut crops". UCANR Publications (1991).
5. MacHardy WE. "Apple scab: biology, epidemiology, and management". APS press St. Paul (1996).
6. Bowen JK., *et al*. "Venturia inaequalis: the causal agent of apple scab". *Molecular Plant Pathology* 12.2 (2011): 105-122.
7. Holb I., *et al*. "Overwintering of conidia of Venturia inaequalis and the contribution to early epidemics of apple scab". *Plant Disease* 88.7 (2004): 751-757.

8. MacHardy WE., *et al*. "Parasitic and biological fitness of Venturia inaequalis: relationship to disease management strategies". *Plant Disease* 85.10 (2001): 1036-1051.

9. Ellis M., *et al*. "Effects of an apple scab-resistant cultivar on use patterns of inorganic and organic fungicides and economics of disease control". *Plant Disease* 82.4 (1998): 428-433.

10. Poleatewich AM. "Development of Biological Control Strategies for Integrated Management of Pre-and Postharvest Diseases of Apple in Pennsylvania" (2010).

11. Sajad Un Nabi., *et al*. "Apple Scab Disease-Cause, Symptoms and Management". Central Institute of Temperate Horticulture, Srinagar, Jammu and Kashmir (2018).

Volume 15 Issue 4 April 2019