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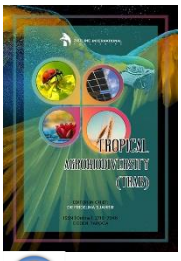

REVIEW ARTICLE

A REVIEW ON: CITRUS GREENING, ITS HISTORY, SYMPTOMS AND MANAGEMENT TACTICS

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ABSTRACT

Citrus greening disease or haunglongbing was critically reviewed with respect to history, symptoms and management tactics. It has been evident that citrus greening disease has emerged as a potential threat in the citrus growing areas of the world including Nepal also. It has been proven that greening disease is major cause of citrus decline; hence necessary steps should be taken for the control of citrus greening disease.

KEYWORDS

Citrus greening, Psyllid, Vector, Haunglongbing

1. INTRODUCTION

Citrus is a globally important fruit crop giving an average annual yield of 124246 thousand tons (FAOSTAT, 2016). It is cultivated in more than 140 countries in the world (Zhong and Nicolosi, 2020). Citrus greening or haunglongbing is a psyllid borne affliction which is caused by phloem restriction by gram negative bacterium commonly referred as greening organism (Garnier et al., 1984a, 1984b). Citrus greening is a highly incurable and destructive disease of citrus is causing a major threat to the citrus industry of the world (Singerman and Rogers, 2019). This disease is more common in Rutaceae family and all the citrus cultivars are affected by citrus greening. Among them, sweet orange and mandarin are most susceptible while lime, lemon and trifoliate oranges are less susceptible to citrus greening (Knapp et al., 2004). A bacterium like organism was found to be associated with citrus greening disease and inciting of this bacterium was established by Lafleche and Bove in 1970. It is caused by bacterium *Candidatus Liberibacter asiaticus* and vector by the Asian citrus psyllid, *Diaphorina citri Kuwayama* (Hemiptera; Liviidae) (Bove, 2006).

2. HISTORY

It has been believed that citrus greening disease originates in China as a yellow shot disease in 1980's (Graca 1991). The first citrus greening epiphytotic conditions were noted in the districts Chaoshan and Yuenchung, Province of Fukien in 1925 (Lin, 1956). The disease later become reported as "yellow branch disease" in South Africa in 1929 and later called "greening", which refers to the green color of fruits at second harvest (Su, 1998). Since the discovery of this disease, it has different names in different countries yet greening is most frequent name (Graca, 1991). It was discovered in Brazil in 2004 and in Florida since 2005. In addition to Asia, America and Africa, it has carried affliction since 1928 (Bove, 2006). In Philippines, this disease become serious problem in late 1950's when the mottle leaf was identified and described in 1921 and it was assumed to be related to zinc deficiency. Mottle leaf symptoms were very similar to haunglongbing symptoms in China and Taiwan and greening in Africa (Salibe and Cortez, 1968). In India, citrus was known to be seriously affected by serious disorder resulting in low development, twigs, dieback, slow death and even wilting unexpected attributes to dieback, a disease first observed in 18th century in Central India (Bove, 2006). In Nepal, for the first-time citrus declining was reported from Pokhara valley (Thrower, 1968). It was suspected that the decline was entered in Nepal through the planting material imported from Saharanpur, India (Knoor et al., 1970). PCR test showed that this disease was spread in pocket areas of Nepal like Kaski, Syanga, Tanahu, Lamjung and Dhading districts (Bove, 2006, Regmi and Yadav, 2007; Regmi et al., 2010).

3. SYMPTOMS

Symptoms can occur throughout the tree especially if the infections occur at or soon after propagation (McClean, 1970). Later the infection, there will be partial confinement of casual organism and symptoms. Infected trees or branches experience extreme leaf drop followed by out of season flushing and blooming with die back in severe cases (Martinez, 1972). Generally, leaf symptoms are two types: Primary symptoms are characterized by yellowing of normal sized leaves along with veins and sometimes blotchy mottle (Schneider, 1968). In secondary symptoms, leaves are small, upright and shows different chlorotic patterns resembles with zinc and iron deficiencies. Infected leaves show higher amount of potassium and lower amount of calcium, magnesium and zinc (Aubert, 1979; Bhagabati et al., 1980). The size of infected fruits is small and lopsided having bitter in taste, which may be due to higher acidity and lower content of sugar (Kapur et al., 1978; McClean et al., 1970). Premature fruit drop occurs in

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infected fruits and those remains on the tree do not develop color properly and remains shaded side, hence named as citrus greening. Root systems of infected trees are poorly developed with relatively few fibrous roots due to root starvation (Aubert, 1987; Salibe and Crotez 1968; McClean et al., 1970). Fresh root growth is suppressed and roots also start decaying from rootlets (Zhao, 1981).

4. Management

Different management tactics are needed to avoid the potential threat of citrus greening.

1. Legislative control: This type of control was introduced to avoid the transmission of pathogen. Following legislative control methods are needed to be established (Kawano, 1988).

    a. Regulatory plants: Plants of Rutaceae family like Poncirus, Trifoliate fortunella and other plants of citrus genus (excluding fruits and seeds).

    b. Regulatory pathogens and insects: Pathogens and insects like bacteria and citrus psylla should be regulated.

    c. Protection of mother stock: Mother plants should be checked regularly and kept in isolation to prevent from insects.

2. Thermotherapy: This is another type of approach which was found to be very effective in the control of citrus greening disease. In this method grafted wood was heated for several minutes at 48-50^{0}C (Graca, 1991; Baniqued 1998). Hot air treatment of grafted wood at 48-58^{0}C gives elimination of yellow shoot disease (Lin, 1969). Two-hour bud treatment at 47^{0}C in India reduces the incidence of citrus greening and the pathogen was eliminated by longer duration treatment (Cheema et.al., 1982; Narani and Bhagabati, 1980). Infected young seedlings budded with infected tissue can be treated within 3 to 4 weeks at 38-40^{0}C temperature killed the pathogen (Haung, 1978; Narani and Bhagabati, 1980).

3. Chemotherapy: Leaf symptoms of citrus greening was controlled by the use of tetracycline hydrochloride and penicillin carbendazide gave full control of citrus greening (Cheema et al., 1986). The best result was obtained through the injection of tetracycline hydrochloride (Schwarz and Van, 1970) and the best time for injection is spring season (Graca, 1991; Martinez et al., 1970).

4. Eradication and replacement: Trees less than 4 year age and non-bearing trees and the trees that shows the symptom of greening should be removed and replaced. Trees having fruits should be pruned. Infected trees up to 50-70% should be eradicated (Baniqued, 1998).

5. Breeding for resistance: Various hybrids of sweet oranges and Tahiti lime have been produced in South Africa and are being tested for possible resistance (deLange et al., 1985).

6. Control of vector: Many attempts have been made for the control of the vector through different approaches like cultural, chemical and biological methods. *Tamarixia radiate* parasite was found to be effective against citrus greening disease (Baniqued, 1998). The major parasite *Tetrastichus erytrea* in South Africa is species of parasitoid *Tetrastichus* that oviposit in the psylla nymph and appears to limit psylla population (Catling, 1969; Samways and Grech, 1986).

Fungi provides another means of biological control. *Tetrastichus erytrea* is attacked by *Cladosporium oxysporium* and *Capnodium citri* but both of them are sensitive to desiccation and population dependent (Samways and Grech, 1986; Aburt, 1987). *D. citri* is parasitized by *Beauveria* and *Cephalosporium lacanii*, later somewhat effective at high density (Xic, 1988; Gavarra and Mercado, 1988). Systemic insecticides like dimethoate and monocrotophis controlled *D. citri* (Graca, 1991). Spraying of Malathion on 10-12 days interval from March to May were not effective against citrus greening. Sometimes 44% EC Dimethoate, 50% EC Malathion and 40.64% FP carbofuran showed economically good condition of psylla (Chiou-Nan Chen, 1998).

5. Conclusion

Citrus greening or haunglongbing is a devastating disease of citrus causing huge affliction in the Citriculture of the World. The disease was first reported from China in 1980's and now it is spread in most of the areas of Asian, African and European Countries. The causative organism of citrus greening is a motile gram-negative bacterium Candidatus Liberibacter asiaticus and vectored by the Asian citrus psyllid, *Diaphorina citri Kuwayama*. Mottling of leaves, premature defoliation, thick irregular shaped fruits with green stylar end are the common symptoms leading to death of entire plant. The disease is creating worldwide hazard, a number of research activities are conducted for its control and management. Researchers suggest that the disease can be prevented by implementing strict quarantine, complete removal of infected parts, use of biological organism and chemical method for the control of bacterium and psyllid.

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