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Editorial Open Access

Citrus Greening Disease (Huanglongbing) a Perilous Threat to Global Citrus Industry

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Editorial

Citrus is the second largest fruit crop of the world with 130947.0 thousand tonnes of fruit harvested annually from an area of over 1441523 hectares [1]. Production per unit area is the highest (32.85 tonnes per hectare) in South Africa compared to world average of 9.73 tonnes per hectare [1]. Total world citrus export was recorded 15912.8 thousand tonnes mainly contributed by oranges (6877.1 thousand tonnes), tangerines (4755.9 thousand tonnes) and lemons limes (2892.3 thousand tonnes) and Grapefruit/pomelos (1104.0 thousand tonnes) during the year 2015 [1]. About 24996.4 thousand tonnes of citrus fruits processed during the year 2015 contributed to an export of 2681.2 thousand tons of concentrated orange juice including re-export of 585.4 thousand tons across the world [1].

Several barriers have been reported to impede citrus production and quality from different regions of the world; including diseases, insect pests, availability of quality irrigation water, seasonal calamities/climate change, and nature of available germ-plasm, farm management practices and quality of farm supplies particularly in developing countries [2-4]. Apart from all other problems, citrus diseases are probably the most important factor reducing production, quality and the tree life in many parts of the world. There is a long list of viral, fungal, bacterial and mycoplasma agents infecting citrus groves across the world. All of them harm citrus commercially to a varying intensity depending upon a diversity of factors in any particular area. However, some of them have become diseases of global importance and demand more collaborative human efforts and knowledge sharing to combat fastidious diseases jointly [5,6]. Among these, it is believed that CTV (*Citrus tristeza virus*) and Huanglongbing (HLB) or citrus greening disease (CGD), are most destructive and both are vectored and bud transmitted. Nevertheless, it is relatively easier to eliminate CTV or can coexist with different rootstock usage options [7]. Contrary to many of other diseases causing citrus decline, Huanglongbing or citrus greening disease has proven to be the most problematic one. Probably this is due to fastidious nature of its non-culturable gram negative bacteria from α-Proteobacteria subdivision [8]. The disease has shown long latency period within plant body and it may take several years before an infected tree expresses peculiar disease symptoms. Uneven distribution of pathogen in plant body and confusing disease symptoms make pathosystem more complicated [9].

HLB or citrus greening disease is more than a century old bacterial disease [10]. It was originated in China and most probably in Indo-Pak subcontinent, as maximum diversity of Asian type of vector (Asian Citrus Psylla) has been reported in this region [9,11]. The disease is assumed to be present in Indo-Pak subcontinent as early as 18th century and associated with citrus decline [3,12]. Indian subcontinent has been a historic trade route since beginning, so the disease and its vector might have proliferated throughout Asia, Africa and Americas [13]. In recent years, it has caused substantial economic losses to the citrus industry by shortening the tree life and reducing productivity with poor quality colorless fruit left on the trees [10]. It was identified in Florida in 2005 and since its discovery it has impacted citrus industry immensely as approximately 80% of Florida citrus is infected with HLB and production is decreased by 70% [14]. Detections of HLB in Japan, Indonesia and Malaysia are an alarm for Australian citrus industry which is thought to be HLB free till today [15]. Both the psyllid vector and disease is continuously invading new citrus areas.

Citrus is grown in most countries in Asia including the Arabian Peninsula, recent studies showed that Oman got lime infected severely with HLB in different parts of the country [16]. It is the major limiting factor for global citrus industries and is rapidly invading new areas. In areas where the disease is endemic, citrus trees may live for 5-8 years and never produce marketable fruit [17]. In the absence of any satisfactory cure ever reported, disease management becomes extremely difficult in different agro-climatic conditions. Even the latest knowledge of disease management through thermotherapy showing success in screen houses does not look adequate under field conditions [18].

HLB, was first reported from southern China in 1919 and was named as Huanglongbing, in Chinese meaning "yellow dragon disease" and is now known to occur in next to 40 different Asian, African, Oceanian, and American countries [11,12]. The agent is a phloem-restricted, non-cultured, Gram-negative bacterium causing "greening" with several other vernacular names in different regions. The HLB pathogens are 3 different species of the genus *Candidatus* Liberibacter, reported from different regions of the world and named after the continents where they were first detected i.e., *Candidatus* Liberibacter asiaticus, *Candidatus* Liberibacter americanus and *Candidatus* Liberibacter africanus [9,19].

During 1950s and 60s, the destruction of citrus by HLB in the Philippines, India, Indonesia and Thailand were so severe that the length of time between the onset of the disease and debilitation of the entire tree was about two years [20]. HLB destroyed 10 to 15% of tangerine trees each year and in the northern regions of Thailand many of the citrus areas went out of production [11,21]. Indeed, Thailand was known as one of the rare countries in the world to use marcotting (air layering) on a large scale to produce nursery trees which largely contributed in disease spreading. This emphasizes nursery sanitation for propagation of disease free stock plants for farmers on mass scale with strict implementation of appropriate remedial strategies.

The visual symptoms of the disease presented the first detailed account of the citrus decline associated with Asian Citrus Psyllid (*Diaphorina citri*); based on the severely affected citrus trees in citrus growing regions of Pakistan [13]. Citrus decline or dieback disease has been present in subcontinent as early as the 18th century and the situation became to very alarming by the 1940s [4]. By the 1960s it was recorded in all citrus growing areas of the India, with the quotation "The once flourishing citrus industry in India is, unfortunately, being slowly wiped out by dieback disease" [22]. After partition of Indo-Pak subcontinent, the first indication of greening symptoms in Pakistan was observed in the citrus collection of the Agricultural Experiment Station in Peshawar [23]. Recent studies conducted on the disease and its vector in the citrus growing areas of the Punjab showed that the HLB is the major factor for citrus devastation in the country [18]. Nonstop production of infected nursery plants and massive infestation of vector in groves with more than 20 alternate host plants of the disease and its vector made worst case scenario for county's citrus industry. Globally, the disease and its vector are being treated as a biological weapon and presence of both may impact on global citrus production and trade much earlier than the real time death of the ignored citrus industry.

Largely, HLB symptoms are much obvious wherever the disease incidence has been occurred [22]. The early and very characteristic symptom of the disease in infected trees is referred to as a blotchy mottle condition of the leaves that results in the development of yellow shoots. Trees are stunted, declining and bear a few, small-sized, and deformed (lop-sided) fruits, normally poorly colored (greening) with coloration starting at the peduncular end (colour inversion). HLB can be transmitted through citrus graft wood and natural insect vectors e. g. psyllids Trioza erytreae; *Diaphorina citri* and other sister species of psyllids [11]. The disease is caused by three species of the genus '*Candidatus* Liberibacter', i.e. 'Ca. *L. africanus'* (Laf), 'Ca. *L. asiaticus*' (Las), and 'Ca. *L. americanus*' (Lam) [24,25]. There are two different types of HLB reported, the African form heat-sensitive transmitted by T. erytreae, which develops at temperatures of 22-25°C, and the heat-tolerant Asian form, transmitted by *D. citri*, which can withstand temperatures more than 30°C. The situation looks more interesting elsewhere where daily maximum temperature are even beyond 40°C and casually above 50°C during summer months, but still both vector and disease are not eliminated [18]. It is also of worth mentioning that when pathogen is detectable in 5% of plants or only 5% plants show disease symptoms; the roots of 19% plants are reported to harbor the pathogen [26]. In the absence of any curative methods like potential use of bactericides, control is preventive and largely based on inoculum elimination by removal of infected trees and chemical control of vectors. However, when infection is on massive scale, plants might be kept productive for some years through improved nutrition and management practices with a hazard of further disease proliferation in the absence of efficient psyllid control strategy [17].

In summary, the conventional HLB control strategy through removal of infected field trees and pesticide based vector was counterproductive in Florida (USA) and Sao Palo (Brazil). Biological vector control is an emerging idea to combat massive disease spread. For example, the University of California, Riverside USA has been exploring the use of imported Tamarixia wasps predator [7]. It looks premature to comment this project is on very initial stages; however, current experience and several new ideas can be considered to make the effort more fruitful. Different natural predators including Tamarixia and Coccinellid beetles are reported to feed on psyllid nymphs, however, vector populations have never considerably reduced even under unfavourable seasonal conditions and natural mortality. So, in a very personal opinion depending upon only one natural predator may not be enough, rather, several other options would be needed to strengthen the biological control. A very important aspect of psyllid control strategy is to regulate the tree flushing pattern in a such that psyllids do not find too many opportunities to find young flushes for egging and hatching more and more generations. Once flushing pattern is regulated, chemical control followed by biological and other means may help knocking out the opportunistic psyllid insects. However, conservation of floral flushes and optimum production objectives along with protection of honeybees, other pollinators and environment must not be overlooked. Regulating flushing patterns in citrus would largely depend on pruning schemes, irrigation and rainfall timings, crop load and meteorological conditions varying from region to region. Field thermotherapy would probably not eliminate bacterium residing in roots; however, it may reduce or kill pathogen in above ground portion which might help reducing acquisition by psyllids. A successive pathogen buildup in aerial plant parts cannot be ruled out, but can be expected on a slower pace, hence reducing disease proliferation rates. Huanglongbing has changed breeding objectives in citrus industry during last decade. Several conventional and somatic hybrids, transgenic citrus germplasm including both rootstocks and scion candidates are under trials. Natural resistance/tolerance against disease and/or vector in citrus is also being studied. Initial results as are encouraging as observed in Tample Sweet orange, however, a lot more is yet to be done and another twenty years of patience and hard work are likely to produce the desired results [27-29].

The most encouraging aspect of this global issue is that scientists and researchers across the world are fully concentrated in finding out the sustainable solution of this ravaging citrus disease. The multidisciplinary global collaborated efforts are needed to halt rapidly declining citrus industry and to make all citrus growers/lovers greatly satisfied.

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