Grafting Using Rootstocks with Resistance to *Ralstonia solanacearum* Against *Meloidogyne incognita* in Tomato Production

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Abstract

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Root-knot nematodes (RKNs; *Meloidogyne* spp.) and *Ralstonia solanacearum*, the causal agent of bacterial wilt, are major soilborne pathogens in U.S. tomato production. Methyl bromide has been used for decades to effectively manage RKN but its phase-out and the high cost of other effective fumigants such as 1,3-dichloropropene has resulted in a need to develop sustainable alternatives. Many of the commercially popular varieties used by the tomato industry do not have resistance to RKNs and *R. solanacearum*. Recent studies worldwide have shown the potential for grafting using resistant rootstocks as a sustainable and ecofriendly practice for *R. solanacearum* management. However, the effectiveness of *R. solanacearum*-resistant rootstocks on RKN management is not known. In this study, three commercially available *R. solanacearum*-resistant tomato rootstocks ('RST-04-106-T', 'BHN 998', and 'BHN 1054') were evaluated for resistance to *Meloidogyne incognita* in field tomato production in four field trials conducted for two consecutive years in two geographical locations: Florida and Virginia. Grafting rootstocks onto 'BHN 602' a tomato scion susceptible to bacterial wilt and RKNs, significantly reduced root galling caused by RKNs in all four field trials and increased yield in two of the trials compared with the nongrafted treatment. This study demonstrates the potential of grafting for managing multiple soilborne pathogens using the same rootstocks.

Fresh-market tomato (*Solanum lycopersicum* L.) is an important vegetable crop in the United States. It is grown on over 38,340 ha and was valued at >$863 million in 2012 (29). Root-knot nematodes (RKNs; *Meloidogyne* spp.) can cause major yield losses in tomato production (16), specifically in fresh-market tomato produced in the southeastern United States (20,21). The wide host range of these nematodes and the ability to survive in soil for many years are the main constraints for the management of these plant-parasitic nematodes. Use of resistant varieties, which is conferred by the presence of the *Mi* gene, is a major component in effective field management of *Meloidogyne arenaria* Chit., *M. incognita* (Kofoid and White) Chit. and *M. javanica* Treub (5,15,16,19,22). The *Mi* gene is highly effective under many conditions; however, resistance is not stable at high soil temperatures and resistance-breaking isolates have been identified (6,30). The genes *Mi*-1 to *Mi*-9 have been identified to confer resistance to *M. arenaria, M. incognita*, and *M. javanica* but only *Mi*-1 has been successfully used in tomato breeding (32). Currently, there are many resistant varieties of *Meloidogyne* spp. available in the U.S. and global market. However, grower and industry preferences are for many varieties that do not have resistance to RKNs but are commercially popular due to the horticultural characteristics of the fruit and resistance to other soil and foliar pathogens.

The Montreal Protocol in 1989 led to the gradual phase out of methyl bromide due to its ozone-depleting properties (7,8,27). For decades, tomato producers relied on this soil-fumigant for the control of plant-parasitic nematodes, weeds, and soilborne pathogens. Many producers have transitioned to other soil fumigants such as 1,3-dichloropropene, metham sodium, and metham potassium. Even though currently available fumigants can be used to suppress nematodes, nematode-resistant hosts are much more preferable because of the current cost, environmental toxicity, and regulatory issues relating to the use of soil fumigants (31).

Grafting as a technique to manage soilborne diseases has been practiced for decades in Asian countries. Grafted plants now account for 81 and 54% of the vegetable acreage in Korea and Japan, respectively, and grafting is increasingly being used in the Mediterranean (14,24). Although used extensively around the world, grafting has only recently gained recognition in the United States for RKN management. Some tomato and tomato-interspecific-hybrid rootstocks are known to have resistance or tolerance to RKN species (17,30,32) and, thus, could be a source of grafting material with resistance to RKNs. Utilizing this information, a recent study was conducted which showed that grafting with the interspecific rootstocks 'Beaufort' and 'Maxifort' (*S. lycopersicum* L. × *S. habrochaites*) effectively reduced RKN galling and second-stage juveniles in soil while maintaining tomato productivity (23). Grafting of RKN-susceptible scions to resistant rootstocks significantly increased yield compared with nongrafted varieties and self-grafted plants (susceptible scion grafted onto itself) in areas with high *M. incognita* populations (23). Similarly, a recent study demonstrated the benefits of grafting susceptible tomato scions onto resistant hybrid rootstocks when planted into soils heavily infested with *Ralstonia solanacearum* (18). Disease incidence was greatly reduced and tomato fruit yield was maintained at levels acceptable to commercial producers. However, none of these hybrid rootstocks with resistance to bacterial wilt have been tested for field resistance against RKNs anywhere in the world. Grafting technology, which utilizes rootstocks with resistance to both RKNs and *R. solanacearum*, may provide one of the most effective and environmentally friendly options for controlling these two soilborne pathogens in the field. Therefore, this technology may serve as an ideal component in an integrated pest management program.

The objectives of this study were to (i) assess the ability of new combinations of *R. solanacearum*-resistant hybrid rootstocks and susceptible scions in reducing root galling caused by *M. incognita* in Florida and Virginia and (ii) determine the effect of grafting in improving tomato fruit yield in fields containing high densities of *M. incognita*.

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Materials and Methods

Four field trials were conducted in Florida and Virginia during fall 2011 and 2012 with three new *R. solanacearum*-resistant hybrid tomato rootstocks: 'RST-04-106-T' (DP Seeds, Yuma, AZ), 'BHN 998' (BHN Seed, Immokalee, FL), and 'BHN 1054' (BHN Seed) (18). Plants were grafted onto RKN-susceptible 'BHN 602' (BHN Seed), a commercially important cultivar with desirable fruit characteristics and resistance to *Tomato spotted wilt virus*. Two trials each were conducted at the University of Florida North Florida Research and Education Center (NFREC; Quincy, FL) and at the Virginia Tech Eastern Shore Agricultural Research and Extension Center (Painter, VA). Soil types were Norfolk sandy loam (Thermic Typic Kandiudults) with pH 6.3 and Bojac sandy loam (Thermic Typic Hapludults) with pH 6.5 in Florida and Virginia, respectively.

In Florida, during the spring seasons, yellow summer squash (*Cucurbita pepo*) 'Dixie' (Seminis Vegetable Seeds, St. Louis) was seeded as a host crop using established production guidelines (20) into fields naturally infested with *M. incognita* race 3. RKN identification was based on morphological characteristics and was further verified by host range tests (25). The squash plants were mowed with a tractor-mounted rotary mower 10 weeks after seeding. Soil at the test sites was then disked and moldboard plowed before creating raised beds covered with polyethylene mulch (Berry Plastics Corporation, Evansville, IN). In Virginia, during the spring seasons, yellow summer squash 'Conqueror III' (Seminis Vegetable Seeds) was planted into a field with no history of *M. incognita*. Field inoculation was conducted using *M. incognita* race 3 population, which was originally isolated from squash in Painter, VA in 2010 and maintained in the greenhouse on Conqueror III yellow summer squash. Nematode eggs were extracted from the squash roots using a 1% NaOCl extraction technique (16). The eggs were collected on a 25-µm pore size sieve. One month after emergence of the squash plants in the field trial, the soil at the base of each of the plants was drench inoculated by pouring a liquid suspension (100 ml) containing 5,000 *M. incognita* race 3 eggs onto the soil surface. Squash was grown following current production guidelines in Virginia (33). The squash plants were mowed with a tractor-mounted rotary mower 10 weeks after seeding. Soil at the test sites was disked and moldboard plowed before creating raised beds covered with polyethylene mulch (Berry Plastics Corporation).

Experimental plots consisted of nonfumigated raised beds covered with white polyethylene mulch, except in the fall 2011 trial in Virginia, where black plastic polyethylene mulch was coated with a white calcium spray. Bed dimensions at both locations were 12.7 cm high and 76.2 cm wide. Beds were spaced 1.8 m apart and plants were spaced 50.8 cm apart within the row at both locations. Inorganic fertilizers were applied to experimental plots based on soil test results and cooperative extension recommendations (20,33).

Plants were tube grafted at the two-leaf stage (13) below the rootstock cotyledon, which has been shown to prevent rootstock shoot regrowth (2). In the 2011 trial in Florida, treatments were (i) nongrafted BHN 602, (ii) self-grafted BHN 602 on BHN 602, (iii) BHN 602 grafted on RST-04-106-T, (iv) BHN 602 grafted on BHN 998, and (v) BHN 602 grafted on BHN 1054. The plants were field transplanted on 8 August. In the 2012 trial in Florida, treatments were (i) nongrafted BHN 602, (ii) self-grafted BHN 602 on BHN 602, (iii) BHN 602 grafted on BHN 998, and (iv) BHN 602 grafted on BHN 1054. The plants were field transplanted on 6 August. In the 2011 and 2012 trials in Virginia, treatments were (i) nongrafted BHN 602, (ii) BHN 602 grafted on RST-04-106-T, (iii) BHN 602 grafted on BHN 998, and (iv) BHN 602 grafted on BHN 1054. Seedlings were transplanted on 4 August 2011 and 21 June 2012. Plots were maintained throughout the season using standard fertility, irrigation, and crop protection practices recommended for commercial tomato production in Florida and Virginia (20,33).

All plants at the Florida location and 12 plants from the center of each plot at the Virginia location were harvested two times in all the trials, except the 2011 trial in Virginia, where only a single harvest occurred. Fruit were harvested at a mature green or early breaker stage typical of tomato production and size graded based on United States Department of Agriculture grades (28). At the end of the experiment, the polythene mulch was removed to facilitate nematode gall ratings. Twelve plants from each plot were dug using a shovel, and roots were washed and then assessed for root galling using the root gall index (RGI), a rating system from 0 to 10, where 0 = complete and healthy root system with no infestation; 1 = very few small galls can be detected upon close examination; 2 = small galls similar to those in 1 but more numerous and easy to detect; 3 = root system is characterized by numerous small galls, some of which may have grown together; 4 = in addition to numerous small galls, some big galls are present; 5 = about 25% of roots system has severe galling; 6 = about 50% of root system has severe galling; 7 = about 75% of roots of the root system has severe galling; 8 = no healthy roots are left, the nourishment of the plant is interrupted but the plant is still green; 9 = the completely galled root system is rotting, the plant is dying; and 10 = plant and roots are dead (34).

Each rootstock scion treatment consisted of six replications in Florida and four replications in Virginia, with 12 and 18 plants per plot, respectively, in each replication. All experiments were arranged in a randomized complete block design. RGI values and marketable yield data were first analyzed using analysis of variance. Mean comparisons, where appropriate, were performed with SAS (version 9.1; SAS Institute Inc., Cary, NC). Fischer's least significant difference was used for analysis of mean separation.

Results

In all field trials, the *R. solanacearum*-resistant hybrid tomato rootstocks had lower RGI compared with the nongrafted and self-grafted controls (Tables 1–4; Fig. 1A–E). An increase in total yield was observed, with grafting with some rootstocks increasing yield

Table 1. Fruit yield and root gall index (RGI) of tomato (*Solanum lycopersicum*) 'BHN 602' grafted onto three bacterial wilt-resistant rootstocks[x]

	Fruit yield (kg/ha)[y]				
Rootstock	Medium	Large	Extra-large	Total	RGI[z]
RST-04-106-T	6,511 bc	11,905 ab	22,449 b	40,864 bc	1.2 b
BHN 998	9,167 a	14,299 a	28,556 a	52,022 a	1.4 b
BHN 1054	7,816 ab	15,076 a	23,788 ab	46,680 ab	1.4 b
BHN 602 self-grafting	5,413 c	8,532 b	13,380 c	27,325 d	5.7 a
BHN 602 nongrafted	6,058 bc	10,496 b	18,593 bc	35,148 cd	5.6 a
LSD (0.05)	2,165	3,559	5,304	9,723	1.0
P > *F*	0.0112	0.0049	<0.0001	0.0002	<0.0001

[x] The trial was conducted in 2011 at the University of Florida, North Florida Research and Education Center, Quincy, FL. Column means followed by the same letter are not significantly different at $P \leq 0.05$ based on Fischer's least significant difference (LSD).

[y] United States Department of Agriculture size grades. Minimum–maximum fruit diameter: medium size = 5.72 to 6.43 cm, large size = 6.35 to 7.06 cm, and extra-large size = 7.00 cm.

[z] RGI is a 0-to-10 scale indicating the severity of root galling (34) in a field naturally infested with *Meloidogyne incognita*. Each entry consisted of six replications, with 12 plants in each replication.

significantly above that of the nongrafted and self-grafted controls in the field trials conducted in Florida (Tables 1 and 3). Here after, in all discussion concerning field trial studies, grafted combinations are referred to by the name of the corresponding rootstock used.

Florida 2011. Plants grafted onto the rootstocks BHN 998, BHN 1054, and RST-04-106-T had significantly lower RGI values than nongrafted and self-grafted plants ($P \leq 0.0001$; Table 1). RGI values were not statistically different among the three hybrid rootstocks used in this test. The highest total yield was obtained from BHN 998 followed by BHN 1054 and RST-04-106-T. The total yield of BHN 998 was not statistically different from that of BHN 1054 but was higher compared with that of RST-04-106-T (P = 0.0002). Lowest total yield was obtained from the self-grafted treatment, which was similar to that of the nongrafted control. There were also significant differences among the treatments in fruit yields for the medium (P = 0.0112), large (P = 0.0049), and extra-large ($P \leq 0.0001$) size classes. The highest yield of medium and extra-large sizes were from BHN 998 and, for the large size, from BHN 1054.

Virginia 2011. Significant reductions in RGI values were observed in all the rootstocks compared with the BHN 602 nongrafted control ($P \leq 0.0001$) (Table 2). BHN 1054 was unexpectedly galled compared with other rootstocks but still had a lower RGI value than that observed for the BHN 602 nongrafted control. The lowest RGI value was observed on RST-04-106-T, which was lower than that on BHN 998 and BHN 1054. There was no difference in total yield between any of the rootstock treatments compared with the nongrafted control. However, there were significant differences among the treatments in fruit yields of medium (P = 0.03), large (P = 0.02), and extra-large (P = 0.04) size classes. In the medium size class, all the rootstocks had significantly higher yields than the nongrafted control; in the large size class, only BHN 998 had significantly higher yield than the nongrafted control and, in the extra-large size class, only RST-04-106-T had significantly higher yield than the nongrafted control.

Florida 2012. Rootstocks BHN 998 and BHN 1054 had lower RGI values than the BHN 602 self-grafted and nongrafted controls ($P \leq 0.0001$; Table 3). However, there was no statistical difference in RGI values between the rootstocks. BHN 998 had a higher total

Table 2. Fruit yield and root gall index (RGI) of tomato (*Solanum lycopersicum)* 'BHN 602' grafted onto three bacterial wilt-resistant rootstocks[x]

	Fruit yield (kg/ha)[y]				
Rootstock	**Medium**	**Large**	**Extra-large**	**Total**	**RGI[z]**
RST-04-106-T	1,443 a	2,040 ab	3,544 a	7,027 a	0.5 d
BHN 998	1,525 a	3,009 a	1,389 b	5,922 a	1.5 c
BHN 1054	1,382 a	1,782 b	1,687 ab	4,852 a	4.5 b
BHN 602 nongrafted	474 b	996 b	725 b	2,195 a	6.9 a
LSD (0.05)	762	1,154	1,949	ns	1.6
P > F	0.03	0.02	0.04	0.06	<0.0001

[x] The trial was conducted in 2011 at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, VA. Column means followed by the same letter are not significantly different at $P \leq 0.05$ based on Fischer's least significant difference (LSD); ns = not significant.
[y] United States Department of Agriculture size grades. Minimum–maximum fruit diameter: medium size = 5.72 to 6.43 cm, large size = 6.35 to 7.06 cm, and extra-large size = 7.00 cm.
[z] RGI is on a 0-to-10 scale indicating the severity of root galling (34) in a field inoculated with *Meloidogyne incognita*. Each entry consisted of four replications with 18 plants in each replication.

Table 3. Fruit yield and root gall index (RGI) of tomato (*Solanum lycopersicum*) 'BHN 602' grafted onto two bacterial wilt-resistant rootstocks[x]

	Fruit yield (kg/ha)[y]				
Rootstock	**Medium**	**Large**	**Extra-large**	**Total**	**RGI[z]**
BHN 998	6,113 a	10,341 a	30,244 a	46,699 a	0.1 b
BHN 1054	5,676 a	9,736 a	20,605 ab	36,018 ab	0.1 b
BHN 602 self-grafting	5,010 a	8,108 a	15,787 b	28,905 b	5.4 a
BHN 602 nongrafted	4,710 a	7,469 a	18,742 b	30,922 b	4.9 a
LSD (0.05)	ns	ns	9,962	14,379	1.0
P > F	0.577	0.2184	0.0367	0.0451	<0.0001

[x] The trial was conducted in 2012 at the University of Florida, North Florida Research and Education Center in Quincy, FL. Column means followed by the same letter are not significantly different at $P \leq 0.05$ based on Fischer's least significant difference (LSD); ns = not significant.
[y] United States Department of Agriculture size grades. Minimum–maximum fruit diameter: medium size = 5.72 to 6.43 cm, large size = 6.35 to 7.06 cm, and extra-large size = 7.00 cm.
[z] RGI is a 0-to-10 scale indicating the severity of root galling (34) in a field naturally infested with *Meloidogyne incognita*. Each entry consisted of six replications with 12 plants in each replication.

Table 4. Fruit yield and root gall index (RGI) of tomato (*Solanum lycopersicum*) 'BHN 602' grafted onto three bacterial wilt-resistant rootstocks[x]

	Fruit yield (kg/ha)[y]				
Rootstock	**Medium**	**Large**	**Extra-large**	**Total**	**RGI[z]**
RST-04-106-T	2,108 a	6,649 a	13,273 a	23,047 a	0.7 b
BHN 998	2,142 a	7,710 a	20,605 a	23,741 a	0.0 b
BHN 1054	2,270 a	8,732 a	15,610 a	26,612 a	0.0 b
BHN 602 nongrafted	2,658 a	8,419 a	15,686 a	26,765 a	4.2 a
LSD (0.05)	ns	ns	ns	ns	1.0
P > F	0.3082	0.3117	0.6222	0.3005	<0.0001

[x] The trial was conducted in 2012 at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, VA. Column means followed by the same letter are not significantly different at $P \leq 0.05$ based on Fischer's least significant difference (LSD); ns = not significant.
[y] United States Department of Agriculture size grades. Minimum–maximum fruit diameter: medium size = 5.72 to 6.43 cm, large size = 6.35 to 7.06 cm, and extra-large size = 7.00 cm.
[z] RGI is a 0-to-10 scale indicating the severity of root galling (34) in a field inoculated with *Meloidogyne incognita*. Each entry consisted of four replications with 18 plants in each replication.

yield compared with the BHN 602 self-grafted and nongrafted controls but was comparable with that of BHN 1054 ($P = 0.0451$) (Table 3). There was a significant difference among the treatments in fruit yield for the extra-large size class, with BHN 998 providing higher yield than the self-grafted and nongrafted controls ($P = 0.0367$). There were no significant differences in yield among the treatments for the medium and the large size classes.

Virginia 2012. In this experiment, no root galling was observed on BHN 998 and BHN 1054 (Table 4). RGI values in all three rootstocks were lower than those of the BHN 602 nongrafted control ($P = <0.0001$). Despite the difference in the RGI values among the treatments, no differences in total yield were found between grafted plants and the nongrafted controls (Table 4). There was also no difference among the treatments in fruit yield for the medium, large, and extra-large size classes.

Discussion

RKNs are one of the major concerns in fresh-market tomato production in the southeastern United States (16,21). Grafting has been widely used for managing RKNs worldwide but limited work has been done in the United States to test the effectiveness of grafting in reducing the damage caused by RKNs in naturally infested soil (13). In the present study, three new tomato hybrid rootstocks with known resistance to bacterial wilt were tested for their possible use as grafting rootstock sources with resistance to RKNs in open-field tomato production. Grafting the hybrid rootstocks onto a

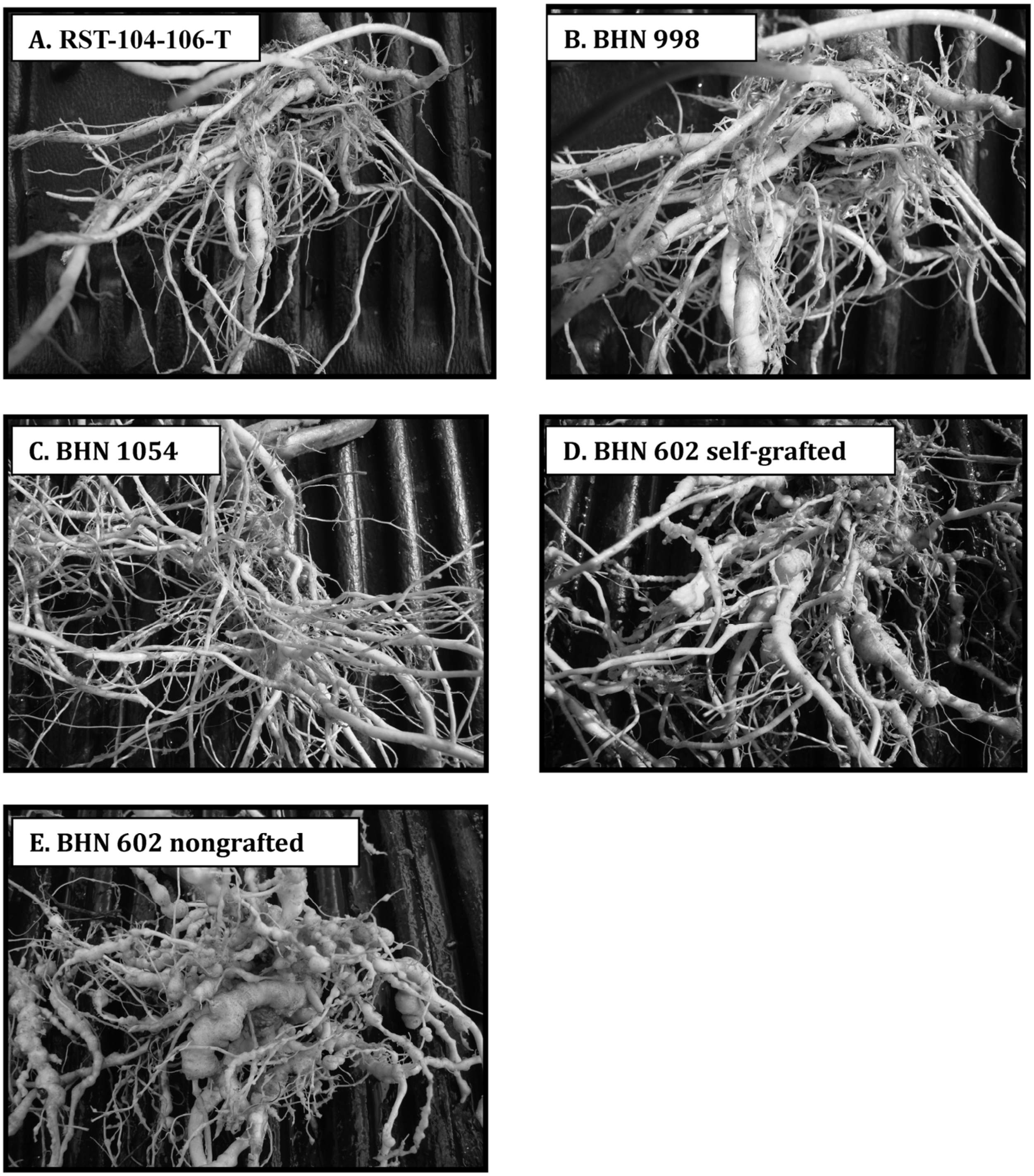

Fig. 1. Root galling on tomato rootstocks infected with *Meloidogyne incognita*: **A,** RST-104-106-T; **B,** BHN 998; and **C,** BHN 1054 grafted below susceptible scion BHN 602; **D,** BHN 602 self-grafted; and **E,** BHN 602 nongrafted (2011, University of Florida, North Florida Research and Education Center, Quincy).

susceptible scion significantly decreased RGI in all the field trials conducted for two consecutive years in Florida and Virginia compared with the nongrafted BHN 602 and self-grafted BHN 602 controls. In the field trial conducted at Painter, VA in 2011, the scion grafted onto BHN 1054 exhibited a higher RGI value than in other trials. BHN Seed Company has tested and confirmed resistance of the BHN 1054 rootstock to *M. incognita* but did not test resistance to *M. arenaria*, *M. javanica*, *M. hapla*, and other species. Greenhouse studies in our lab have demonstrated resistance of BHN 1054 rootstock to *M. javanica* (*data not shown*). In tomato, the *Mi* gene, a single dominant gene, has been reported to provide effective resistance against *M. arenaria, M. incognita*, and *M. javanica* (5,19). The *Mi* gene does not confer resistance to *M. hapla*. We did not reisolate the RKN species from the BHN 1054 rootstock, which exhibited higher RGI values, to confirm which species was responsible for the galling. Thus, further experiments are required to determine the resistance of BHN 1054 and other hybrid rootstocks in this study to *M. arenaria, M. hapla*, and other species.

In both field trials conducted in Florida, grafting a susceptible scion onto the resistant rootstocks showed a positive effect on yield with some graft combinations in each trial. These results were similar to a previous study, where grafting a susceptible scion onto nematode-resistant rootstocks significantly increased fruit yields in fields infested with *Meloidogyne* spp. (16). In all of the field trials where self-grafted BHN 602 was included, the self-grafted treatment was comparable with the nongrafted control, indicating that grafting itself did not affect fruit yield. RGI values in the 2011 and 2012 Virginia trials were significantly different among the grafted and the nongrafted plants but total marketable yield responses were statistically similar. In the 2011 trial, Hurricane Irene passed through the Virginia trial location, causing severe aboveground damage on tomato, thus affecting total marketable yield. In the 2012 trial, the lack of yield response may have been due to an absence of an advantage of using resistant rootstocks compared with a susceptible variety under low inoculum pressure. A recent study conducted using *M. javanica* on the yield of RKN-susceptible 'Moneymaker' and 'Castlerock II' tomato and resistant 'Motelle' and 'Sun 6082' conducted in both greenhouse and microplots demonstrated that, under low inoculum levels of 8,000 and 20,000 eggs/plant, nematode infection did not affect yield of the susceptible cultivar compared with the resistant cultivar (3). However, at 200,000 eggs/plant, the use of resistant cultivars led to a significant increase in yield, which was attributed to the fitness benefit of these cultivars under high nematode pressure. Another study on the impact of initial RKN inoculum level on the yield of susceptible 'Blitz' tomato grafted onto resistant rootstock Beaufort demonstrated that, at inoculation densities of 100, 1000, 10,000, and 100,000 eggs/plant under greenhouse conditions, only inoculation at 100,000 eggs/plant led to a significant reduction in yield (16). In our studies, we did not enumerate the number of RKNs in soil before planting tomato after disking infected squash. Based on the findings from the previous studies (3,16), it is likely that the low initial nematode pressure in the 2012 trial in Virginia may have led to no yield impact.

Resistance against bacterial wilt disease was already verified in the rootstocks utilized in this study (18). Bacterial wilt caused by *R. solanacearum* is widely distributed in the southeastern United States and causes significant yield loss of tomato (9–11,26). To the best of our knowledge, this is the first study reporting that grafting-mediated effective field management of RKN in tomato using commercially available bacterial wilt-resistant rootstocks. Therefore, this technology may serve as an ideal component in integrated pest management programs to simultaneously reduce RKN and bacterial wilt incidence in the field. However, a previous study showed that, in fields with both RKN and *R. solanacearum*, the nematodes significantly increased bacterial wilt in 'Floradel' and 'Caraibo', both tomato cultivars susceptible to bacterial wilt and RKNs (4). Based on this, further studies are in progress to test these new hybrid rootstocks for the ability to reduce both root galling and bacterial wilt in fields with both *R. solanacearum* and *M. incognita* inoculum.

The results from this study show the horticultural feasibility of grafting market-preferred susceptible scions onto a suitable rootstock to manage RKN in tomato production. Use of this grafting technique was shown to mitigate crop damage by reducing nematode populations and root galling, which improved tomato yield under high RKN pressure (23). Grafting also provides a number of other advantages, including (i) it is a simple technique requiring minimal training and (ii) it is an ideal alternative for organic tomato production, where chemical treatments cannot be applied in the field (12). A recent study on cost-benefit analysis of grafting in organic tomato production showed that, under high RKN pressure, grafting would be a feasible approach to maintain profitable production (1). Selection of suitable rootstocks resistant to a wide variety of pathogens presents a good potential option for effective soilborne pathogen control in integrated pest management programs, and would be potentially cost beneficial if multiple pests can be managed at the same time. Current studies on the effectiveness of grafting using these rootstocks in the presence of both *R. solanacearum* and *M. incognita* inoculum in the same field is expected to provide input for studying the broad impact of grafting in a multipathogen system.

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