Acta Sci. Pol. Hortorum Cultus, 20(5) 2021, 107–118
https://czasopisma.up.lublin.pl/index.php/asphc ISSN 1644-0692 e-ISSN 2545-1405 https://doi.org/10.24326/asphc.2021.5.10
ORIGINAL PAPER
Accepted: 14.12.2020

DEVELOPMENT OF BIOTIC STRESS RESISTANT F1 INTERSPECIFIC HYBRID ROOTSTOCK DERIVED FROM *Solanum lycopersicum* AND *Solanum habrochaites*

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ABSTRACT

Tomato is major horticultural plant consumed worldwide. Biotic stress (nematodes, fungus and bacteria) has negative effect on tomato production due to causing reduced yield or plant death. Rootstocks confer resistance to soil-borne pathogen are considered the most effective and environment friendly approach for such a stress management. Thus, development of genetic resources having multiple resistance genes is essential for sustainable tomato breeding. *Solanum habrochaites* is one of the most studied wild tomato species due to its high genetic potential for biotic and abiotic stresses. In the present study, rootstock potential of an interspecific F1 hybrid derived from *S. habrochaites* was evaluated as using resistance genes (*Frl, I-2, I-3, Mi-3, Pto Ty-1, Ty-3* and *Sw-5*) specific molecular markers for 6 major tomato diseases and 31 fruit quality traits. The study reported that F1 hybrid had resistance alleles for 5 genes (*Frl, I-2, I-3, Pto* and *Sw-5*) confer resistance to fusarium crown rot disease, crown – root rot disease, race 2 and 3 of *Fusarium oxysporum* f. sp. *radicis lycopersici*, bacterial speck and tomato spotted wilt virus (TSWV), respectively. Despite high performance of F1 hybrid for biotic stress, the study pointed *S. habrochaites* specific graft incompatibility due to poor rate of grafting efficiency, small fruit formation and low yield. This is the first comprehensive study evaluated the horticultural performance of an interspecific hybrid in tomato.

Key words: marker assisted selection, interspecific F1 hybrid, fruit quality traits, resistant

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) from Solanaceae family is one of the most important plant due to high content of nutrient and antioxidant compounds such as lycopene and phenolics [Frusciante et al. 2007]. Although origin of tomato is Americas, it distributed worldwide due to higher adaptation capacity of wild tomato species to different climate [Fischer et al. 2011]. China, EU, India, US and Turkey are major tomato producer with total of 182 million tons production [FAO 2018]. Biotic stresses caused by pathogens such as nematodes, fungus and bacteria have negative effect on tomato production due to causing reduced yield or plant death. Although some soil fumigants such as methyl bromide were used to prevent soil-borne pathogen and nematode infections, these chemicals were banned due to negative effect to environ-

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ment and human health [Yücel et al. 2007, Louws et al. 2010]. Thus, cultivars and rootstocks confer resistance to soil-borne pathogen are considered the most effective and environment friendly approaches for biotic stress management as an alternative to soil sterilization [Ashita 1927, Yamakawa 1983, Kurata 1992]. Rootstocks are not only effective to biotic stress but also they were used to manage abiotic stresses such as salinity and drought [Louws et al. 2010, Keatinge et al. 2014]. In addition to advantages of rootstocks in biotic and abiotic stresses management, rootstocks affect plant grow and development due to transferring cytokinin which is produced by roots to plant tissues. Thus, root structure and density are important for accurate plant development. Effect of rootstocks on plant development was reported in various studies. These studies showed that suitable rootstocks could increase fruit number, fruit quality, water use efficiency, harvesting period and earliness [Leoni et al. 1991, Zhang et al. 1995, Oda et al. 1996, Jaksch and Kell 1997, Lee et al. 1997, Kell and Jaksch 1998, Cohen and Naor 2002, Lee and Oda 2003]. Also several studies performed in eggplant and tomato reported that rootstocks were efficient in biotic stress management [Keatinge et al. 2014]. Although there are few rootstocks such as 'Big Power', 'Beaufort' and 'Maxifort' widely used in tomato production, evolution of pathogens and changing environment might reduce efficiency of them in grating and tomato production. Thus, development of new tomato rootstocks is essential for sustainable tomato production by evaluation of new tomato genetic resources. Thus, wild tomato species is promising candidate for rootstock development due to their high tolerance to biotic and abiotic stresses. Despite the importance of wild tomato species, rootstock potential of wild tomato species was not evaluated. *Solanum habrochaites* is one of the most studied wild tomato species due to its high genetic potential for biotic and abiotic stresses. In a study 3 hybrids derived from cross *S. lycopersicum* and *S. habrochaites* were used as rootstock and reduction of infection of *Sclerotium rolfsii* and southern root-knot nematode was reported [Rivard et al. 2010]. Although this study provided primary information about rootstock potential of an interspecific hybrid, interspecific F1 hybrid needed to be evaluated comprehensively to reveal their rootstock performance. The present study evaluated rootstock potential of interspecific F1 hybrid derived from *Solanum lycopersicum* and *Solanum habrochaites* for 6 tomato diseases and 30 horticultural traits such as firmness, fruit weight and fruit color. Biotic stress was major problem in tomato production. Fusarium crown rot disease (*Fusarium oxysporum* f. sp. *radicis lycopersici*), fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*), root not disease (*Meloidogyne incognita*), bacterial speck (*Pseudomonas syringae* pv. tomato 'Okabe' Y. D. & W), virus diseases such as tomato spotted wild virus (TSWV) and tomato yellow leaf curl virus (TYLCV), are major diseases in tomato. Resistance genes (*Frl*, *I-2*, *I-3*, *Mi-3*, *Pto*, *Ty-1*, *Ty-3*, *Sw-5*) confer resistance to these diseases were identified in wild tomato species and mapped in tomato genome (*Frl*, *I-2*, *I-3*, *Mi-3*, *Pto*, *Ty-1*, *Ty-3*, *Sw-5*) confer resistance to these diseases were identified in wild tomato species and mapped in tomato genome [Hemming et al. 2004, Yang and Francis 2005, Garcia et al. 2007, Ji et al. 2007, Pérez de Castro et al. 2007, Staniaszek et al. 2007, Dianese et al. 2010, Mutlu et al. 2015]. Markers linked to these resistance genes were commonly used in marker assisted selection (MAS) in tomato breeding. In the present study markers linked to these genes were used for determination of resistance alleles of newly developed interspecific hybrid.

MATERIAL AND METHODS

Plant materials and F1 hybrid development. For hybrid development *S. lycopersicum* cv. 'AY1' was emasculated and fertilized with pollen of *S. habrochaites* (LA1777) in a greenhouse. After that F1 fruits were harvested and incubated overnight in fruit juice for extraction of seeds. Dried seeds were stored at +4°C. Hybrids were used as rootstock in all analysis. *Solanum lycopersicum* cv. 'Beaufort' and *S. lycopersicum* cv. 'Arazi' obtained from Titiz Agrogroup and Sygenta Companies, respectively were used as control groups. *Solanum lycopersicum* cv. 'Bigmek F1' obtained from Seraseed Company was used as scions.

Seedling development. Seeds of all plant materials were planted in pouches contained sterilized peats for germination. After that seedlings were transferred to fruit tray contained peat and perlite mixture (3:1).

Determination of seed germination efficiency. For determination of germination efficiency 60 seeds of F1 hybrid were planted in fruit tray contained peat and perlite mixture (2 : 1). Fruit trays were covered with vermiculite and incubated in germination room at 24°C. Germination of the seeds were observed until 28th day. Seedlings having horizontal cotyledon were considered as germinated.

Grafting of tomato seedlings. Grafting was preformed using tube grafting method [Oda et al. 1999, Yetisir et al. 2004]. Grafting was performed using rootstock after one month from germination which was planted 3 days earlier and scions had 3 leafs. Grafted seedlings were incubated in post grafting growth chamber under 95% humidity at 25°C.

Determination of grafting efficiency. Morphological traits of 20 seedlings such as percentage of successfully grafted seedlings, length (cm) and diameter (mm) of seedlings, length (mm) and diameter (cm) of scions and number of leafs were measured after 2 weeks.

Determination of horticultural performance. *Solanum lycopersicum* cv. 'Bigmek' was used as scions for determination of horticultural performance of the F1 hybrid. A total of 60 individuals for each genotype were grown in greenhouse located in Elmalı, Antalya, Turkey. *Solanum lycopersicum* cv. 'Arazi' and *S. lycopersicum* cv. 'Beaufort' were used as controls. All genotypes were evaluated for 6 quantitative (plant and fruit diameter, plant height, fruit wall yield and fruit weight) and 25 qualitative traits listed in Table 1.

Resistance gene screening using linked molecular markers. Resistance gens of plant material were screened using molecular markers tightly linked to resistance genes and loci. Resistance genes used in the study are *Frl* for fusarium crown rot disease caused by *Fusarium oxysporum* f. sp. *radicis lycopersici* [Mutlu et al. 2015]; *I-2* and *I-3* for race 2 and 3, respectively of *Fusarium oxysporum* f. sp. *lycopersici* (fusarium wilt) [Hemming et al. 2004, Staniaszek et al. 2007]; *Mi* for root knot nematodes [Garcia et al. 2007]; *Pto* for bacterial speck *Pseudomonas syringae* pv. tomato 'Okabe' Y. D. & W [Yang and Francis 2005]; *Ty-1* and *Ty-3* for tomato yellow leaf curl virus (TYLCV) [Pérez de Castro et al. 2007, Ji et al. 2007] and *Sw-5* for tomato spotted wild virus (TSWV) [Dianese et al. 2010] (Tab. 2). Genomic DNA was extracted using a CTAB method from fresh leaf tissue and disease resistance assays were performed accosting to respective publications [Doyle and Doyle 1987].

RESULTS AND DISCUSSIONS

Determination of seed germination efficiency. Germination efficiency of the interspecific F1 hybrid and control groups were evaluated. Germination of the seeds were observed until fourth weeks. Germination frequencies of all plants were highest in fourth weeks. Although the F1 hybrid (40%) had higher (36%) germination rate than *S. habrochaites* (LA1777), it had slightly lower germination than *S. lycopersicum* cv. 'AY1' (56%). Control groups (*S. lycopersicum* cv. 'Beaufort' and *S. lycopersicum* cv. 'Arazi') had the highest (90%) germination rate (Tab. 3).

Uniform and high rate of seed germination is essential for efficient agriculture. Despite this importance, wild species have low rate of germination due to complex dormancy systems for ensuring reproduction in nature [Samfield et al. 1991]. Thus, low rate of germination of *S. habrochaites* (LA1777) and F1 hybrid was expected. In the study performed by Ibrahim et al. [2001] germination frequency of 8 solanum species and hybrids (*S. sisymbriifolium*, *S. torvum*, *S. sanitwongsei*, *S. indicum*, *S. integrifolium*, *S. khasianum*, *S. surattense*, *S. insanum* and 3 *Solanum* amphidiploids of *S. melongena* 'Uttara' × *S. integrifolium, S. melongena*) were ranged from 14.22% to 86.44%.

Determination of grafting efficiency. The present study aimed to determine performance of interspecific hybrid as rootstock. To achieve this aim, length (cm) and diameter (mm) of rootstocks, length (mm) and diameter (cm) of scions and number of leafs were evaluated. Although F1 hybrid had higher grating rate than wild tomato, it had lower grafting rate than *S. lycopersicum* genotypes ('AY1', 'Beaufort' and 'Arazi'). F1 hybrid had shorter stem for rootstock and scion (2.8 cm and 3.9 cm for rootstock and scion, respectively) than control groups 'Beaufort' (4 cm and 4.9 cm for rootstock and scions, respectively) and 'Arazi' (5.7 cm and 5.1 cm for rootstock and scion, respectively). F1 hybrid had thicker diameter for rootstock (3.5 mm) and scion (2.1 mm) than 'Beaufort' (3.1 mm and 1.7 mm for rootstock and scion, respectively). Although F1 hybrid had slimmer diameter for rootstock (3.5 mm) than 'Arazi' (3.1 mm), it had thicker diameter for scion (1.7 mm). F1 hybrid had lowest number of leafs (Tab. 4).

Table 1. Quantitative and qualitative fruit quality traits and scores

Horticultural traits	Abbreviation	Parameters	Scores
Plant habitus	PH	weak, medium, strong	1–3–5
Seedling: anthocyanin coloration of hypocotyl	SA	present, absent	1–3
Inflorescence: type	IT	mainly uniparous, equally uniparous and multiparous, mainly multiparous	1–3–5
Plant growth habit	PG	determinate, indeterminate	1–3
Plant stem thickness	PS	average of 5 fruits	
Stem hairs	SH	weak, medium, strong	1–3–5
Flower sepal color	FS	yellow, white	1–3
Fruit green shoulder (before maturity)	FG	absent, present	1–3
Leaf length	LL	short, medium, long	1–3–5
Leaf width	LW	narrow, medium, broad	1–3–5
Leaf colour	LC	light, medium, dark green	1–3–5
Leaf type of blade	LT	pinnate, bipinnate	1–3
Anthocyanin coloration of leaf	AC	present, absent	1–3
Fruit color at maturity	FC	yellow, pink, red	1–3–5
Fruit weight	FW	average of 10 fruits	–
Predominant fruit shape (after the fruit turns color)	PF	flattened, oblate, circular, oblong, elliptic, or obovate	1–3–5–7–9–11
Fruit width	FW	average of 5 fruits	–
Fruit length	FL	average of 5 fruits	–
Number of seed at fruit	NS	little, medium, very	1–3–5
Green shoulder (at maturity)	GS	present, absent	1–3
Fruit shape at blossom end	FSE	indented, indented to flat, flat to pointed, pointed	1–3–5–7
Size of blossom end	SBE	small, medium, large	1–3–5
Fruit firmness	FF	very soft, medium, very firm	1–3–5
Transvers section	TS	round, angular, irregular	1–3–5
Colors of pericarp	CP	cream, pink, red,	1–3–5
Fruit thickness of pericarp	FTP	average 5 fruits	–
Size of fruit locules	SFL	small, medium, big	1–3–5
Leaf attitude	LA	erect, horizontal, drooping	1–3–5
Length of stem at first inflorescence	LSF	short, medium, long	1–3–5
Status of calix	SC	horizontal, medium, vertical	1–3–5

Table 2. Disease resistance gene, primer sequence and reference source of primer

Resistance gene	Primer sequence (forward and reverse)	Reference source of primer
I2	F: ATTTGAAAGCGTGGTATTGC R: CTTAAACTCACCATTAAATC	Staniaszek et al. 2007
I3	F: GGATTTTGGTGCTGTATTTGAAG R: TAGCCTGATGTTCCTCTCATTGTTC	Hemming et al. 2004
Ty-1	F:5-AACCATTATCCGGTTCACTC R:5-TTTCCATTCCTTGTTTCTCTG	Pérez de Castro et al. 2007
Ty-3	F:GGTAGTGGAAATGATGCTGCTC R:GCTCTGCCTATTGTCCCATATATAACC	Ji et al. 2007
Frl	F:CATCTGTTTTTAGTCTATTC R:TTGGCCATTGAATGAAGAAC	Mutlu et al. 2015
Sw-5	F:AATTAGGTTCTTGAAGCCCATCT R:TTCCGCATCAGCCAATAGTGT	Dianese et al. 2010
Mi3	F:TGGAAAAATGTTGAATTTCTTTTG R:GCATACTATATGGCTTGTTTACCC	Garcia et al. 2007
Pto	F: ATCTACCCACAATGA GCATGAGCTG R: GTGCATACTCCAGT TTCCAC	Yang and Francis 2005

F – forward, R – reverse

Table 3. Germination of genotypes

Genotype	Germination efficiency (%)			
	1st week	2nd week	3rd week	4th week
S. habrochaites (LA1777)	16	26	32	36
S. lycopersicum cv. 'AY1'	48	50	52	56
Interspecific hybrid F1 (CR)	10	10	30	40
S. lycopersicum cv. 'Beaufort'	70	80	80	90
S. lycopersicum cv. 'Arazi'	80	80	80	90

Table 4. Grafting efficiency of genotypes

Rootstocks*	Grafting efficiency (%)	Length of rootstock (cm)	Diameter of rootstock (mm)	Length of scion (cm)	Diameter of scion (mm)	Number of leafs
S. habrochaites (LA1777)	58.3	2.8	2.4	4.5	2.1	2.6
S. lycopersicum cv. 'AY1'	100	4.8	4.2	5	2.2	2.3
Interspecific hybrid F1 (CR)	66.6	2.8	3.5	3.9	2.1	2
S. lycopersicum cv. 'Beaufort'	100	4	3.1	4.9	1.7	2.6
S. lycopersicum cv. 'Arazi'	100	5.7	3.9	5.1	1.8	2.3

**S. lycopersicum* cv. 'Bigmek F1' used as scions

Grafting efficiency of F1 hybrid developed were evaluated. F1 hybrid had similar grafting rate to *S. habrochaites* (LA1777). Also F1 hybrid was similar to *S. habrochaites* (LA1777) in terms of rootstock and scion length. Overall F1 hybrid generated shorter and thicker scion than control groups. Although positive effect of scion thickness on yield were reported in tree called *Sclerocarya birrea* (marula), there was no such a report performed in vegetables [Mng'omba et al. 2012]. The reason of different effect of F1 hybrid on scion might be due to different root structure and mineral uptake. The relation between root and scion structure needs for further investigation. Low rate of grafting pointed out a species specific graft incompatibility as described between tomato and pepper [Kawaguchi et al. 2008].

Determination of horticultural performance. Horticultural performance of the interspecific F1 hybrid was evaluated using 6 quantitative and 25 qualitative traits. Six quantitative traits (plant and fruit diameter, plant height, fruit wall yield and fruit weight) were evaluated. Traits were scored according to the guidelines for the conduct of tests for distinctness, uniformity and stability of tomato (UPOV 2001).

As results, F1 hybrid (15.65 ±0.55, 64.2 ±0.3 and 56.55 ±1.95, respectively) had slightly higher mean value of plant and fruit diameter and fruit height than *S. habrochaites* (LA1777) (12.35 ±0.05, 60.5 ±1 and 51.75 ±2.15, respectively). For fruit wall and yield of F1 hybrid (7.1 ±0.1 and 41.06 ±4.14, respectively) had lower mean than *S. habrochaites* (8.25 ±0.25 and 62.08 ±13.9, respectively). F1 hybrid had horticultural performance similar to control groups for plant and fruit diameter and plant height. Although F1 hybrid (7.1 ±0.1 mm) had thicker wall than *S. lycopersicum* cv. 'Arazi' (6.75 ±0.05), had thinner wall than *S. lycopersicum* cv. 'Beaufort' (8.1 ±0.1). Unfortunately, F1 hybrid had lowest fruit weight and yield (Tab. 5).

Also 25 qualitative traits were evaluated for determination of horticultural performance of F1 hybrid as rootstock. As results, there was no variation for 14 qualitative traits: SA, PG, SH, FS, FG, LL, LW, LT, AC, FC, GS, FSE, TS, CP (Tab. 6). F1 hybrid produced unique fruit structure which is not similar neither *S. habrochaites* nor *S. lycopersicum* for 2 traits (PF and NS). F1 hybrid produced higher number of seeds with flatter fruits. Also F1 hybrid produced fruits had simple flower type (IT) similar to *S. lycopersicum* genotpes. For LC and LSF F1 hybrid produced higher cluster length (LSF) and darker leafs (LC) similar to control groups but different than *S. lycopersicum* cv. 'AY1' and *S. habrochaites*. For other 6 traits (PH, SBE, PF, SFL, LA, SC) there is a variation among control groups and F1 hybrid was similar to at least one control genotipe (*S. lycopersicum* cv. 'Beaufort' or *S. lycopersicum* cv. 'Arazi'). Most importantly F1 hybrid produced firmer tomato then control groups.

Effect of F1 hybrid developed in the present study were evaluated for 6 quantitative traits. For all traits except for yield F1 hybrid produced fruits similar to control groups rather than *S. habrochaites* (LA1777). For these traits F1 hybrid had no significant effect on fruit shape. But F1 hybrid produced lowest yield interestingly. The reason of that might be graft incompatibility derived from *S. habrochaites*. Yield of the 'Beaufort' (5.92 ±0.26 kg plant^{-1}) was similar to previous study (6.77 kg plant^{-1}) [Turhan et al. 2011]. Smaller fruit weight of interspesific hybrids was also reported in a study perfomed in interspecific hybrid rootstocks by Djidonou et al. (2016). Also qualitative traits were evaluated to better access horticultural performance of F1 hybrid. Although these was no variation in more than half of the traits (14 traits), a total of 11 traits were used to determine the effect of F1 hybrid on fruit quality. Most dramatic effect of F1 hybrid was observed in seed number and fruit firmness. F1 hybrid produced small but firmer fruits had high number of seeds. Thus, despite low yield, F1 hybrid might be used as rootstock to increase firmness in tomato production. Six quality traits (PH, SBE, PF, SFL, LA, SC) varied in control groups. Thus this study showed that these traits were highly effected by even genotypes of S. *lycopersicum.*

Resistance gene screening using molecular markers. Performance of F1 hybrid for biotic stresses were evaluated using 8 allele specific molecular markers linked to genes resistance genes (*Frl*, *I-2*, *I-3*, *Mi-3*, *Pto*, *Ty-1*, *Ty-3* and *Sw-5*) confer resistance to 6 diseases [Hemming et al. 2004, Yang and Francis 2005, Garcia et al. 2007, Ji et al. 2007, Pérez de Castro et al. 2007, Staniaszek et al. 2007, Dianese et al. 2010, Mutlu et al. 2015]. As results, F1 hybrid had resistance alleles for 5 genes (*Frl*, *I-2*, *I-3*, *Pto* and *Sw-5*) confer resistance to fusarium crown rot disease, fusarium

Table 5. Quantitative traits of *S. lycopersicum* cv. 'Bigmek F1' used as scions

Rootstock	Plant diameter (cm) ±SD	Fruit diameter (cm) ±SD	Fruit height (cm) ±SD	Fruit wall (mm) ±SD	Fruit weight, average (g)	Yield (kg plant^{-1}) ±SD
S. habrochaites (LA1777)	12.35 ±0.05	60.5 ±1	51.75 ±2.15	8.25 ±0.25	85	3.10 ±0.70
S. lycopersicum cv. 'AY1'	14.05 ±1.05	60.15 ±0.15	51.2 ±1.3	7.5 ±0.1	138	6.10 ±0.45
Interspecific hybrid F1 (CR)	15.65 ±0.55	64.2 ±0.3	56.55 ±1.95	7.1 ±0.1	55	2.05 ±0.20
S. lycopersicum cv. 'Beaufort'	14.6 ±1.4	66 ±5.2	55.95 ±2.95	8.1 ±0.1	131	5.92 ±0.26
S. lycopersicum cv. 'Arazi'	15.15 ±0.85	77.25 ±7.35	58.75 ±5.15	6.75 ±0.05	182	7.14 ±0.37

Table 6. Qualitative fruit quality traits

Traits	*S. habrochaites* (LA1777)	*S. lycopersicum* cv. 'AY1'	Interspesific hybrid F1 (CR)	*S. lycopersicum* cv. 'Beaufort'	*S. lycopersicum* cv. 'Arazi'
PH	1	5	3	5	3
SA*	3	3	3	3	3
IT	5	1	1	1	1
PG*	3	3	3	3	3
SH*	3	3	3	3	3
FS*	1	1	1	1	1
FG*	3	3	3	3	3
LL*	3	3	3	3	3
LW*	3	3	3	3	3
LC	1	1	5	5	5
LT*	1	1	1	1	1
AC*	3	3	3	3	3
FC*	5	5	5	5	5
PF	5	5	3	5	5
NS	3	3	5	3	3
GS*	3	3	3	3	3
FSE*	5	5	5	5	5
SBE	1	3	3	1	3
FF	3	3	5	3	1
TS*	3	3	3	3	3
CP*	5	5	5	5	5
SFL	3	3	3	3	5
LA	1	1	1	3	1
LSF	1	3	5	5	5
SC	1	5	3	5	3

* Traits did not have variation

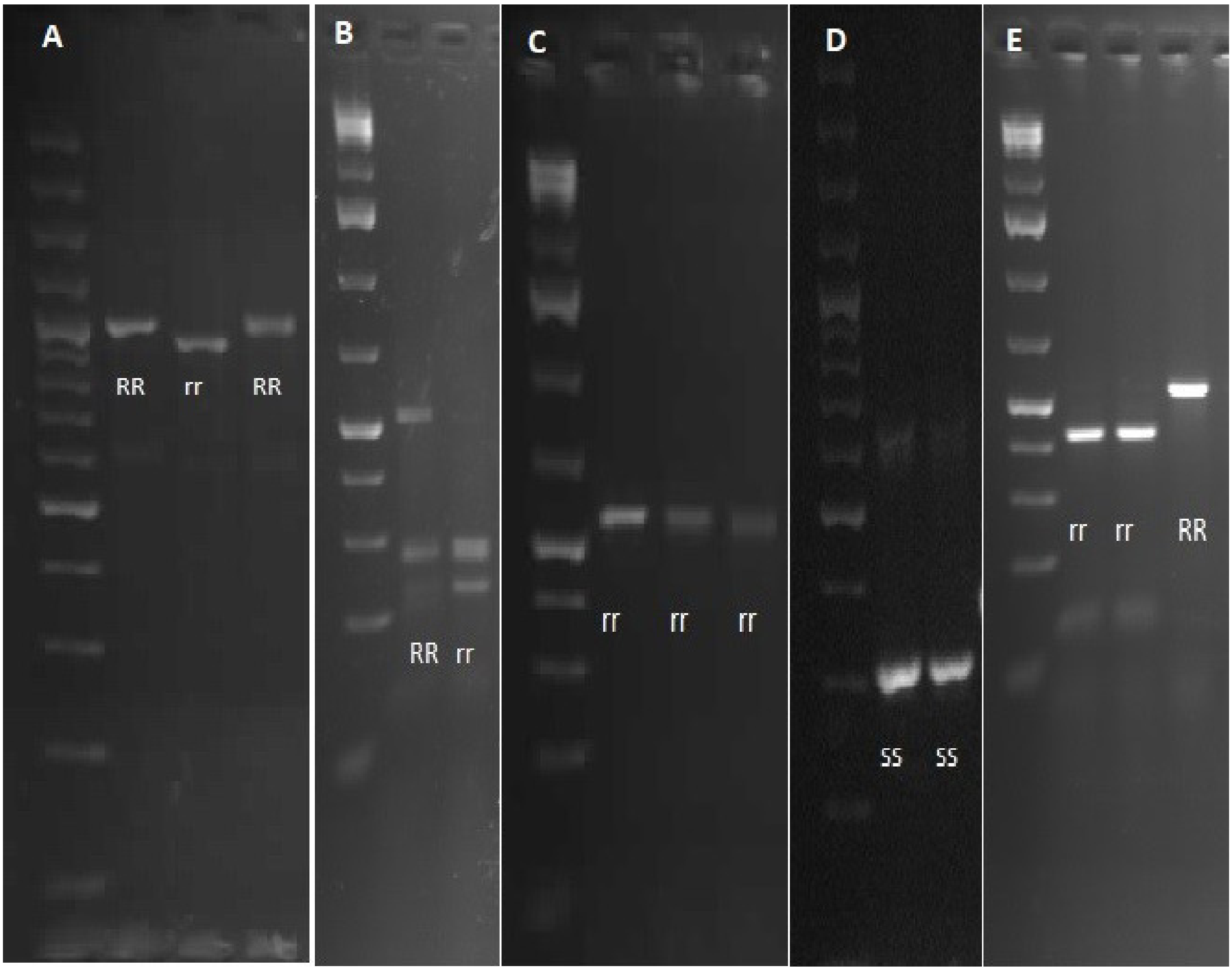

Fig. 1. PCR amplification of allele specific primers for: **a.** *Frl*, **b.** *I-2*, **c.** *Ty-1*, **d.** *Ty-3* and **e.** *Pto*, disease resistance genes

RR – homozygous resistant, Rr – heterozygous resistant, rr – susceptible

Table 7. Screening of genotypes using molecular markers linked to resistance genes confer resistance to 5 diseases (resistance gene / marker)

Genotype	*FRL* / Scar Frl	*I-2* / TAO902	*I-3* / P7-43	*Mi-3* / Mi3	*Pto* / pto	*Ty-1* / JB1	*Ty-3* / P6-25	*Sw-5* / Sw5-2
S. habrochaites (LA1777)	R	–	R	S	R	S	S	R
S. lycopersicum cv. 'AY1'	S	S	H	S	S	S	S	S
Interspesific hybrid F1 (CR)	R	R	R	S	R	S	S	R
S. lycopersicum cv. 'Beaufort'	R	R	R	R	R	S	S	S
S. lycopersicum cv. 'Arazi'	R	S	R	R	R	S	S	S

H – heterozygous alleles, R – resistance, S – susceptible wilt, bacterial speck and tomato spotted wild virus (TSWV) respectively (Fig 1). Although just *S. lycopersicum* cv. 'Arazi' had susceptible allele for *I-2*, both control groups had resistance alleles for *Frl*, *I-3* and *Pto* similar to F1 hybrid. Molecular analysis demonstrated that F1 hybrid had resistance allele for *Sw-5* was promising rootstock due to absence of this gene in control groups. Despite high performance of F1 hybrid for biotic stresses, it did not have resistance allele for root knot nematode while control groups had resistance allele (Tab. 7).

PCR primers used in the molecular analysis produced expected results with previous studies due to standard implementations of this markers in tomato breeding programs [Yang and Francis 2005, Hemming et al. 2004, Garcia et al. 2007, Ji et al. 2007, Pérez de Castro et al. 2007, Staniaszek et al. 2007, Dianese et al. 2010, Mutlu et al. 2015]. None of the genotypes including control groups had resistance alleles for *Ty-1* and *Ty-3* confer resistance to tomato yellow leaf curl virus (TYLCV).

Naturel resistance genes is the most effective and environmental friendly control methods for plant diseases. F1 hybrid had resistance alleles for 5 genes. All resistance alleles of F1 hybrid were derived from wild tomato species *S. habrochaites* (LA1777). Thus, the hybrid developed in the present study is good rootstock candidate for biotic stress management especially due to presence of *Sw-5* gene confer resistance to tomato spotted wild virus (TSWV) which is absent in control groups. None of the genotypes did not have resistance gene for tomato yellow leaf curl virus (TYLCV). Thus *Ty-1* and *Ty-3* genes need to be introgressed to potential rootstock candidates.

CONCLUSION

Rootstocks is the most popular technique in many parts of the world to control soil borne diseases and to improve many traits of the scion such as fruit yield and quality [Zhang et al. 1995, Oda et al. 1996, King et al. 2010]. Wild tomato species is valuable source of rootstocks due to tolerance of biotic and abiotic stresses. Thus, present study evaluated horticultural performance of an interspecific F1 hybrid derived from *S. habrochaites* (LA1777) as rootstock candidate. Quantitative and qualitative fruit quality traits of the hybrid was evaluated. As result, although F1 hybrid produced lowest yield and smaller fruits, produced firmer fruits had higher number of seeds. These limitations of the hybrid might point out species specific graft incompatibility. The study demonstrated that a F1 hybrid derived from a wild tomato species *S. habrochaites* (LA1777) had multiple resistance genes (*Frl*, *I-2*, *I-3*, *Pto* and *Sw-5*).

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