

INTRODUCTION

Introduction

Tomato (*Lycopersicon esculentum* Mill.) originated in Latin America, is one of the world's most widely grown vegetable crop with the ability to survive in diverse environmental conditions. It is one of the most important vegetable crops cultivated for its fleshy fruits and is considered as important commercial and dietary vegetable crop. It is also known as protective food because of its special nutritive value. Tomato is a rich source of minerals, vitamins, organic acids, essential amino acids and dietary fibres. It is a rich source of vitamin A and C and also contains minerals like iron, phosphorus. It contains lycopene and beta-carotene pigments. It is used in preserved products like ketch-up, sauce, chutney, soup, paste, puree etc. Being a short duration high yielding crop, it is important from economic point of view and hence area under its cultivation is increasing day by day. At present, tomato is cultivated worldwide in estimated area of 3.7 million hectares and a production of 100 million tons (FAOSTAT 2001). Tomato production has been reported from 144 countries (FAOSTAT Database, 2004), among which China is the major tomato-growing country in both hectares of harvested production (1,255,100 hectares) and weight of fruit produced (30,102,040 mt).

The estimated area and production of tomato in India (during 2007-2008) are 572000 hectares with a total production of 10261000 mt (productivity 17.9 mt/ha), respectively [National Horticultural Board (NHB) Database, 2008]. According to NHB 2008 database, during 2007-2008, the average productivity of tomato in our country was merely 18 mt/ha, while its productivity in USA was 66 mt/ha, in Brazil 59 mt/ha, in Italy 51 mt/ha and 65 mt/ha in Spain. Thus, ToLCD causes a great loss to tomato production in our country. It is mostly grown throughout India in almost all vegetable growing region and throughout the seasons except during the extreme summer in May-June. In some regions, this crop is cultivated as overlapping crops through out the year. In India, the major tomato producing belts resides within states of Uttar Pradesh, Punjab, Himachal Pradesh, Bihar, Jharkhand and Rajasthan, Maharashtra etc.

Tomato production is affected by various bacterial, fungal and viral diseases which resulted in considerable yield losses. Among those diseases, damping off, early blight, late blight, powdery mildew, bacterial leaf spot, bacterial canker, buck eye rot, fusarium wilt, tomato spotted wilt, tomato big bud, tomato bunch top, tomato mosaic and tomato leaf curl are major constraints of tomato production. Early study

suggested that eight different geminiviruses could infect tomato under natural condition (Brun^l*et al.*, 1996). However in the recent past there is considerable increase in number of tomato-infecting begomoviruses. Recent review suggested the occurrence of 55 tomato-infecting geminiviruses throughout the world (Fauquet *et al.*, 2008). Among all of these, *Pseudo curly top virus* is transmitted by leaf hoppers and remaining are by whiteflies. Among all the diseases of tomato, leaf curl disease of tomato (ToLCD) is the most devastating one as its incidence and severity is increasing worldwide. It is caused by viruses belonging to genus *Begomovirus* within the family *Geminiviridae*. In India also, ToLCD is the major constraint to tomato production and causes serious yield loss.

ToLCD have seriously hampered the cultivation and production of tomato in India (Vasudeva and Samraj, 1948; Banerjee and Kalloo, 1987; Saikia and Muniyappa, 1989; Rataul and Barar 1989; Varma and Malathi, 2003; Chakraborty, 2008). In India, the disease is widespread in tomato, found during the summer season in southern India (Saikia and Muniyappa, 1989) and during the autumn in northern India (Banerjee and Kalloo, 1987). The symptoms of the disease showed enormous variation depending on the plant varieties cultivated. Infected tomato plants (infected) exhibit severe reduction in leaf size, upward and downward curling of leaves, crinkling of interveinal areas, interveinal and marginal chlorosis and in some cases purple discolouration of the abaxial surface of the leaves. The disease induces severe stunting, development of small branches that causes bushy growth, reduced fruiting or partial to complete sterility if infection takes place at early stage of plant development. In some cases, bright yellow spots are also seen on leaves. Based on biological properties and differences in symptoms, tomato diseases caused by begomoviruses are called as 'leaf curl' or 'yellow leaf curl' disease of tomato. However, viruses causing these diseases are distinguished by their genomic analysis and are collectively known as tomato leaf curl viruses (ToLCVs).

ToLCV is shown to be transmitted by the vector whitefly (*Bemisia tabaci* Genn.) (Varma, 1990; Muniyappa *et al.*, 1991; Padidam *et al.*, 1995; Srivastava *et al.*, 1995), dodder and through grafting. Generally whitefly transmitted geminiviruses are not sap transmissible, as has also been reported for ToLCV with few exceptions. For the management of whitefly transmitted geminiviruses, the use of virus free vegetative propagules, avoidance of weeds and volunteers, overlapping crops, chemical control

of vector, clean cultivation, mulches and the use of resistant varieties are the recommended approaches (Varma, 1984). These approaches have been used in India and other parts of the world for management of ToLCD. The best results are obtained when large field of tomato are kept free from weeds particularly in the semi-tropic conditions (Varma, 1984). Cultural practices like intercropping, mulching and the use of chemical for vector control have also been found useful in managing the incidence of ToLCV. Attempts to generate transgenic resistant tomato plants also yielded successful results (Lucioli *et al.*, 2008). However, breeding varieties for resistance through conventional breeding methods have not yielded promising results as no good source of resistance have been identified in *Lycopersicon esculentum*. Even the resistant varieties of tomato to TYLCV were found to be susceptible by agroinoculation (Kheyr-Pour *et al.*, 1991). A much greater effort is required to examine tomato germplasm from diverse sources and related genes in host as well as pathogen. (Tripathi and Varma, 2003).

Indian ToLCV species include diversified group of begomoviruses inhabiting almost all the geographical climates and consist of monopartite as well as bipartite viruses, where monopartite species are occasionally associated with betasatellite molecule. All Indian ToLCV species consists of several isolates, for example *Tomato leaf curl Bangalore virus* (ToLCBV) consists of 7 isolates, *Tomato leaf curl Gujarat virus* (ToLCGV) consists of 4 isolates and *Tomato leaf curl New Delhi virus* (ToLCNDV) consists of 21 isolates (Fauquet *et al.*, 2008). *Tomato leaf curl Kerala virus* (ToLCKeV) has 3 reported isolates whereas in case of *Tomato leaf curl Rajasthan virus* (ToLCBV-[Raj]), *Tomato leaf curl Pune virus* (ToLCBV-[Pun]), *Tomato leaf curl Palampur virus* (ToLCPMV) only single isolates is reported till date. Hence, the available information on ToLCV indicates existence of disparate species/varieties of ToLCVs in India. This is revealed by the diversity of symptoms induced by different isolates/species and with limited sequence homology between the species sequenced so far. Further, B-biotype of whitefly while transmitting provides chances for intermixing two viruses, eventually of different hosts too. Indian ToLCVs are well known for occurring as mixed infection and ability to recombine (Muniyappa *et al.*, 2000; Chatchawankanphanich *et al.*, 2002; Kirthi *et al.*, 2002).

Considerable progress has been made in understanding of the genome organization of the tomato-infecting begomoviruses associated with ToLCD in India, but very

little or no information is available on the detailed genome organization of begomoviruses causing severe ToLCD in important vegetable growing areas of Jharkhand and Bihar. Therefore, the present investigation was undertaken with the following objectives:-

1. Distribution and genetic diversity of tomato-infecting begomoviruses in India.
2. Characterization of a new species of begomovirus associated with a novel betasatellite
3. Differential pathogenicity among three isolates of *Tomato leaf curl Gujarat virus*
4. Pathogenicity of a naturally occurring recombinant begomovirus species causing tomato leaf curl disease in India
5. Transreplication of betasatellites with three distinct tomato-infecting begomoviruses.