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GENES AND ASSOCIATED MOLECULAR MARKERS CONFERRING THE RESISTANCE FOR MAJOR FUNGAL DISEASES OF TOMATO (*Solanum Lycopersicum* L.)

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Introduction

Tomato is one of the important solanaceous vegetable crops, cultivated in almost countries of world. Tomato is the richest sources of minerals, vitamins and biomolecules. Cultivated tomato crop is highly susceptible to both biotic and abiotic stresses. Some wild landraces of the tomato have several genes and quantitative trait loci for various biotic and abiotic stresses. Molecular marker systems have been developed for the detection of the genes/*QTLs* at various chromosomal location of the tomato germplasm and released varieties. Using robust tools of molecular marker, the future breeding programmes of improvement in tomato for various pathogens and diseases may definitely get high rate of success. Among biotic stresses, tomato is severely affected by several fungal diseases which not only reduce the crop yield but also reduces the economic yields of the crop.

Major fungal disease and genes/molecular markers conferring the resistance

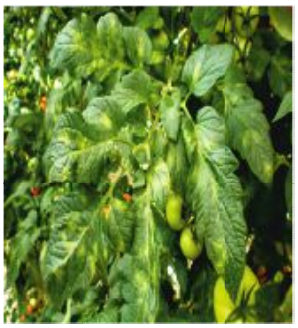
Fungal diseases are broad group of foliar pathogen. The fungal diseases of tomato affect the crop right from seedling stage to the last stage of the crop. Cultivated tomato is highly influenced by *Verticillium wilt*, *Fusarium wilt*, *Late blight*, *Early blight*, *Leaf mold*, *Powdery mildew*, *Gray leaf spot*, *Fusarium crown*, *Root rot*, and *Corky root rot*. The descriptions about the causal organism and symptoms of some devastating fungal diseases of tomato have been discussed below:-

(i) Early and Late blight of tomato: Early and late blight of tomato is a very dangerous disease damaging the leaf of tomato plants and later on affects the fruits. The early blight of tomato is caused by *Alternaria solani.* Late blight of tomato is caused by *Phytophthora infestans*. The blight disease appears on leaves of tomato as circular or irregular lesions, rather large, greenish-black and water-soaked. These lesions enlarge rapidly and turn dark brown to purplish-black. When the disease develops on green tomato fruit, it results in large, firm, brown, leathery-appearing lesions, often concentrated on the sides or upper fruit surfaces. Infected areas on stems appear brown to black and entire vines might be killed in a short period when moist conditions persist. Resistances against these have been recognized in the wild species of tomato. Two candidate genes *Ph2* and *Ph3* have been identified from the wild

Early blight of tomato

Late blight of tomato

source *Solanum pimpinellifolium.* These genes are confirmed and validated using CAPS markers.



Leaf mold of tomato

(ii) Leaf mold of tomato: Leaf moldis other fungal disease of the tomato which affects tomato leaves by molding them.Leaf mold of tomato is caused by the fungus *Fulviafulva*. It is also called 'brown leaf mold'. Pale-green or yellowish areas appear on the upper leaf surface, often becoming distinctly yellow later. The edges are indefinite and spots might grow together. Lower leaves are affected first, then younger leaves. The grown fungal spots are olive-green to grayish purple and velvety.Many resistance genes for these severe pathogens have been identified form the wild tomato species and some are indentified from the cultivated tomato varieties. The major genes *cf1, cf2, cf4, cf5, cf9, cf19, Hcr-9-4E* have been identified from different tomato species. The resistant gene *cf1* is found on the chromosome 1 of the *S. lycopersicum var. cerasiforme* whereas *cf2* on chromosome 6 of *S. pimpinellifolium.* (Hausbeck, 1997).

Fusarium wilt

(iii) Fusarium wilt: Fusarium wilts a very devastating fungal disease of tomato which is commonly spread around the world. Fusarium wilt is a soil borne disease caused by fungus *Fusarium oxysporum* f. Different host plants are attacked by special forms or races of the fungus viz., *F. oxysporum* sp. *Lycopersici* attacks only on tomato. Most Fusarium wilts have disease cycles and develop similarly to those of Fusarium wilt of tomato, which begins as a slight vein clearing on outer leaflets and drooping of leaf petioles. Subsequently, the older leaves wilt, turn yellow and necrotic, and the entire plant might be killed, often before the plant reaches maturity. Four resistance genes namely *I-1, I-2, I-3* and *I-7* have been identified against *Fusarium wilt* from different wild species of tomatoes. The resistance gene *I-1* and *I-2* have been identified on chromosome 11 of *S. pennellii* using SCAR marker. (Arif *et al*., 2011).

Verticillium wilt

(iv) Verticillium wilt: Verticillium wilt is one of the severe fungal diseases of the tomato. Verticillium wilts of tomato are caused either by *Verticilliumdahliae* or *V. albo-atrum*. The symptoms develop slowly and often appear only on the lower or outer part of the plant or on only a few of its branches. Older plants infected with the fungus are usually stunted and their vascular tissues show characteristic discoloration. There are two candidate genes namely *Ve1* and *Ve2* conferring the resistance for Verticillium Wiltfrom *S. lycopersicum*. These genes are linked with cleaved amplified polymorphism (CAPS) markers. The genome wide surgery for Verticillium wiltusing CAPS marker conferred the visibility of *Ve1* and *Ve2 I* genes on the chromosome 9 of the tomato genome.(Davis *et al*., 1996)

Powdery mildew

(v) Powdery mildew: The *causal organism* of powdery mildew in tomatoes has been primarily identified as *Pseudo oidium neolycopersici*, formerly *Oidium neolycopersici*. The genes for Powdery mildewresistance in tomato have been identified from wild species *S. habrochaites*, *S. chilense*, *S. peruvianum* and some genes from *S. lycopersicum*. Most of the genes conferring the resistance against powdery mildew have been found on the chromosome 6 and 12. The resistance gene *lv* is found on the chromosome 12 of *S. chilense, Ol-3* and *Ol-4* on chromosome 12, *Ol-1* on chromosome 6 of *S. habrochaites* but no any tightly linked markers has been identified for these genes.

Corky root rot

(vi) Corky root rot: Corky root rot is a soil borne disease caused by *Pyrenochaeta lycopersici.* This disease influences the tomato crop when temperature is below than normal. The exact resistance source of this fungal pathogen is not exactly known but *S. lycopersicum* has the resistance gene Py-1 for this disease.

(vii) Gray leaf spot: Another fungal disease of tomato is Gray leaf spot having less infection as compared to other fungal pathogens. This gene was mapped on chromosome 11of *S. lycopersicum* using InDel markers. The InDel marker is closely linked to these particular genes but no evidences are available for the marker in the marker assisted breeding.

Gray leaf spot

Conclusion and future prospects

Fungal diseases of cultivated tomato crop are one of the severe problems for the tomato grower across the world. The use and proper utilization of the molecular markers in tomato breeding for various biotic stresses would prove to be a marvelous gift. Most of the candidate genes, governing the resistance against fungal pathogen of the tomato have been identified and molecular marker system has also been developed. Use of molecular marker in the marker assisted backcross breeding would be helpful in the future breeding programmes for the development of resistance tomato varieties.

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