National Watermelon Association Research Project 2009

TITLE

Evaluation of rootstocks for managing root-knot nematodes in grafted watermelon

PERSONNEL

Judy A. Thies, U.S. Vegetable Laboratory, USDA, ARS, Charleston, SC
E-mail: judy.thies@ars.usda.gov
Shaker Kousik, U.S. Vegetable Laboratory, USDA, ARS, Charleston, SC
Richard Hassell, Clemson University, Charleston, SC

INTRODUCTION

The southern root-knot nematode (*Meloidogyne incognita*) is a serious pest of watermelon in the southern U.S. (Davis, 2007; Sumner and Johnson, 1973; Thies, 1996). Pre-plant fumigation of soil beds with methyl bromide is the primary method for controlling root-knot nematodes (RKN) in watermelon. Approximately six percent of methyl bromide applied for pre-plant soil fumigation in vegetable crops world-wide was used for watermelon (*Citrullus lanatus* var. *lanatus*) and melon (*Cucumis melo* L.) (USDA, 1993). In Georgia, RKN significantly reduced fruit yield of 'Cooperstown' seedless watermelon grown in non-treated soil beds compared to that grown in methyl bromide treated soil beds (Davis, 2007). The reduced availability and escalating cost of methyl bromide for pre-plant soil fumigation has resulted in increased interest in the use of rootstocks for managing root-knot nematodes in watermelon and other cucurbit crops.

Bottle gourd (*Lagenaria siceraria*) and hybrid squash (*Cucurbita moschata x C. maxima*) are currently used as rootstocks for watermelon in Europe, Asia, and the Middle East, primarily because of their resistances to Fusarium wilt. The loss of methyl bromide from the U.S. market has increased interest in using rootstocks because Fusarium wilt can be controlled by grafting watermelon on resistant rootstocks such as bottle gourd and hybrid squash (Core, 2005; Cohen et al., 2007; Edelstein and Ben-Hur, 2006). However, we have demonstrated in field tests in Charleston, SC that hybrid squash and bottle gourd are highly susceptible to RKN (Thies et al., 2008). Thus, bottle gourd and hybrid squash would not be preferred rootstocks for use in many areas of the southern U.S., where RKN are a serious pest of watermelon. Recently, we evaluated more than 200 accessions of wild watermelon (*Citrullus* spp.) from the U.S. Plant Introduction (PI) Watermelon Collection for response to RKN in greenhouse tests (Thies and Levi, 2003). We identified several wild watermelons (*Citrullus lanatus* var. *citroides*) in the USDA Watermelon Plant Introduction Collection that are moderately resistant to RKN (Thies and Levi, 2007). We have developed breeding lines derived from these wild watermelon Plant Introductions that may be useful as rootstocks for grafted watermelon. Availability of RKN-resistant wild watermelon rootstocks would provide an alternative to pre-plant soil fumigation with methyl bromide or other fumigants for managing root-knot nematodes in watermelon.

OBJECTIVES

(1) Compare rootstocks of experimental lines of wild watermelon (*C. lanatus* var. *citroides*) with commercial rootstocks of *L. siceraria*, *C. moschata* x *C. maxima*, and *C. lanatus* var. *citroides,* and with rootstocks of wild tinda (*Praecitrullus fistulosus*) for managing southern root-knot nematodes in grafted watermelon. (2) Identify wild watermelon lines that may be useful for developing superior rootstocks that are resistant to root-knot nematodes and produce high yield and fruit quality on the grafted watermelon cultivars.

METHODS

Rootstocks

Seedless watermelon 'Tri-X 313' was grafted on to five wild watermelon (*Citrullus lanatus* var. *citroides*) germplasm lines (RKVL 301, RKVL 302, RKVL 303, RKVL 316, RKVL 318), one bottle gourd (*Lagenaria siceraria* 'Emphasis') cultivar, one squash (*Cucurbita moschata* x *C. maxima* 'Strong Tosa') hybrid, one commercial watermelon rootstock cultivar (*C. lanatus* var. *citroides* 'Ojakkyo'), and three wild tinda (*Praecitrullus fistulosus*) rootstocks (P0004, P0005, and P0006). 'Tri-X 313' self grafted and 'Tri-X 313' non-grafted also were included as checks in the study.

The study was conducted in a field infested with the southern root-knot nematode, *Meloidogyne incognita*, in Charleston, S.C. The soil was a Yonges fine loamy sand. Grafted plants were transplanted on raised white plastic mulch beds at a plant density of 30 ft^2/plant on 4 June 2009. The experimental design was a randomized complete block with six replicates of six plants per replicate. The pollenizer 'SP-4' was interplanted between every third and fourth grafted seedless watermelon.

Data collected

Watermelon fruit were harvested and fruit weight, fruit size (length x diameter), and fruit quality traits including total soluble solids (brix) were recorded on 30 July, 3 August, 6 August, 11 August, 13 August, and 17 August 2010. At the end of the harvest season on 26 August, roots of all plants were dug and evaluated for percent of root system galled by southern root-knot nematode. Nematode eggs were extracted from the roots using 1% NaOCl (Hussey and Barker, 1973) and eggs were counted using a stereomicroscope. Root galling percentages were arcsine transformed and eggs per gram fresh root were $\log^{10}$ (x + 1) transformed to normalize data. Analysis of variance was conducted on transformed data using the GLM procedure of SAS v.9.1 for Windows (SAS Institute Inc., Cary, NC) and means were separated using Fisher's Protected Least Significant Difference (LSD).

RESULTS and DISCUSSION

Root-knot nematode infection was severe in 'Emphasis' bottlegourd (*L. siceraria*) (86% root system galled) and 'Strong Tosa' (Fig. 1) squash hybrid (*C. moschata* x *C. maxima*) (100% galled) rootstocks (Table 1). The three tinda (*P. fistulosus*) rootstocks were also severely infected by root-knot nematodes with percentages of root system galled ranging from 91 to 100%. The five wild watermelon rootstocks exhibited significantly lower ($P \leq 0.05$) percentages of root galling (range: 9.1 to 16.2%) than non-grafted 'Tri-X 313' (40.9%) (Fig. 2), 'Emphasis', 'Strong Tosa', and the *P. fistulosus* accessions. Although 'Ojakkyo' exhibited heavier root galling (26.0%) than the five wild watermelon rootstocks, the differences were not significant.

Fig. 1. 'Strong Tosa'

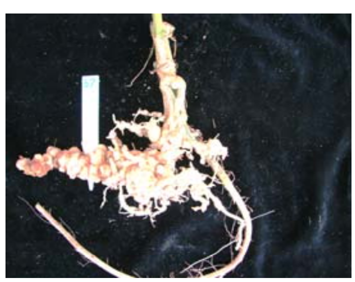

Fig.2. 'Tri-X 313' watermelon

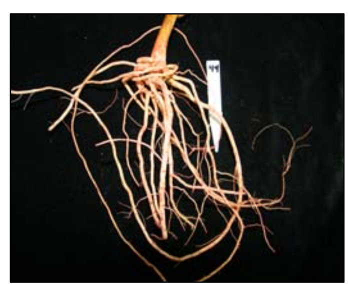

Fig. 3. RKVL 302 wild watermelon

Root-knot nematode reproduction was lowest for the five wild watermelon rootstocks and 'Ojakkyo'. Two of the wild watermelon rootstocks, RKVL 302 (Fig. 3) and RKVL 318, had significantly fewer ($P \leq 0.05$) eggs of *M. incognita* per gram fresh root than 'Tri-X 313' (non-grafted and self grafted), 'Emphasis', 'Strong Tosa', P0004, P0005, and P0006. 'Emphasis' and 'Strong Tosa' supported the greatest numbers of *M. incognita* eggs per gram fresh root (835 and 3137, respectively).

The five wild watermelon rootstocks and 'Ojakkyo' had significantly greater amounts of fibrous roots than 'Tri-X 313' (non-grafted and self grafted), 'Emphasis', 'Strong Tosa', P0004, P0005, and P0006. Large amounts of fibrous roots are often associated with the ability of a host plant to tolerate attack by plant parasitic nematodes. We have often observed that many of the *Citrullus lanatus* var. *citroides* germplasm accessions have excellent fibrous root systems.

The wild watermelon rootstock RKVL 318 produced significantly more fruit (12 per plot) ($P \leq 0.05$) than any other entry and also produced the heaviest yield (29.5 lbs per plot) ($P \leq 0.05$) compared to all other entries except self grafted 'Tri-X 313' (21.5 lbs per plot). 'Strong Tosa' and the three *P. fistulosus* rootstocks produced the lowest yields in the study, which is associated with the extensive root galling, root damage, and poor fibrous root systems (range: <1% to 35% fibrous roots) observed for these rootstocks. No significant differences were detected among rootstocks for total soluble solids and fruit size (length x diameter) (data not shown).

CONCLUSIONS

All five of the wild watermelon exhibited resistance to southern root-knot nematode in this test. Furthermore, the wild watermelon rootstock RKVL 318 produced the most fruit and highest yield of any of the rootstock entries in the test. The results of the present study suggest that these wild watermelon rootstocks (*C. lanatus* var. *citroides*) possess durable resistance to root-knot nematodes in the field. These results are consistent with our earlier observations of resistance to root-knot nematodes in seedling evaluations of *Citrullus* accessions in greenhouse experiments (Thies and Levi, 2003; Thies and Levi, 2007). Grafting allows a rapid response to the development of new races of a pathogen if resistant rootstocks are available and provides an alternative to breeding new resistant watermelon cultivars for controlling soil-borne diseases. In Japan and other parts of Asia, watermelons have been grafted on cucurbit rootstocks to suppress Fusarium wilt in watermelon caused by *Fusarium oxysporum* Schlechtend.: Fr. f. sp. *niveum* (E.F. Sm.; W.C. Snyder and H.N. Hans) that causes Fusarium wilt in watermelon but not in the cucurbit rootstocks (Cohen et al., 2007; Miguel et al., 2004). However, the cucurbit rootstocks presently used for grafting watermelon are highly susceptible to root-knot nematodes. The *C. lanatus* var. *citroides* rootstocks may offer a solution for suppressing root-knot nematodes and be useful to rotate with the susceptible cucurbit rootstocks if watermelon is grown in successive years in the same fields. We are planning further studies to compare the performance of these wild watermelon rootstocks in both nematode-infested and non-infested fields in order to determine their yield potential for seedless watermelon production.

LITERATURE CITED

Cohen, R., Y. Burger, C. Horev, A. Koren, and M. Edelstein. 2007. Introducing grafted cucurbits to modern agriculture. The Israeli experience. Plant Dis. 91:916-923.

Core, J. 2005. Grafting watermelon onto squash or gourd rootstock makes firmer, healthier fruit. Agricultural Research Magazine, July 2005. USDA, ARS. http://www.ars.usda.gov/is/AR/archive/jul05/fruit0705.htm

Davis, R.F. 2007. Effect of Meloidogyne incognita on watermelon yield. Nematropica 37:287-293.

Hassell, R., F. Memmott, and D. Liere. 2008. Grafting methods for watermelon production. HortScience 43:1677-1679.

Hussey, R.S. and K. R. Barker. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp., including a new technique. Plant Dis. Rpt. 57:1025-1028.

Edelstein, M. and M. Ben-Hur. 2006. Use of grafted vegetables to minimize toxic chemical usage and damage to plant growth and yield quality under irrigation with marginal water. ISHS Acta Horticulturae 699: I International Symposium on Improving the Performance of Supply Chains in the Transitional Economies.

Miguel, A., J.V. Maroto, A.S. Bautista, C. Baixaull, V. Cebolla, B. Pascual, S. Lopez and J.L. Guardiola. 2004. The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of Fusarium wilt. Sci. Hortic. 103:9-17.

Sumner, D. R., and A. W. Johnson. 1973. Effect of root-knot nematodes on Fusarium wilt of watermelon. Phytopathology 63:857-861.

Thies, J. A. 1996. Diseases caused by nematodes, Pp. 56-58 *In* T.A. Zitter, D. L. Hopkins, and C. E. Thomas, eds. Compendium of cucurbit diseases. St. Paul, MN: APS Press.

Thies, J. A., J. Ariss, C. S. Kousik, and R. Hassell. 2008. Is Grafting Useful for Managing Root-Knot Nematodes in Watermelon? HortScience. 43:623.

Thies, J. A. and A. Levi. 2003. Resistance of watermelon germplasm to the peanut root-knot nematode. HortScience 38:1417-1421.

Thies, J. A., and Levi, A. 2007. Characterization of watermelon (Citrullus lanatus var. citroides) germplasm for resistance to root-knot nematodes. HortScience 42: 1530-1533.

United States Department of Agriculture. 1993. USDA workshop on alternatives for methyl bromide. June 29-Jul. 1, 1993. Crystal City, VA.

Table 1. Percentages root system galled and covered with *Meloidogyne incognita* egg masses, numbers of *M. incognita* eggs per gram fresh root, fibrous root index, watermelon fruit yield and number for 'Tri-X 313' seedless watermelon grafted on rootstocks of wild watermelon lines and selected commercial rootstocks. Charleston, SC.

Rootstock	Percentage root system galled[a]		Percentage root system covered with egg masses[a]		Eggs per gram fresh root[b]		Fibrous Root Index[c]		Total Weight (lbs/plot)[d]		No. Fruit/plot[d]	
Citrullus lanatus var. *citroides*												
RKVL 303	16.2	ab[d]	2.6	a	58	abc	97.78	e	16.6	cd	6	cd
RKVL 318	13.4	ab	2.1	a	16	a	87.22	fe	29.5	e	12	e
RKVL 316	13.9	ab	3.5	a	31	ab	82.99	fe	18.8	cd	8	d
RKVL 301	9.1	a	2.6	a	24	ab	92.17	fe	20.0	d	7	cd
RKVL 302	10.0	a	1.6	a	21	a	71.02	cd	14.8	cd	5	bd
Ojakkyo	26.0	ac	7.9	ab	34	abc	74.05	cd	19.8	d	7	cd
Citrullus lanatus var. *lanatus*												
Tri-X 313 non grafted	40.9	c	3.8	a	140	cde	54.51	bc	15.7	cd	6	cd
Tri-X 313 self grafted	30.9	bc	13.1	ab	91	bcd	51.42	bc	21.5	de	8	d
Lagenaria siceraria												
Emphasis	85.8	d	39.8	bc	835	fg	32.92	b	17.2	cd	7	cd
Cucurbita moschata x *Cucurbita maxima*												
Strong Tosa	99.2	e	67.2	cd	3137	g	35.21	a	11.6	abc	3	abc
Praecitrullus fistulosus												
P0004	97.8	de	41.5	c	284	def	2.41	a	6.2	a	2	a
P0005	90.6	de	17.5	ab	128	cde	5.83	a	4.7	a	2	a
P0006	100.0	f	83.3	d	448	ef	0.92	a	7.0	ab	3	ab

[a]Data was arcsine transformed before analysis; non-transformed data are shown.
[b]Data was $\log_{10}(x+1)$ transformed before analysis; non-transformed data are shown.
[c]Root systems were rated on a 0 to 100% scale, where 100% = a very heavy fibrous root system.
[d]Six plants per plot (12' x 15' = approx. 30 square ft per plant).
[e]Means within a column followed by the same letter are not significantly different (P<0.05) according to Fisher's Protected LSD.