Selection of Melon Genotypes with Resistance to *Fusarium* Wilt and *Monosporascus* Root Rot for Rootstocks

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ABSTRACT A panel of 65 melon germplasm was used to screen for resistance to *Fusarium oxysporum* f. sp. *melonis* (*Fom*) and *Monosporascus cannonballus*. The screening test revealed 35 accessions that are highly resistant to *Fom* race 1 and 11 accessions with high resistance to *M. cannonballus*. A total of four accessions, 'K134068', 'K133069', 'Wondae' and 'PI 414723', showing resistance to both pathogens were selected as candidates for melon rootstock. Yield and quality of fruits harvested from 'Earl's elite' (Muskmelon, *Reticulatus* Group) grafted onto the selected melon rootstocks were found comparable to or better than those of non-grafted melons. Nearly negligible incidence of fruit fermentation was observed when 'Homerunstar' (Honeydew type, *Inodorus* Group) was grafted with the selected melon rootstocks, unlike when it was grafted onto 'Shintozwa' (*Cucurbita* spp.) rootstock. The selected melon accessions with resistance to *Fusarium* wilt and *Monosporascus* root rot are considered to be potential and valuable genetic resources for breeding program of melon.

Keywords Melon rootstock, Grafting, Soil-borne diseases, *Monosporascus* Root Rot, *Fusarium* wilt

INTRODUCTION

Soil-borne diseases aggravated by continuous cropping caused severe yield loss in melon production in Korea. *Fusarium oxysporum* f. sp. *melonis* (*Fom*) is believed to be the most destructive disease of melon (Lee 1994; Oda 1995). *Fom* attacks melon at any growth stage, even before sprouting, but mainly when the fruit is ripe (Mas *et al.* 1981). It causes either slow wilting accompanied by progressive yellowing, or a sudden wilting without prior yellowing and other related symptoms. Based on the host resistance genes associated with variants of this pathogen, *Fom* isolates were classified into four physiological races designated 0, 1, 2, and 1,2 (Risser *et al.* 1976).

Monosporascus cannonballus is another pathogen of melon which induces sudden wilting and has become a major production problem worldwide (Martyn and Miller 1996). Root infection and damage occur at all developmental

stages but increase in water demand especially during fruit development and maturation can lead to vine collapse due to loss of water-uptake capacity (Martyn and Miller 1996).

Breeding new cultivars for disease resistance is time-consuming and does not guarantee durable resistance against new races of pathogens. However, grafting onto resistant rootstocks may enable the control of soil-borne diseases (Lee 1994; Oda 1995). Hence, combined breeding programs could be applied to prevent the occurrence of soil-borne diseases (McCreight *et al.* 1993).

Grafting is an important technique for sustainable production of fruit-bearing vegetables in Korea, Japan, and European countries where land is being used intensively (Lee 1994; Oda 1995). Grafting in melon cultivation makes possible increase in disease resistance and tolerance to environmental stresses such as soil salinity and low temperature. The use of rootstocks also increases adaptability of melon cultivars against different type of soil conditions

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including resistance to soil-borne diseases, which in turn contributes to total production yield and water use efficiency (Caruso *et al.* 1996; Yano *et al.* 2002). The available rootstock species for melon grafting are melon, pumpkin (*Cucurbita* spp.) and wax gourd (*Benincasa hispida*) (Traka-Mavrana *et al.* 2000). It was reported that the *Cucurbita* rootstock can influence performance of scion cultivars of melon in terms of plant growth (Ruiz and Romero 1999), fruit quality, yield, and wilt incidence (Ruiz *et al.* 1997; Traka-Mavrana *et al.* 2000; Nisini *et al.* 2002). Effects of grafting to the performance of plants depend on the compatibility between rootstocks and scions, existing environmental condition, and cultivation. This is the reason why Lee (1994) suggested *Cucumis melo* is suitable rootstock for melon.

The objectives of this study were to select melon rootstocks for resistance against *F. oxysporum* f. sp. *melonis* (Fom) and *M. cannonballus*, and investigate the compatibility of the rootstock and scion being used.

MATERIALS AND METHODS

Experiment location and plant materials

The experiment was conducted at the National Institute of Horticultural & Herbal Science in Suwon, Korea (37°18'23"N, 126°58'40"E). A total of 65 melon accessions (Table 1) were screened for resistance against *F. oxysporum* f. sp. *melonis* race 1 and *M. cannonballus*.

Screening against *F. oxysporum* f. sp. *melonis* race 1 and *M. cannonballus*

Fom race 1 was isolated from infected melon plants grown in Suwon, Korea and grown on potato dextrose agar (Difco) in plastic petri-dishes at 25°C for eight days. Colonies were scraped off using sterilized glass rod from the petri dish added with 5 ml sterile distilled water. The suspension was filtered through two layers of sterile cheesecloth and the conidia were adjusted to 1×10^6 mL⁻¹ using hemacytometer. The roots of the 20-day-old plants were dipped into inoculum suspension for one minute and later transplanted into pots. Disease ratings were recorded

three weeks after inoculation.

Screening of melon genotypes for resistance to *M. cannonballus* was conducted under infested greenhouse. Melon plants were transplanted on July 9, 2011 in a randomized complete block design with three replications per genotype. Each bed was of 190 cm in size containing rows which were set at 45 cm apart.

Rootstock and scion compatibility test

Two melon cultivars, 'Homerunstar' and 'Earl's elite', were grafted onto selected rootstocks: 'K134068', 'K133069', 'Wondae', and 'PI 414723', 'Shintozwa' (*Cucurbita* spp.). Both the rootstocks and scions were sown at the same time on March 31, 2011 for a synchronized grafting time. Grafting was done on April 8, 2011 when the melon seedlings (eight-day-old) are at cotyledon stage using the splice grafting technique described in Lee *et al.* (2010). The grafted seedlings were transferred into a mist room maintained at relative humidity of 95% for seven days. Humidity was gradually decreased later for acclimatization one week before transplanting.

Melon seedlings were transplanted in a greenhouse in rows with black polyethylene mulching films on May 7, 2011. The experimental design was consisted of randomized blocks with three replicates. A total of seven plants per replication was grown horizontally and spaced at 3 × 0.5 m (row-row × plant-plant) for each rootstock combination and cultivar. The cultivation was practiced as method described in Rural Developmental Administration (2005). Fruits from 'Homerunstar' and 'Earl's elite' were harvested 45 and 55 days after fruit setting, respectively. The weight, length, width, soluble solid content, net formation, fermentation and appearance rate of fruits were investigated after harvest.

Statistical analyses

The statistical analysis was done using SAS software (SAS Institute 1995). The data from all the experiments were subjected to ANOVA and Duncan's multiple range tests to determine the statistical significance of differences between treatments.

RESULTS AND DISCUSSION

Of the 65 melon accessions screened to develop disease resistant rootstocks, 35 were found highly resistant (HR) to

Fom race 1 and 11 accessions showed high resistance to *M. cannonballus* (Table 1). Accessions with high resistance to both pathogens were selected as potential rootstocks for grafting, which include 'K134068', 'K133069', 'Wondae'

Table 1. Disease severity of melon genotypes against *Fom* race 1 and *M. cannonballus*.

Accession	Disease severity ^z		Accession	Disease severity	
	<i>Fom</i> race 1	<i>M. cannonballus</i>		<i>Fom</i> race 1	<i>M. cannonballus</i>
K134068	HR	HR	Seolnaehyang	HR	S
K134069	HR	HR	V-3-6	HR	S
Wondae	HR	HR	Earlsace	MR	MR
PI 414723	HR	HR	Acur	S	HR
Irannetmelon	HR	MR	Busan no.914	S	HR
Dalaman	HR	MR	Busan no.920	S	HR
Hwangkeumchamoe	HR	MR	Unknown 3	S	HR
Romans	HR	MR	Unknown 4	S	HR
Sageumok	HR	MR	Unknown 5	S	HR
Unknown 1	HR	MR	Unknown 6	S	HR
Unknown 2	HR	MR	PMR Honeydew	S	SR
B1	HR	SR	Unknown 7	S	SR
Baekdangkwan	HR	SR	05M40	S	S
Seonghwanchamoe	HR	SR	Charentais Fom 1	S	S
Cheongpisokwa	HR	SR	Chunhyang	S	S
Chogambaekok	HR	SR	Unknown 8	S	S
Daryang no.1	HR	SR	05M15	S	-
Julchamoe	HR	SR	05M28	S	-
Seonghwanchamoe	HR	SR	Acur Badem	S	-
05M41	HR	S	Busan no.912	S	-
05M42	HR	S	Busan no.928	S	-
Charentais Fom 2	HR	S	Busan no.951	S	-
Eunchoen	HR	S	Earlshappy	S	-
Gam	HR	S	Gamkwaniho	S	-
Gamro	HR	S	Giallo Canaria	S	-
Geumnodagieuncheon	HR	S	Iranmelon	S	-
Hong	HR	S	Papais	S	-
Icheon	HR	S	Superstar	S	-
Joseonchamoe	HR	S	Unknown 9	S	-
Korea no.18	HR	S	Unknown 10	S	-
Korea no.2	HR	S	Veedrantaish	S	-
New melon	HR	MR	West	S	-
Oknaehyang	HR	S	Homrunstar	S	S

^zDisease severity : HR=highly resistant, MR=moderately resistant, SR=slightly resistant, S=susceptible

and ‘PI 414723’ (Table 1).

Assessment of the yield and quality of fruits harvested from ‘Earl’s elite’ (Muskmelon, *Reticulatus* Group) and ‘Homerunstar’ (Honeydew type, *Inodorus* Group) grafted onto selected melon rootstocks was conducted. ‘Homerunstar’ and ‘Earl’s elite’ are the most popular cultivars being harvested between July and August in Korea. The former is a honeydew type melon with creamy-white color and oblong shape, while the latter is a muskmelon with round shape. Performance of ‘Earl’s elite’ grafted onto selected melon rootstocks was comparable to or even better than that grafted onto ‘Shintozwa’ and non-grafted melon (Table 2). There were no significant differences in both soluble solid content and net formation among ‘Earl’s elite’ fruits from different rootstocks (Table 2). In particular, the ‘Earl’s elite’ and ‘K134069’ combination outperformed the others in terms of fruit weight and fruit length (Table 2).

‘Homerunstar’ grafted onto selected four accessions also performed well or even better than that grafted onto ‘Shintozwa’ and non-grafted (Table 3). Combinations with

‘K134068’ and ‘P1414723’ edged out ‘Shintozwa’ rootstock and non-grafted in terms of fruit weight, fruit width, and appearance rate. No significant differences in fruit length and soluble solid content were observed among ‘Homerunstar’ fruits from different rootstocks (Table 3). Interestingly, the four rootstock-scion combinations had negligible fermented fruit incidence (0-6%) which is similar to the non-grafted check (6%) but way lesser than with ‘Shintozwa’ rootstock (81%, Table 3).

Several conflicting reports regarding the role of grafting on changes in fruit quality have been published (Proietti *et al.* 2008; Flores *et al.* 2010). Reasons for differences in the previous reports might be attributed to different production environments and type of agricultural practice, kind of rootstock/scion combinations, and harvesting period. Previous reports also showed that *Cucurbita* spp. rootstock causes a remarkable deterioration in the taste of melons (Lee 1994; Oda 1995) even when the same cultural treatments such as fertilizer application and irrigation were practiced. The four rootstock accessions selected for disease resistance in

Table 2. Fruit quality of ‘Earl’s elite’ (Muskmelon, *Reticulatus* Group) grafted onto different rootstocks.

Rootstock	Fruit weight (kg)	Fruit length (mm)	Fruit width (mm)	Soluble solid content (°Bx)	Net formation ^z
K134068	1.4 ab	151.4 ab	136.4 ab	14.6 a	3.1 a
K134069	1.5 a	155.2 a	137.9 ab	13.8 a	3.5 a
Wondae	1.4 ab	151.4 ab	133.4 a	14.2 a	3.3 a
PI 414723	1.3 ab	147.3 ac	131.7 ab	14.2 a	3.9 a
Shintozwa	1.2 b	138.3 c	131.3 ab	14.8 a	3.5 a
non-grafted	1.2 b	144.1 bc	129.3 b	13.7 a	3.1 a

^zNet formation : 1 good ~ 9 poor

Table 3. Fruit quality of ‘Homerunstar’ (honeydew type melon) grafted onto different rootstocks.

Rootstock	Fruit weight (kg)	Fruit length (mm)	Fruit width (mm)	Soluble solid content (°Bx)	Fermented fruit (%)	Appearance rate ^z
K134068	1.5 a	158.5 a	134.8 a	16.0 a	6	4.3 a
K134069	1.4 ab	155.7 a	133.6 a	16.0 a	6	3.9 ac
Wondae	1.4 ab	155.6 a	130.1 ab	15.7 a	0	3.8 ac
PI 414723	1.5 a	160.3 a	135.1 a	15.8 a	0	4.2 ab
Shintozwa	1.3 b	150.8 a	126.8 b	16.2 a	81	3.5 c
non-grafted	1.3 b	153.1 a	126.4 b	15.9 a	6	3.6 bc

^zAppearance rate : 1 poor ~ 5 good

the present study did not cause deterioration in fruit quality while a conventional rootstock 'Shintozwa' did cause remarkable deterioration (Table 3). It was then suggested that the agents associated with fruit quality were translocated to the scion through the xylem which is likely not the case here considering the fruit quality of the rootstock-scion combination.

CONCLUSION

This study was conducted to select melon rootstocks with resistance against *Fusarium oxysporum* f. sp. *melonis* (Fom) and *Monosporascus cannonballus*, and to investigate the compatibility of the rootstock and the scion being used. The initial screening of 65 genotypes led to selection of four accessions ('K134068', 'K133069', 'Wondae' and 'PI 414723') with high resistance to both Fom race 1 and *M. cannonballus* for use as rootstocks. Subsequent compatibility assessment of grafted plants with the selected four rootstocks revealed comparable or even better performance of these plants compared to the checks 'Shintozwa' and non-grafted ones in terms of yield, fruit quality and fruit fermentation incidence. The findings further disproved the previous report that rootstock caused a remarkable deterioration in the fruit quality.

The selected melon genotypes with resistance to Fusarium wilt and Monosporascus root rot would serve as potential and valuable genetic resource for improvement of melon. These genotypes could also be utilized in the breeding programs that target to combine with other desirable characteristics such as cold and salt tolerance among others to address the needs of new hybrid varieties that can be produced successfully under greenhouse conditions.

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