AGRICULTURE & ENVIRONMENT
E-NEWSLETTER
agrinenv.com

Article ID: AEN-2020-01-01-017

Exploring marker assisted selection for development of disease resistance in Tomato

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Major yield loss in tomato is mainly because of several biotic factors like pathogens. This is due to lack of tomato genotypes resistance to diseases which leads to affect both the financial cost and environmental impact on yield and quality in tomato. Host resistance is the most cost effective strategy for controlling disease incidence in tomato. Recent technological advancement like development of DNA based molecular markers closely linked to genes in tomato chromosomes that bestowed resistance to various kinds of biotic factors. Deployment of marker assisted selection (MAS) process, where genes of preferred traits were transferred into single tomato genotype which hasten the advancement of resistant tomato cultivars in its lowest population with gene pyramiding or stacking.

Introduction

Tomato (*Solanum lycopersicum* L., 2n=24) is one of the most important widely grown solanaceous vegetable crop of both tropical and sub-tropical climates. It is a typical day neutral plant with self-pollination mechanism in nature. Tomato is considered to be originated in Peru, Equador region (Rick, 1969) and is the second most important vegetable crop in the world after potato. In India tomato occupies an area of 0.79 mha with a production of 19.75 mt with an average productivity of 22.7 t/ha (Anonymous, 2019). In Karnataka, tomato has been grown in an area of 0.064 mha with a production of 2.08 mt with an average productivity of 31.58 t/ha (Anonymous, 2019). Nutritionally, tomato is a rich source of vitamin A and C furthermore, lycopene is a major component of red tomatoes has an antioxidant properties may help to protect against human diseases such as cancer and cardiovascular disease.

Cultivated tomatoes are susceptible to many diseases which are the serious threats in tomato cultivation and is a cause of low productivity. In south India, leaf curl virus, late blight & bacterial wilt are the major limiting factors in tomato production. No effective control measures were available to manage leaf curl virus. However chemical control gave poor results for bacterial diseases. Use of resistant varieties is the ideal way for the control of diseases in tomato. Although conventional plant breeding is used for the development of disease resistant varieties in tomato, it will take time for making of back crosses and selection of desired resistant progeny. However, in disease resistance breeding, breeders frequently counter various interactions among the resistance genes confusing selection through conventional breeding. These problems can be overcome by identifying specific molecular marker linked to disease resistant genes and utilizing these molecular markers in breeding programme through marker assisted selection (Foolad and Panthee, 2012).

Marker assisted selection: It refers to indirect selection process where a trait of interest is selected based on a marker linked to trait of interest.

Marker assisted selection (MAS) for disease resistance

Severe yield loss in tomato is mainly because of several biotic factors (Pathogens). Hence major aim of the plant breeders is to develop multiple disease resistant varieties in tomato. Utilization of host resistance is the most effective strategy for controlling reduction in yield and quality of tomato caused by various biotic factors. Advancement in breeding techniques leads to the development of DNA based markers which are tightly linked to gene of interest in tomato chromosomes that conferred resistance to various kinds of biotic factors. Through marker assisted selection genes of preferred traits transferred in to single tomato genotype which now speeds the advancement of resistance tomato cultivars in its lowest population with gene pyramiding or stacking.

Why MAS in vegetable breeding?

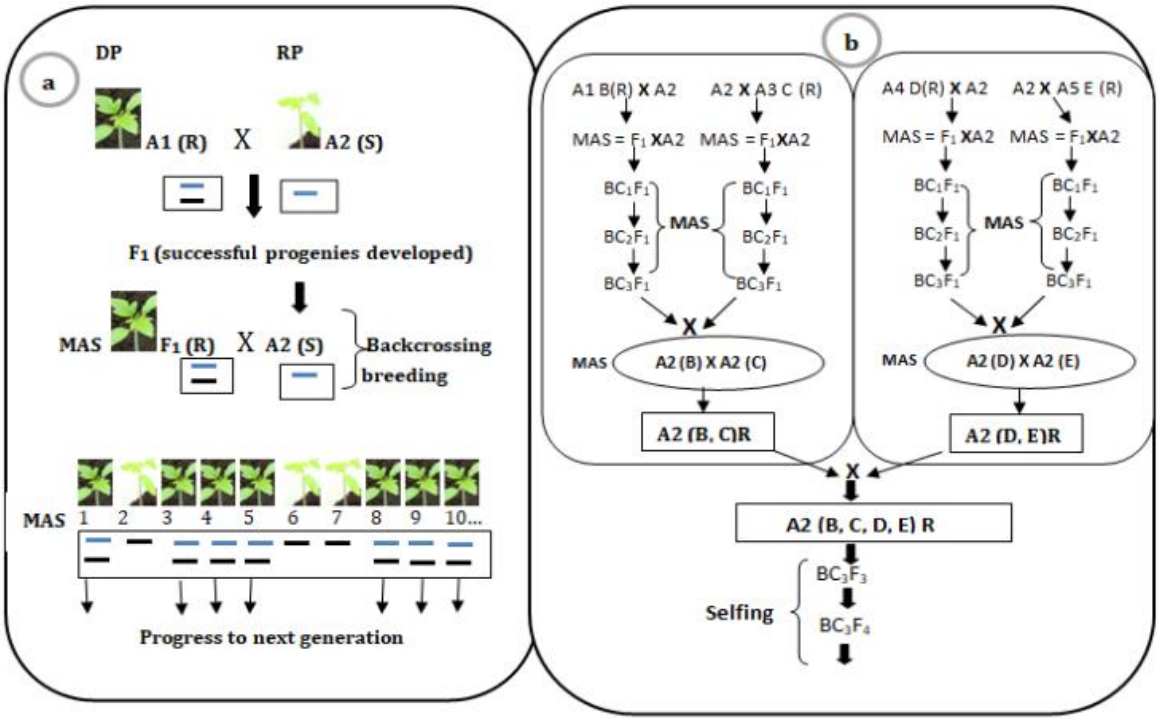
For disease resistance through conventional breeding individual plant must be evaluated for all traits tested. Therefore it is very difficult to assess plants from certain populations (e.g. F_2) or for traits with destructive bioassays. However MAS has great advantage because in this technique markers linked to the gene selection of tomato progenies with desired traits in a population are easily identified for several effective backcrossing schemes whereas progenies not carrying the conferred gene are discarded. In this technique, selection for disease resistance gene pyramiding plays an important role because in gene pyramiding resistant genes are transferred in to a single tomato line for each disease to prevent the breakdown of resistance against specific disease. Plant breeders now make use of this marker assisted selection to deliberate resistance by several genes with the help of markers which are closely linked against several diseases like Tomato leaf curl virus disease (TLCV), Tomato spotted wilt virus (TSWV), Bacterial spot, Bacterial speck diseases, late blight, Fusarium wilt and so on.

Table: Molecular markers in Tomato

Trait	Gene	Marker	Year
ToLCV resistance	*Ty2*	SCAR	Yang *et al*., 2016
	Ty3	SCAR	Dong *et al*., 2016
Late blight resistance	Ph-2	CAPS	Panthee *et al*., 2012
	Ph-3	SCAR	Panthee *et al*., 2012
Bacterial wilt resistance	Bwr-6	SCAR	Wang *et al*., 2013
	Bwr-12	SCAR	Wang *et al*., 2013
Fusarium wilt resistance	I-2	SCAR	Popoola *et al*., 2014
ToMV resistance	$Tm2^2$	CAPS	Sobir *et al*., 2000

Achievements

Variety/line	Resistance for
Arka Rakshak	Bacterial wilt, tomato leaf curl virus and early blight.
Arka Abhed	Tomato leaf curl disease, Bacterial wilt, Early blight and Late blight.
Raina (Raasi seeds)	Bacterial wilt and tomato leaf curl virus
Lakshmi (Nunhems)	Bacterial wilt and tomato leaf curl virus
US440 (US agri seeds)	Bacterial wilt, tomato leaf curl virus and early blight.



(a) General overview of marker assisted backcross in a tomato breeding program; DP (Donar parent); RP(Recipent parent); X (Crosses); R (Resistant genotype); S(Susceptible genotype); A1,B,C,D,E(Represents different tomato genotypes of tomato resistant to different diseases; A2 (high yielding genotype but susceptible to A1, B, C, D, E) (b) Basic flow diagram showing steps involved in gene pyramiding of multiple biotic resistance (R) genes into a single genotype using marker assisted backcross

Several biotic factors affect the productivity of tomato. Recent development in the molecular markers leads to increase in the use of disease resistant quantitative trait loci (QTL) in tomato breeding. Through molecular marker genotyping breeders can reduce the number of generations for evaluation to ensure that desired gene combinations introgressed in to the desired genotype of interest. In order to reduce the incidence of pathogencity, resistance breeding schemes like use of MAS by gene pyramiding should be thoroughly explored with deployment strategies of resistant genotypes and combination strategies of divere disease control methods. However, to pyramid multiple resistance genes into a single cultivar of tomato, tomato breeders should be able to monitor the effects of the genes stacked in the same cultivar, which is not redily possible through phenotypic measurements. Therefore through the use of marker assisted pyramiding in tomato breeding programs, breeding for qualitative disease resistance has been proven to be useful and should be effectively utilized on tomato germplasms that have high yielding ability but with significant rate of susceptibility to pathogens.

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