Crop Protection 96 (2017) 22–29

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

World status of phytoplasma diseases associated with eggplant

G.P. Rao*, Manish Kumar

Plant Virology Unit, Division of Plant Pathology, ICAR - Indian Agricultural Research Institute, New Delhi- 110 012, India

ARTICLE INFO

Article history:
Received 30 September 2016
Received in revised form
9 January 2017
Accepted 13 January 2017

Keywords:
Eggplant
Phytoplasmas
Distribution
Biology
Diagnosis
Epidemiology
Management

ABSTRACT

Brinjal or eggplant (*Solanum melongena* L.) is an important vegetable crop of sub-tropics and tropics. Among the major biotic constraints, phytoplasmas associated eggplant diseases are major limiting factors affecting its cultivation and yield. Almost all the eggplant varieties under cultivation are susceptible to the phytoplasma disease and caused severe economic losses. Different symptoms associated with disease are reported as little leaf, phyllody, flower virescence, giant calyx, big bud and witches' broom. Several diagnostic methods like Diene's staining, florescence staining and transmission electron microscopy are developed for the localization and detection of phytoplasma bodies in the sieve tubes of phloem tissues of the infected plants. But the PCR based assays along with sequence comparison and RFLP analysis of 16SrRNA gene has been well established and most reliable diagnostic criterions for the phytoplasma identification associated with eggplants. A wide range of genetic diversity was detected among eggplant associated phytoplasmas. Six phytoplasma ribosomal groups (16SrI, 16SrII, 16SrIII, 16SrVI, 16SrIX,16SrXII) were reported to be associated with eggplant from all around the world. The phytoplasma diseases in eggplants are reported to be transmitted by dodder, grafting and through leaf hopper vectors. Moreover, many weed species are reported as alternate hosts of the phytoplasma strains identified on eggplants. No absolute effective control measures of the disease could be developed so far, except resistance, management of insect vectors and altering the dates of sowing to avoid peaks of insect vector population. This review reports an up-to-date account of history, distribution, symptoms, diagnosis, genetic diversity, epidemiology and management of eggplant associated phytoplasma diseases.

Contents

1. Introduction

Vegetables are important agriculture commodity which provides food, nutrition and economic security. Vegetables with higher productivity, shorter maturity periods provide greater income. Eggplant (*Solanum melongena* L.) is an important vegetable crop of sub-tropics and tropics. The eggplant is widely cultivated in India, Bangladesh, Pakistan, China, Philippines, Egypt, France, Italy and United States. Brinjal fruit is reported to be a good source of minerals and vitamins, total water soluble sugars, free reducing

* Corresponding author.
E-mail address: gprao_gor@rediffmail.com (G.P. Rao).

http://dx.doi.org/10.1016/j.cropro.2017.01.005
0261-2194/

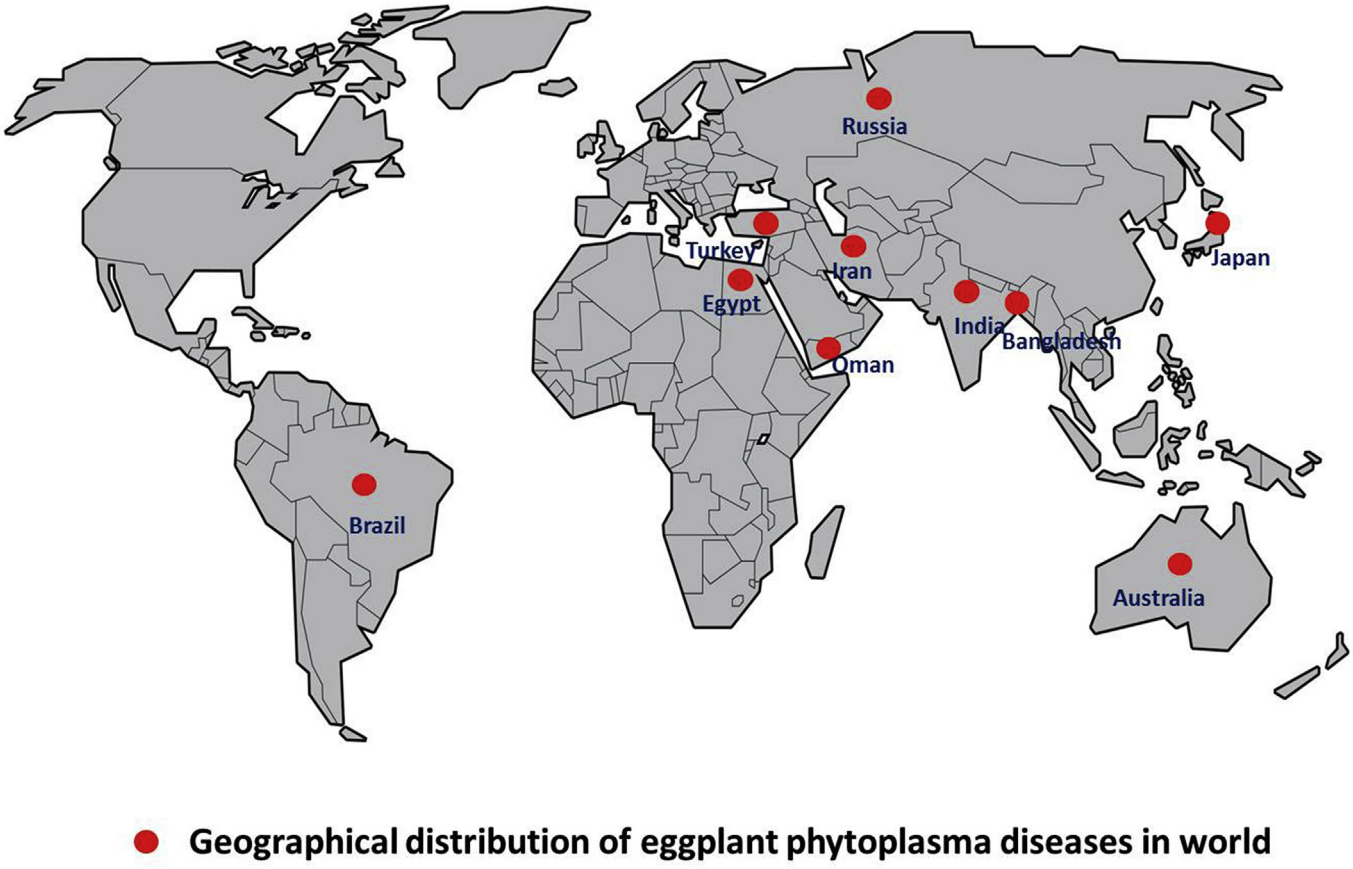

Fig. 1. Geographical distribution of eggplant phytoplasma diseases in world.

sugars and amide proteins (Gopalan et al., 2007). Eggplant fruits have also medicinal properties especially for diabetic patients and those suffering with liver diseases (Shukla and Naik, 1993).

India is considered as origin place of eggplant where the domestication of large fruit cultivars took place. In 1886 De Candolle in "Origin of cultivated plants", stated that the species *S. melongena* has been known in India from ancient times and regarded it to native of Asia (De Candolle, 1886). However, according to Vavilov (1928) its centre of origin was in the Indo-Burma region.

Eggplant is attacked by several biotic stresses of which phytoplasma associated diseases are one of the most important disease in eggplant capable of causing yield losses up to 40 per cent (Mitra, 1993; cited by Rao et al., 2010). The phytoplasmas associated eggplant diseases generally appears 1–2 months of age of the crop and become epidemic later. The infected plants are characterized by severe stunting, little leave, shortened internodes, proliferation of shoots, reduction in leaf size and with phyllody symptoms (Rao et al., 2010). In case of early infection, no fruiting takes place and the loss is more severe. In late infection, fruits become malformed and shriveled. The yield loss is hundred per cent in the severely infected diseased plants.

The phytoplasma diseases infecting eggplant crops are alarming in causing significant losses to the crop worldwide and are reported regularly from the newer locations. So far there is limited understanding and information available on phytoplasma diseases infecting eggplants such an economic losses, epidemiology, genetic diversity, mechanism of infection, host-pathogen-insect-interactions and resistance sources. Hence, the objective of this review is to discuss an up-to-date information available on eggplant phytoplasma diseases in the world which would help in explaining the abovementioned topics and may be used in the management for eggplant phytoplasma diseases.

2. Historical background and geographic distribution

The phytoplasma associated disease in eggplants has a history of more than 75 years. The first record of brinjal little leaf (BLL) disease was reported by Thomas and Krishnaswami (1939) in India and was suspected to be of viral nature. Sulochona and Solomon (1973) later again suspected little leaf disease to be caused by a virus, but the mycoplasmal etiology was further substantiated through tetracycline treatment (Varma et al., 1975; Verma and Dubey, 1978). The presence of mycoplasma-like organisms (MLOs) in the phloem cells of the little leaf infected eggplant in electron microscopic studies was confirmed by Shantha and Lakshamanan, (1984) and later by Mitra (1993).

Phytoplasma associated diseases in eggplant is mostly prevalent in Asian, American and African continents. So far eggplant associated phytoplasma diseases have been reported from India (Kumar et al., 2012; Kumar, 2015; Kumar and Katiyar, 2016), Bangladesh (Siddique et al., 2001; Kelly et al., 2009), Japan (Okuda et al., 1997), Egypt (Omar and Foissac, 2012), Iran (Tohidi et al., 2015), Oman (Al-Subhi et al., 2011), Turkey (Sertkaya et al., 2007; Usta et al., 2015), Russia (Ember et al., 2011), Australia (Davis et al., 1997; Martin, 2010) and Brazil (Boiteaux et al., 1994; Mello et al., 2011) (see Fig. 1).

3. Disease etiology, diagnosis and genetic diversity

Different types of symptoms are reported to be associated in