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Review

Alternaria epidemic of apple in Kashmir

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During the months of July-August 2013, apple orchards of the valley were suddenly struck with *Alternaria* disease which was so far considered a disease of minor importance as compared to apple scab. The disease spread like wild fire leading to very high severity and often resulted in extensive defoliation and fruit fall in almost all the orchards through the valley, resulting into a widespread epidemic. The various factors which lead to this epidemic were a possible effect of climate change leading to untimely prolonged rains following high temperatures. The situation was worsened due to extensive presence of susceptible delicious cultivars, non adherence of practice of orchard sanitation, use of inappropriate or spurious fungicides and absence of disease forecasting system in the valley.

Key words: *Alternaria,* apple, kashmir, epidemic.

INTRODUCTION

The Valley of Kashmir is the leading producer of apple (*Malus x domestica* Borkh.) in India which contributes a major portion of about 65% of total apple production in India which ranks 7th with an annual production of 2163400 MT of apple fruit (FAO, 2012). Apple production has attained status of industry in the state of Jammu and Kashmir. Like other crops apple is also attacked by a number of diseases like apple scab, Alternaria leaf blotch, Marsonena, sooty blotch, fly speck and a number of post-harvest diseases. After the heavy outbreak of scab disease in 1970s decade major thrust were given on its management and Alternaria was considered a disease of less importance in comparison to apple scab. Like in all apple growing areas of the world, this disease is prevalent in almost all districts and all apple orchards of Kashmir (Sofi et al., 2013a; Shahzad, 2003). The occurrence of the disease (*Alternaria mali*) was reported by Shahzad et al. (2002) in Kashmir valley of Jammu and Kashmir state.

During the summer of 2013 starting in the month of July due to consistent Rainfall coupled with high temperature, the environment set a most favorable stage for the Alternaria and within no time Alternaria leaf blotch cached apple growers of Kashmir by a sudden surprise. The leaves rapidly started blotching leading to heavy leaf blight rendering less photosynthetic area for the plant which badly effected development of apple fruit by influencing it at its critical fruit developmental stage. Although exact official figures have not been estimated yet but it is estimated that in the districts of Baramula and Bandipore the disease spread like wild fire infecting more than 70% of delicious cultivars; lower belt of Bandipora and District Handwara was hit most. Similarly, Zainageer belt of of Baramulla was worst hit followed by Rafiabad

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Figure 1. Areas which reported breakout of Alternaria disease in apple in Kashmir during summer 2013.

(Annonymous, 2013a). Areas of Bandipore Viz., Sumbal, Hajin, Safapora and Bandipora reported heavy intensity of the disease (Annonymous, 2013b). In district Budgam the lower belts of Chadura and Magam like Bugam, Kralpora, Wanabal, Chewdara, Berwah etc, were worst hit as compared to upper belts of Khag and Khan Sahab (Figure 1). Certain reports based on growers estimates have reported losses of 40-60% and the disease has considerably reduced the market value of apple by reducing it from grade “A” to grade “C”. (Annonymous, 2013c).

The infection of the disease was almost uniform though the valley had moderate to severe intensity. A moderate intensity was however observed at remote upper reaches of the valley with comparatively much lower temperature but at other places the onslaught of disease was so intense that apple trees defoliated and at a number of places along with leaf fall there was a heavy fruit fall also, leading to a direct set back to the apple production. Blighting however reduced the production indirectly by reducing photosynthetic area and hence less accumulation of photosynthetic products into the developing fruits which negatively affected the total apple production of the entire valley. This article deals with the objectives of the description of the disease, main causes of its epidemic, and lessons learnt in some detail.

ALTERNARIA LEAF SPOT

Lesions of *Alternaria* disease in apple first appear on leaves in late spring or early summer as small, round, purplish or blackish spots, gradually enlarging in diameter, with a brownish purple border. Lesions may coalesce or undergo secondary enlargement and become irregular and much darker, acquiring a "frog-eye “appearance. When lesions occur on petioles, the leaves turn yellow and 50% or more defoliation may occur (Plates 1 and 2). Severe defoliation (Plates 3 and 4) leads to premature fruit drop (Plate 4).

The pathogen

Alternaria disease of apple is caused by a fungal pathogen *Alternaria mali* belonging to phylum ascomycota and family Pleosporaceae. A full description of the fungus is given by Roberts (1924). Hyphal segments are short, mostly unbranched and without constrictions at their septa and 3-8 µm wide. Conidia are produced in chains of 3-9 and average 28 x 12 µm (maximum 29 x 13 µm). They are similar to those of *A. gaisen* but smaller. They are typically 3-septate, with transverse and longitudinal septa, with constrictions at the septa, especially when old. Conidiophores are usually fasciculate on apple leaves and are of variable length and show a dark-coloured scar at the point of attachment of the conidium. The fungus was first identified in United States in 1924 but was not considered a serious pathogen (Roberts, 1924). However, a disease outbreak occurred in Japan in 1956 (Sawamura, 1972). The disease was also observed in north Carolina in 1987 where it caused widespread damage to apple crop (Filajdic and Sutton, 1991). The fungus appear over winter as mycelium on dead leaves

Plate 1. Symtoms of Alternaria leaf spot on apple and yellowing of leaf due to petiole infection (photo taken during Alternaria disease breakout in Kasmir during summer 2013).

Plate 2. Enlargind and coalescing lesions of Alternaria disease on apple during epidemic of 2013 in Kashmir valley.

Plate 3. Defoliation in apple leaving behind developing fruit due to Alternaria disease breakout in district Budgam of Kashmir valley during 2013.

Plate 4. Whole orchard defoliated along with fruit drop due to Alternaria disease in Kashmir valley during 2013.

on ground, in mechanical injuries, in twigs or in dormant buds. Primary infection usually occurs around one month after petal fall (Sawamura, 1990). All pathogenic species of fungus attacks the susceptible cultivars using chemical toxin (Logrieco, et al., 2003; Otani et al., 1995). Existence of considerable variation in cultural, morphological, pathogenic and molecular characters of *A. mali* isolates prevalent in Kashmir valley have already been reported (Sofi et al., 2013b) besides *A. mali* isolates from valley of Kashmir which exhibited considerable variation in their virulence. The wide variation of isolates indicated that the fungus has a high potential to adapt to resistant cultivars or fungicides (Sofi et al., 2013a). European red mite (Panonychus ulmi Koch.) significantly increases the incidence of Alternaria Leaf Blotch and premature leaf fall in Apple. A significant positive correlation was found between Alternaria Leaf blotches intensity and number of mites per leaf (Shahzad, 2007).

In Kashmir valley the disease outbreak occurred in late summer due to secondary infection of this polycyclic pathogen which might be due to already existing pathogen density available from previous cycles. Since the pathogen mostly survives in fallen leaves and non adherence to orchard sanitation practice in Valley, will always keep such pathogens available for such breakouts in case of favorable environments for the disease developments.

Alternaria leaf blotch is most likely to occur on 'delicious' strains of apple. The disease assumed alarming threat to the crop owing to premature defoliation in North Carolina and has potential of becoming threat especially in those apple producing regions where susceptible cultivars/strains of Delicious are grown which also included North Carolina (Filajdic and Sutton, 1991). By 1993, growers in nine counties in southern and central Virginia reported seeing this problem, some with as much as 50 to 60% (Yoder and Biggs, 1998). Reportedly, it can infect up to 85% of leaves on susceptible cultivars, compared with less than 1% on resistant cultivars (Yoon and Lee, 1987). Apple cultivars can be ranked in order of increasing resistance (Sawamura, 1990) as follows: Indo, Red Gold, Raritan, Delicious, Fuji, Golden Delicious, Ralls, Toko, Tsugaru, Mutsu, Jonagold, Jonathan. Yellow Newtown, American Summer Pearmain, McIntosh, Ben Davis and Stayman Winesap are other resistant cultivars, to which Shin et al*.* (1986) would add Gala, Honey Gold and Mollie's Delicious. Resistant cultivars are homozygous for the recessive gene *alt alt*. Certain *Malus* spp. are highly resistant, for example *M. asiatica*, *M. baccata* and *M. robusta*, but resistance in these species is controlled by a single dominant gene, epistatic to the dominant gene controlling susceptibility (Saito and Niizeki, 1988).

In Kashmir valley one of the most favorable situations for the Alternaria disease breakout was a uniform cultivation of susceptible cultivars of “delicious” verities. During the curse of the epidemic it was observed where ever resistant varieties like American Aprigoue, (Plate 5) Gala, Ambri Maharaji and other varieties which are traditionally local verities where seen defending the disease even if such trees were surrounded by heavily infected Delicious verities.

The favorable environment

Through the early part of the fruit production season the pathogen stays relatively inactive, causing only small lesions and often not being observed at all. The disease develops explosively following heavy summer rainfall events and high humidity. Trees that have mite infestations are predisposed to rapid disease development. Secondary spread of the disease occurs where spores (conidia) that develop on lesions are splashed by wind-blown rain. This dispersal is relatively rapid, and entire orchard blocks are quickly infected (Annonymous, 2013d). Primary infection takes place about one month after petal fall. The disease advances rapidly in the optimum temperature range of 77 to 86 F (25-30°C) and wet weather. At optimum temperatures, infection occurs with 5.5 h of wetting, and lesions can appear in the orchard two days after infection, causing a serious outbreak. The fungus produces a chemical toxin which increases the severity of the disease on susceptible cultivars (Yoder and Biggs, 1998).

In valley of Kashmir, the summer of 2013 reported excessive hot temperatures and in the month of July there were heavy and consistent rains which prolonged for long periods coupled consistently with high temperatures. Such conditions favored the disease and within no time due to continuing rain and favorable temperatures for a period of several weeks, the disease spread rapidly. It is unusual for the valley of Kashmir to have such a combination of high temperature and a sudden and prolonged rainfall during this period of year, however probably it might be due to the effects of climate change scenario leading to erratic rainfall behavior and rise in temperature which resulted in this minor disease causing major losses in apple in Kashmir.

Control measures

Chemical control of *A. mali* can be achieved through use of fungicides such as iprodione, mancozeb and captan (Osanai et al*.*, 1987; Asari and Takahashi, 1988). However, later it was reported by Filajdac and Sutton (1992) that fungicides like captan, mencozeb, and mixtures with benomyl are unable to control Alternaria disease in apple and iprodione gives best control of the disease. In South Korea and Japan best chemical control and suppression of *A. mali* was achived by Polyoxin, captafal, and iprodione (Lee and Lee, 1972; Filajdac and Sutton, 1992). Yoder and Biggs, 1998, reported that

Plate 5. A resistant cultivar “American” showing no disease symptoms surrounded by susceptible and disease Delicous trees during Alternaria disease outbreak in Kashmir.

currently registered fungicides do not provide satisfactory control under severe disease pressure and some strobilurin fungicides are registered for management of Alternaria blotch in the U.S. Moshe and Dimitri (2002) studied the activity of azoxystrobin, difenoconazole, Polyoxin B and trifloxystrobin on one or more stages of the life cycle of *A. alternata* and on decay development in fruits and suggested that these compounds potentially could provide control of moldy-core disease in apple. They further reported chopping leaves with a mower or removing them from the orchard will help reduce the inoculum level for the following season. Since defoliation from the disease is more severe if high mite populations are present, mites population should be maintained at or below the established IPM thresholds.

Under the conditions of Kashmir valley where orchard sanitation and other good horticultural practices to manage diseases are absent, the management is solely carried out by chemicals. During the course of this epidemic there were complaints from a good number of growers that chemicals they used failed to check the disease. In all the cases it was assumed that chemicals used are spurious (Annonymous, 2013a; Annonymous, 2013c) however, since it is a fact from above reports that most of the conventional fungicides used in apple management fail to control this disease (Lee and Lee, 1972; Filajdac and Sutton, 1992) and weather fungicides were spurious or they were not the right ones to control this disease or both is a matter demanding study. Under the changing environment there is a good possibility that this disease might be a problem to apple industry in future as well, therefore, it is imperative that researchers should work out right chemicals that could check this disease effectively under severe disease stress.

Disease forecasting

Modern agriculture being cost oriented requires greater vigilance than before to ensure stable yield and for reducing expenditure on chemicals for disease management. This is possible only if reliable disease forecasting systems are developed at least, for some of the destructive diseases of major crops (Bedi, 1986). A model of the relationship between the temperature threshold for infection and the influence of rainfall has been developed to predict the severity of Alternaria disease in apple (Kim et al., 1986). This predictive model developed in the Korea Republic has been evaluated in the USA (Filajdic and Sutton, 1992b). Disease simulation models helpful in disease forecasting, have been developed for diseases caused by *Alternaria spp.* like

EPIDEM and TOM-CAST (forecasting early blight of tomato and potato). Since apple is an important industry for the state of Jammu and Kashmir and the state being a major producer of apple in India coupled with the facts that majority of orchards have susceptible delicious plantations, non adherence of orchard sanitation and changing weather conditions there is and “always was” a need for disease and pest forecasting systems to avert or minimize the losses due to diseases or pests at least in this important crop of the Valley. Hence this is the time that researchers should also consider disease forecasting seriously for disease management in near future.

CONCLUSION

During the late summer months of year 2013 in Kashmir valley, due to possible effects of climate change, there was a consistent period of rainfall couple with high temperature which resulted an epidemic of *Alternaria* disease in apple which was otherwise considered a disease of less importance. Other major factors which became helpful tools for wide spread destruction due to this disease were availability of highly susceptible cultivars of “delicious” variety of apple, little or non-practicing of orchard sanitation and availability of less effective and spurious fungicides or both. Hence, the need for an effective forecasting system for this disease and other diseases of major and minor importance of this important horticultural crop is warranted coupled with introduction and use of effective chemicals, and effective integrated disease management strategy.

Conflict of interests

The authors did not declare any conflict of interest.

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