

CALIFORNIA FRESH CARROT ADVISORY BOARD
Research Report
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Project Title: Identification of gene sources for resistance to root-knot nematodes attacking carrots in California

Project Leader: P. A. Roberts, Department of Nematology, U.C. Riverside

Cooperators: W. C. Matthews, Department of Nematology, U.C. Riverside
P. W. Simon, USDA/ARS, University of Wisconsin-Madison

Root-knot nematodes (*Meloidogyne* spp.) are a major problem to carrot production because their root infection causes galling and forking distortion of the taproot, rendering the carrots unmarketable. They are especially prevalent in the loam to sandy soils used for carrot production in California. In an approach to find alternative management strategies to soil fumigation treatments, our goal is to characterize carrot germplasm with genetic resistance and tolerance to root-knot nematodes, and to provide advanced lines that will enable carrot breeders to develop resistant cultivars suitable for California fresh market production. In collaboration with Dr. Phil Simon, USDA, Wisconsin, different sources of resistance and tolerance are being advanced and combined to provide carrot cultivars with a broad-based protection against the spectrum of root-knot nematode species. Emphasis is being placed on the high resistance to *M. incognita*, *M. javanica*, and *M. arenaria* in Brasilia line BR-1252, high resistance in several non-Brasilia resistance sources, and moderate to high tolerance to the northern root-knot nematode *M. hapla* in some of the USDA Wisconsin inbred lines. Genetic characterization and combining abilities of different resistance sources are being investigated through crossing, progeny screening, and molecular marker analysis in allelism tests. New combinations among the resistance sources show excellent promise for developing broad-based root-knot nematode resistant carrots.

Our field screening of carrot breeding lines for nematode resistance has been expanded in recent years to include materials from seed companies, and we are fostering their collaborative involvement in the field trial assessments. Some of the most advanced nematode resistant selections have been seed-increased by seed companies to provide seed quantities large enough to perform small-scale field testing in commercial fields. An important feature in the process of selecting and advancing field and greenhouse screened materials is leaf tissue sampling for DNA extraction and marker analysis at time of resistance evaluation. Field and greenhouse selected roots were shipped to Dr. Simon in Wisconsin for selfing or crossing, following vernalization for several weeks in cold storage either before or after shipping.

Field screening of inbred lines and resistant progeny selections:

Kearney REC trials: Field screenings of advanced lines including inbred crosses developed by Dr. Simon were made in 2015 at the U. C. Kearney Research and Extension

Center (KREC), Parlier, Fresno Co. Carrot lines together with known resistant and susceptible control lines were tested on two field sites, one infested with *M. incognita* (MI) and a second with *M. javanica* (MJ). The *M. incognita* population (isolate Project 77) at the KREC site is originally from Tulare Co. in the San Joaquin Valley, California, and representative of *M. incognita* infestations in carrot growing areas of the state. The complete screening results from approximately 1,600 plots on the two sites are summarized in Table 1. Tests were made in 3-foot plots as in previous years, planted 5/21/15 and harvested for evaluation 10/6-7/2015. Infection was excellent in both MI and MJ trials, on the basis of the susceptible I-58 controls, which were planted every 5th plot. The mean control score in the MI trial was 7.02 (range 5.5 to 8), higher than the 2014 South Coast REC trial. The mean control score in the MJ trial was 6.99 (range of 36.5 to 8), also higher than the 2014 South Coast trial. Crop rotation at Kearney where a field block of 44-rows is used for trials every 4 years has improved the infection levels and uniformity, and also minimized problems associated with other diseases. The 3-year crop cycle before the test year was sorghum followed by a susceptible legume followed by susceptible tomato.

The root symptom evaluations were based on a 0 to 8 scale for amount of taproot galling and galling of fibrous roots. Plots with scores of 1 to 2 were mostly resistant with evidence of possible segregation. Plot with a score of 5 had > 50% susceptible roots, but often some resistant roots could be selected from the plot. Plots with a score of 7 were fully susceptible, and a plot with a score of 8 was susceptible mixed with some rot, mostly from infection by *Sclerotium rolfsii*. Rot was slightly more of a problem in the MI trial, but did not significantly impact scoring or selection. Both trials were very effective in distinguishing resistant and susceptible entries, and a substantial percentage of entries were resistant (scores of 2 or lower), indicating resistance held up well to the high infection levels and high temperature.

In contrast to the 2014 trials conducted at South Coast REC, there was little evidence of forking in 2015. Horticultural quality overall was quite good given the harsh conditions (nematode infection level and temperature), enabling selection for both nematode resistance and quality (root shape, etc.).

About 1600 plots in total were planted in the two main field trials (MI and MJ), roughly the same number as planted in 2014. In each trial, 567 USDA breeding material entries from Phil Simon, about 150 susceptible Imperator 58 checks, and 29 industry submissions (not including industry dedicated rows for breeding material) were planted. Entries were replicated once in each trial with the exception of the 29 industry submissions and 7 of the USDA entries (F1's), which were replicated twice. In addition to the main trials, 8 rows consisting of 560 plots (70 plots/row) were allocated to industry in each trial for nematode screening and selection for resistance. For consistency, industry plantings followed the protocol used in the main trials with a susceptible check every 5th plot along each row. Entries in the industry-dedicated rows were replicated twice.

A field day was held during the harvest evaluations on 10/7/15, highlighted by the *M. incognita* trial, and attended by seed company and carrot industry personnel.

Main Nursery trials: Data from the USDA trials are presented in Table 1. Data on the 29 industry submissions were reported directly to the respective industry partners. USDA entries included 43 F2 populations (section 1 of the table), 460 more advanced (F3 to F5) populations (section 2 of the table), 4 inbreds for release (section 3), and a group of 60 entries that had been seed-produced by industry and consisted of inbreds, and crosses with inbreds, including 7 F1 hybrids that were replicated twice in each trial.

Entries in the F2 section (entries 101 to 143) were new and being nematode-screened for the first time. Most of the F2 populations were derived from crossing single resistance sources with root quality sources (e.g., plot 106 – 0568B x HM), from combining multiple resistances with quality (e.g., plot 112 – (HM x Bx6) x 9359B), or from crossing resistance by resistance sources (e.g., plot 116 – (Bx6 x HM) x (8483 x 9256)). Plot scores indicated most F2's segregated for resistance (scores of 1 to 2) or had moderate levels of resistance (scores of 3 to 5), as expected with one of the parents (the root quality source) in the cross being susceptible.

In the large section of more advanced material consisting of 460 entries (entries 144 to 603), 277 entries or 60% had scores of 2 or less in each trial and are highlighted (shaded and in bold letters) in Table 1. Most entries were derived from roots selected from the 2013 Kearney REC trials (entries with root source designation 3K), from the 2012 South Coast REC trials (root source designation 2SC) or from the 2014 South Coast REC trials (designation 4SC). The high percentage of entries that were very resistant or segregated with a low incidence of galling (plot scores of 2 or lower) reflect the efficacy in selection for resistance in 2012 to 2014. Many entries in the more advanced group were derived from crosses combining different resistance sources, e.g., SFF x HM (entries 477 to 486) or PD x WR (entries 491 to 495). Some single resistance sources were also highly resistant (e.g., Scarlet Fancy x Favourite, entries 407 to 412, or Homs, entries 396 to 400, or Nb8483B, entries 322 and 323). The F3 to F5 group included a number of entries designated as inbreds (N designation in the pedigree), and most were highly resistant. Most of the inbreds were developed from crosses with the Brasilia 1252 resistance source, hence the Nb designation in the pedigree. Other inbreds have Brasilia and Homs in the pedigree (designated Nbh, entries 437 to 439) or Ping Ding and Western Red in the pedigree (designated Npw, entries 432 to 436) and were also highly resistant. Entries that were derived from roots selected in 2013 and 2014 where a resistant inbred was crossed with a root quality source were also very resistant, e.g., Nb8524B x (FN2-9 x 2302) (entries 461 to 463) or Nb8483B x 9256B (entries 414 to 422 and 283 to 285). The four inbreds targeted for release were either derived from Brasilia 1252 (Nb) or Scarlet Fancy x Favourite (Ns) and were highly resistant (entries 604 to 607).

Of the 60 entries in the industry seed-production section (entries 608 to 732), 27 entries or 45 % had scores of 2 or less and are highlighted in Table 1. This group included some older inbreds (e.g., 6526B, 8542B, 8524B, 4001B), all with Brasilia 1252-based resistance in the pedigree (Nb designation). These have been tested extensively in field

and greenhouse in the past and were mostly consistently resistant. 4001B was one of the genotypes used in the nematode multi-isolate greenhouse test in both 2014 and 2015 (see below). Some new inbreds with Brasilia 1252 in the pedigree were also tested (e.g., Nb9296B, 9297B, and 9324B). Of interest in this section are HM x (Bx6) – entries 632 to 635 and Nb8483 x 9256 – entries 642 to 648, both having the same pedigree as two of the genotypes used in the nematode multi-isolate greenhouse tests of 2014 and 2015 (see below). These together with 4001B were some of the most consistently resistant genotypes in those greenhouse tests. It is promising that an F1 hybrid of HM x (Bx6) crossed with a resistant male sterile (4001B in the pedigree) as the female parent – entry 636, was highly resistant in both field trials. This suggests that combining Homs and Brasilia 1252 resistance genes on one side of the cross may be a useful strategy. Scores of the 7 F1 hybrids at the end of the table were disappointing, especially in the MI trial, considering there was putative resistance (all Brasilia 1252-derived) on both sides of the cross. It is possible that some of the parents used in these crosses were not homozygous for all resistance genes.

Selection for resistance and quality were made on entries in both MI and MJ trials. Selected roots were shipped to Wisconsin to be vernalized and planted in the 2015-16 winter nursery for crossing and (or) seed production.

Greenhouse evaluations:

Greenhouse trials were conducted with two objectives. The first major effort was to repeat and expand the screening of a carrot genotype resistance panel with multiple root-knot nematode isolates, in order to determine how broadly effective are the identified resistance sources to the main root-knot nematode species attacking carrots (sections 1-3). A second major effort was a continuation of controlled screening of populations segregating for *M. incognita* resistance (sections 4 and 5), in attempts to define the trait loci and to develop markers for the loci for use in the breeding programs.

1. A second round of a multi-isolate screening of 11 resistant carrot genotypes (listed in Table 2) and 1 susceptible control (Imperator 58) was conducted to look at possible variability among root-knot nematode isolates on different sources of resistance. The focus in 2015 was to re-test the genotypes with the *M. incognita* isolates. In addition to the isolates used in 2014 (refer to Table 2 in the 2014 report), four more *M. incognita* isolates were included, for a total of 29 *M. incognita* isolates. The additional isolates came from fields in California where tomato resistance was compromised. These isolates have been re-tested in the greenhouse to confirm that they are virulent on the *Mi-1* resistance gene in tomato. Of the 29 isolates, 8 were found to be partially to fully virulent on the *Rk* resistance gene in cowpea (blackeyes), 8 were partially to fully virulent on the *Mi-1* gene in tomato, and 13 were avirulent to both resistance genes. Most isolates had been identified to species (and race where appropriate) previously using a host differential test. In addition, to confirm identification, all isolates were submitted to the CDFA diagnostic lab in Sacramento for species-specific molecular fingerprinting.

2. With the exception of two carrot genotypes (UCR 40 and the F5 genotype), seed for the carrot genotypes tested in 2015 came from roots selected from the 2014 multi-isolate test (Table 2). The most resistant roots of each genotype were vernalized and sent to Wisconsin to be caged together to produce a new more homogeneous population. This was done to reduce variability in the test due to segregation for resistance and therefore give a more reliable test of variability among the nematode isolates. The UCR 40 roots sent to Wisconsin failed to produce seed, so the seed source used in 2014 was used in 2015. The F4 roots sent to Wisconsin also failed to produce seed, so an F5 source with the same pedigree (BR 1091 x Homs) and root source was substituted. Each genotype x isolate combination was replicated 4 times. Carrots were direct-seeded into pots, 2 seeds/pot, and thinned to 1 plant/pot before inoculation. One month-old carrots at the 3- to 5-leaf stage were inoculated with approx. 50,000 eggs per plant in late May 2015. The Western Red genotype again germinated poorly, and there were only enough plants available for 2 reps.
3. As in 2014, some genotypes were prone to early bolting, primarily Ping Ding, F5 and HxB, but this was less of a problem in 2015 due to selection away from bolting. The test ran for about 10 weeks. The roots were washed and fibrous roots scored for galling. Some segregation for resistance occurred in some genotypes to most of the isolates, primarily in the two Homs genotypes, Western Red and Ping Ding. The most resistant roots of each genotype were vernalized and sent to Wisconsin for seed production and DNA extraction. Of the 11 genotypes, only 1 of them (SEM, or 8483 x 9256 and derived from Brasilia 1252) showed significant improvement in having an overall lower gall score in 2015 than in 2014, indicating this genotype benefited from the 2014 selection process. SEM was the most resistant of the 11 genotypes in the 2015 test. Depending on the isolate, there was good resistance in some of the genotypes, especially Ping Ding and Western Red. However, the most resistant genotypes across isolates were derived from Brasilia 1252 (UCR 40, 4001B, SEM, and HxB) and the F5 genotype. Among isolates, there was little evidence of a correlation between virulence on the *Mi-1* and *Rk* genes and their ability to parasitize the carrot genotypes. Of the 29 isolates, 3 did appear to be slightly more aggressive on some carrot genotypes, especially on Homs and Ping Ding. The Brasilia 1252 sources, especially SEM, appeared unaffected by those more aggressive isolates.

The preliminary data analysis from this experiment confirmed the 2014 results in revealing broadly effective resistance among the carrot panel to the large collection of *M. incognita* isolates, although some moderate ability to parasitize resistance sources was evident in some isolates, but no evidence of clear virulence.

4. A screen with *M. incognita* was conducted on B3999 cage 333-1 BR-1252 derivatives that were fixed for the *Mj-1* gene resistance and segregated for resistance to *M. incognita*. These were all designated UCR sources, two of which (UCR 4 and 40) were used in the multi-isolate test (sections 1-3). Seven F3MS families were screened including two families that segregated with a range of

scores from 0 to 8 (150 plants per family) plus about 50 each of five families that were either uniformly resistant or susceptible, or which segregated. A total of 550 plants were tested. Leaf samples were taken for DNA extraction and shipped with roots to Wisconsin for genotyping, selfing and crossing to resistant and susceptible male sterile plants. This effort is being conducted to genetically map the *M. incognita* resistance determinants and to provide molecular marker information for the resistance loci.

5. Screens with *M. incognita* of one F2 (95644 – long x 8503) and one F3 (80080 – 8483 x 9256) populations were completed or are in progress. The purpose of these screens is to fine map BR1252 x 6274 MI resistance in different susceptible backgrounds. The test of the 95644-derived F2 was successful, with 180 roots and galling scores ranging from 0 to 8 and representing strong segregation. Roots from these tests were sent to Wisconsin for inclusion in the summer nursery. Another F2 was screened in the summer but did not segregate for *M. incognita* resistance. Screening with *M. incognita* of additional F2 and other populations has been started with 270 F2 plants per population.

Please also refer to the report by Dr. Phil Simon (Carrot Breeding to Develop and Introduce Improved Cultivars).

Table 1. 2015 Carrot Nematode Trials

Entry No.	Pedigree	Gen.	Root		Seed Source	Rem.	M. javanica		M. incognita	
			Source	Source			Check score	Entry score	Entry score	Check score
10	· F2	15K_101	—	15K_143						
54	· F3-F5 Includes Some Inbreds	15K_144	—							
517	· Inbreds for Release	15K_604	—	15K_607						
522	· Industry Production	15K_608	—	15K_732						
590	· end									
· F2										
15K_101	((B x 6) x (PD x PI326011)) x FS	F2	30031	113014	4.1	2.5	4	4		
15K_102	(FN2-9 x 2302) x ((B x 6) x (PD x PI326011))	F2	30035	113016	3.4	5.5	4	4		
15K_103	2566B x (SFF x HM)	F2	30036	113017	1.4	6	5	5		
15K_104	8542B x ((4367B x ((D.c. Germ.) x (D.c. Germ. x 3475B)))	F2	30037	113018	1.4	3	3	7	7	
15K_105	0566B x ((B x 6) x (PD x PI326011))	F2	30038	113019	2.2	3	2.5	2.5		
15K_106	0568B x HM	F2	30039	113020	0.8	5.5	5	5		
15K_107	(HM x NF) x 0569B	F2	30040	113023	1.5	4	4.5	4.5		
15K_108	(FN2-9 x 2302) x (WR x PD)	F2	30056	113031	0.6	5	6	6		
15K_109	(FN2-9 x 2302) x (WR x PD)	F2	30056	113032	0.9	4.5	4	4	7	
15K_110	(FN2-9 x 2302) x (WR x PD)	F2	30056	113034	1.5	3.5	5.5	5.5		
15K_111	0572B x (HM x SFF)	F2	30076	113038	1.3	5	5	5		
15K_112	(HM x Bx6) x 9359B	F2	30090	113044	1.4	3.5	3	3	7	
15K_113	(HM x Bx6) x 9359B	F2	30090	113045	2.0	3	1.5	1.5		
15K_114	(HM x SFF) x 0556B	F2	30092	113046	0.9	6	5	5		
15K_115	(HM x SFF) x 0556B	F2	30093	113047	2.2	7	6	6		
15K_116	(Bx6 x HM) x (8483B x 9256B)	F2	30098	113048	1.1	3	0	0	6.5	
15K_117	(Bx6 x HM) x (8483B x 9256B)	F2	30098	113049	1.2	2.5	1	1		
15K_118	(PD x WR) x 9782B	F2	30105	113050	0.1	4	2.5	2.5		
15K_119	(PD x WR) x 9782B	F2	30105	113051	0.7	4	3	3		
15K_120	(PD x WR) x 7553B	F2	30106	113052	0.2	5	4	4	7	
15K_121	SFF x (SFF x HM)	F2	30112	113056	1.8	2	1	1		
15K_122	(8483B x 9256B) x (Bx6 x HM)	F2	30117	113058	5.3	5	1	1		
15K_123	(8483B x 9256B) x (Bx6 x HM)	F2	30125	113062	2.0	3	1	1		
15K_124	(8483B x 9256B) x (Bx6 x Homs)	F2	30126	113063	0.7	3	1	1	7	
15K_125	(8483B x 9256B) x (Bx6 x Homs)	F2	30128	113064	0.7	2.5	0	0		
15K_126	HM x 0568B	F2	20134	97381	0.2	4.5	4	4		
15K_127	(HM x NF) x 0569B	F2	20138	97385	0.1	5	1	1		
15K_128	0571B x (HM x SFF)	F2	20139	97386	3.1	5	3	3	7	
15K_129	(HM x SFF) x 0571B	F2	20140	97387	1.0	5.5	4.5	4.5		
15K_130	(HM x SFF) x 0571B	F2	20140	97387	0.9	6	3.5	3.5		
15K_131	((B x 6) x (PD x PI326011)) x 0572B	F2	20142	97389	2.7	5	4	4		
15K_132	7262B x HM	F2	20146	97393	0.2	2.5	3.5	3.5	7	
15K_133	((B x 6) x (PD x PI326011)) x (8483B x 9256B)	F2	20147	97394	3.1	1	1	1		
15K_134	(8483B x 9256B) x ((B x 6) x (PD x PI326011))	F2	20148	97395	2.1	3	1.5	1.5		
15K_135	(B x 6) x ((PD x PI326011) x WR)	F2	20149	97396	2.7	3	3	3		

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Entry	Pedigree	Gen.	Root		Seed	M. javanica		M. incognita	
			Source	Rem.		Entry score	Check score	Entry score	Check score
15K_136	(PD x PI326011) x WR) x (B x 6)	F2	20150	0.6	97397	2.5	7	2	6.5
15K_137	White Pop x (B x 6)	F2	20154	1.1	97405	3		NS	
15K_138	SFF x NF	F2	20161	1.5	97411	3.5		2.5	
15K_139	NF x (HM x (B x 6))	F2	20164	0.9	97414	4		3	
15K_140	NF x (HM x (B x 6))	F2	20164	0.7	97415	3	7	4.5	7
15K_141	(WR x HM) x 2566B	F2	20165	1.4	97416	3.5		5	
15K_142	2566B x (WR x HM)	F2	20166	1.4	97418	3		4	
15K_143	(FN2-9 x 2302) x ((B x 6) x (PD x PI326011))	F2	20212	3.7	97450	5		1.5	
F3-F5 Includes Some Inbreds									
15K_144	(HM x (B x 6)) x ((B x 6) x WR)	F3	2SCI103	2.3	98037	1	7	0	7
15K_145	(HM x (B x 6)) x ((B x 6) x WR)	F3	2SCI103	1.0	98038	3		1	
15K_146	FS x (HM x (B x 6))	F3	2SCI105	0.0	98040	2		2.5	
15K_147	FS x (HM x (B x 6))	F3	2SCI105	1.4	98042	4		2	
15K_148	9782B x (9256B x 8483B)	F3	2SCI115	0.6	98062	2	7	3.5	6.5
15K_149	9782B x (9256B x 8483B)	F3	2SCI115	1.2	98068	1		3	
15K_150	8524B x (FN2-9 x 2302)	F3	2SCI121	0.1	98094	6		3.5	
15K_151	0493B x SFF	F3	2SCI172	3.5	98189	2.5		5	
15K_152	NF x HM	F3	2SCI180	2.1	98190	6	7	4.5	7
15K_153	NF x HM	F3	2SCI181	2.8	98196	4		4.5	
15K_154	NF x HM	F3	2SCI181	1.3	98197	5		4	
15K_155	NF x HM	F3	2SCI181	1.3	98202	5		2.5	
15K_156	HM x SFF	F3	2SCI192	2.2	98206	1	7	1	7
15K_157	HM x SFF	F3	2SCI192	0.8	98208	1		0	
15K_158	WR x (FN2-9 x 2302)	F3	2SCI204	2.8	98209	5		3.5	
15K_159	8503B x (SNts x EFM)	F3	2SCI217	3.8	98215	2.5	7	2.5	7
15K_160	8503B x (SNts x EFM)	F3	2SCI217	2.5	98216	2		3	
15K_161	8503B x (SNts x EFM)	F3	2SCI217	1.6	98217	3		4	
15K_162	8503B x (SNts x EFM)	F3	2SCI217	3.2	98219	3		3.5	
15K_163	SFF x HM	F3	2SCI223	1.6	98236	1	7	2	7
15K_164	SFF x HM	F3	2SCI223	0.5	98239	3.5		0	
15K_165	(PD x PI326011) x WR	F3MS2	2SCI266	2.4	98289	6		2.5	
15K_166	(PD x PI326011) x WR	F3MS2	2SCI266	3.3	98292	2.5		2.5	
15K_167	(PD x PI326011) x WR	F3MS2	2SCI267	2.8	98295	1	7	0	7
15K_168	(PD x PI326011) x WR	F3MS2	2SCI267	3.5	98296	2		1	
15K_169	(PD x PI326011) x WR	F3MS2	2SCI267	2.6	98298	2		1.5	
15K_170	(PD x PI326011) x WR	F3MS2	2SCI267	2.6	98302	1		0	
15K_171	(PD x PI326011) x WR	F3MS2	2SCI267	1.6	98303	0	7	1	7
15K_172	(PD x PI326011) x WR	F3MS2	2SCI271	0.9	98306	1		1	
15K_173	(PD x PI326011) x WR	F3MS2	2SCI271	0.6	98307	2		2	
15K_174	(PD x PI326011) x WR	F3MS2	2SCI271	1.4	98308	1		0	
15K_175	(PD x PI326011) x WR	F3MS2	2SCI271	1.7	98311	2	7	1	6.5
15K_176	(PD x PI326011) x WR	F3MS2	2SCI271	1.3	98312	0		1	
15K_177	(PD x PI326011) x WR	F3MS2	2SCI271	0.5	98312	NS		NS	
15K_178	(PD x PI326011) x WR	F3MS2	2SCI271	0.6	98313	2		0	
15K_179	(PD x PI326011) x WR	F3MS2	2SCI271	1.4	98315	2	7	1	7

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Entry	Root			Seed			M. javanica		M. incognita	
	Gen.	Source	Source	Rem.	Entry score	Check score	Entry score	Check score		
15K_180	F3MS2	2SCI271	98317	0.4	1		1.5			
15K_181	F3MS2	2SCI271	98318	1.2	1		0			
15K_182	F3MS2	2SCI271	98319	2.3	2		1.5			
15K_183	F3MS2	2SCI271	98320	2.1	1	7	1.5	7		
15K_184	F1M2SMS2M2S2	2SCI312	98361	1.2	1		1.5			
15K_185	F1M2SMS2M2S2	2SCI312	98363	1.7	1.5		1			
15K_186	F1M2SMS2M2S2	2SCI312	98364	0.8	1		1.5			
15K_187	F1M2SMS2M2S2	2SCI320	98366	1.1	1.5	7	1	7		
15K_188	F1M2SMS2M2S2	2SCI320	98368	0.8	1		1			
15K_189	F1M2SMS2M2S2	2SCI320	98369	0.1	0		0			
15K_190	F1M2SMS2M2S2	2SCI320	98371	1.1	1		0			
15K_191	F2MSMS5	2SCI328	98383	0.8	3	7	1.5	6.5		
15K_192	F4MS2	2SCI334	98390	0.1	4.5		1			
15K_193	F4MS2	2SCI334	98392	1.9	1		0			
15K_194	F1XMS2MS3	2SCI348	98401	0.4	1		1			
15K_195	F1XMS2MS3	2SCI350	98412	0.9	2	7	0	8		
15K_196	F2MS6	2SCI353	98418	0.6	1.5		0			
15K_197	F6	2SCI360	98423	0.3	2		2			
15K_198	F6	2SCI360	98427	3.0	4		0			
15K_199	F6	2SCI360	98428	1.4	5	7	0	6.5		
15K_200	F7	2SCI364	98439	0.1	3		1			
15K_201	F2MS2	2SCI375	98460	1.0	4.5		3			
15K_202	F6	2SCI380	98467	1.4	1		0			
15K_203	F6	2SCI381	98474	0.2	0	7	1	7		
15K_204	F6	2SCI381	98477	0.6	2		1			
15K_205	F6	2SCI381	98478	0.7	2		0			
15K_206	F5	2SCI397	98485	0.0	3		0			
15K_207	F5	2SCI397	98486	1.3	2	7	1	7		
15K_208	F5	2SCI397	98492	0.8	1		1			
15K_209	F4	2SCI460	98536	0.4	4.5		2			
15K_210	F4	2SCI460	98538	0.7	2		0			
15K_211	F4	2SCI518	98584	4.0	1	6.5	1	6.5		
15K_212	F4	2SCI518	98585	0.2	0		NS			
15K_213	F3MS	2SCI518	98593	3.4	0		0			
15K_214	F3MS	2SCI518	98594	0.8	0		1			
15K_215	F4	2SCI610	98734	2.2	3		1.5			
15K_216	F3	4049	116236	10.0	5	7	6.5	7		
15K_217	F3	4131	117242	11.9	7		7			
15K_218	F3	4057	116254	3.4	NS		5			
15K_219	F3	4062	116268	5.4	6		5			
15K_220	F3	4062	116270	3.4	6	7	6	7		
15K_221	F3	4186	116332	5.0	6		5			
15K_222	F3	4187	116418	1.4	2.5		0			
15K_223	F3	4195	116420	0.6	2	7	1.5	7		
15K_224	F3	4201	116432	4.4	2		1			

Table 1. 2015 Carrot Nematode Trials

Entry	M. javanica				M. incognita			
	Gen.	Root	Seed	Check score	Entry score	Check score	Entry score	Check score
15K_225	PD x PI326011) x WR	F3MS	4217	116438	2.0	1.5	1	1
15K_226	SFF	F1XMS4	4219	116460	4.9	2	0	0
15K_227	Nb8483B x 9256B	F6	4226	116462	0.8	1	0	0
15K_228	(FN2-9 x 2302) x HM	F4	4239	116472	12.5	3	1	7
15K_229	Nb8524B x (FN2-9 x 2302)	F4	4253	116482	1.2	5	4	4
15K_230	Nb8524B x (FN2-9 x 2302)	F4	4253	116494	6.6	2.5	1.5	1.5
15K_231	Nb8524B x (FN2-9 x 2302)	F4	4253	116498	13.3	6	5.5	5.5
15K_232	HM x (Nb8483B x 9256B)	F4	4257	116502	3.3	3	NS	7
15K_233	PD x ((Bx6) x WR)	F4	4260	116504	13.4	7	5	5
15K_234	(Snts x EFM) x (HM x (Bx6))	F4	4271	116518	1.6	5.5	7	7
15K_235	Horns	XXMXSM3S	4333	116646	15.0	3	1.5	7
15K_236	SFF	F1XMS3M2S	4335	116650	12.3	3	3	7
15K_237	9782B x (9256B x 8483B)	F2MS	4432	116780	2.1	6	5	5
15K_238	(FN2-9 x 2302) x 4002B	F2MS	4434	116786	1.7	6	5	5
15K_239	(8483B x 9256B) x HM	F2MS	4434	116788	3.0	5	3.5	3.5
15K_240	(8483B x 9256B) x HM	F2MS	4444	116810	0.4	2	1	7
15K_241	(8483B x 9256B) x HM	F2MS	4446	116818	1.5	2	0	0
15K_242	(PD x PI326011) x WR	F3MSMS	4460	116858	0.1	2	1	1
15K_243	S.C. x ((PD x PI326011) x WR)	F1	4933	116859	7.1	5	5.5	5.5
15K_244	PD x PI326011	F1M2SMS2M	4461	116860	0.9	1	3	7
15K_245	Bx6	2SMS						
15K_246	Bx6	F2MSMSMS	4465	116864	5.2	7	6.5	6.5
15K_247	S.C. x SFF	F2MSMSMS	4465	116866	0.9	6	4.5	4.5
15K_248	(PD x PI236011) x WR	F1	4942	116871	0.6	3	4	4
15K_249	S.C. x WR x HM	F1	4473	116882	12.7	4.5	4.5	7
15K_250	(PD x PI326011) x WR	F1	4942	116885	1.1	6	5.5	5.5
15K_251	HM x SFF	F5	4477	116888	9.6	4	1.5	1.5
15K_252	S.C. x (HM x SFF)	F3MS	4478	116890	4.8	1.5	3	3
15K_253	(Bx6) x ((PD x PI326011) x WR)	F1	4942	116891	2.0	6	6	7
15K_254	Bx6 x PD	F3	4115	117168	0.4	7	7	7
15K_255	Bx6 x PD	F5	30193	113075	0.4	3	5	5
15K_256	(FN2-9 x 2302) x HM	F5	30193	113076	2.1	1.5	1.5	1.5
15K_257	(FN2-9 x 2302) x HM	F3	31454	113526	0.7	6	7	7
15K_258	HM x (Bx6) x (Snts x EFM)	F3	31454	113527	1.5	6	7	7
15K_259	PD	F3	31456	113531	2.3	4	3	3
15K_260	PD	XXMXSM2MS	K196	114103	0.9	0	1	1
15K_261	PD	XXMXSM2MS	K196	114104	0.5	0	1	1
15K_262	(HM x (Bx6)) x FS	XXMXSM2MS	K196	110446	10.4	6	7	7
15K_263	(FN2-9 x 2302) x HM	F3	3143	110482	10.2	7	7	7
15K_264	(FN2-9 x 2302) x Nb8503B	F3	3157	110490	0.3	5	5.5	5.5
15K_265	PD x ((Bx6) x WR)	F3	3176	110522	4.7	6	5	9
15K_266	(Snts x EFM) x HM x (Bx6)	F3	3196	110552	7.2	5.5	2.5	2.5
15K_267	FN2-9 x 2302	F3	3204	110574	7.2	3	5	5
15K_268	WR x (FN2-9 x 2302)	F1X4M2S3	3307	110678	7.9	7	6	6
		F3	2SCJ204	111618	15.6	6	6	7

Table 1. 2015 Carrot Nematode Trials

Entry	Pedigree	Gen.	Root		Seed	M. javanica		M. incognita	
			Source	Source		Entry score	Check score	Entry score	Check score
15K_269	(HM x Bx6) x 9359B	F3	40975	118849	2.2	1.5	0	0	
15K_270	(HM x Bx6) x 9359B	F3	40975	118850	1.0	1	1	1	
15K_271	(HM x Bx6) x 9359B	F3	40975	118851	1.0	3.5	2	7	
15K_272	(HM x Bx6) x 9359B	F3	40975	118852	1.9	6	6	6	
15K_273	(FN2-9 x 2302) x (WR x PD)	F3	40972	118853	3.0	5	3.5	3.5	
15K_274	(FN2-9 x 2302) x (WR x PD)	F3	40972	118854	3.8	6	5.5	5.5	
15K_275	(FN2-9 x 2302) x (WR x PD)	F3	40972	118856	3.1	3.5	4	7	
15K_276	(HM x Bx6) x 9359B	F3	40976	118859	3.0	4	2.5	2.5	
15K_277	(Bx6 x HM) x (8483B x 9256B)	F3	40979	118860	3.4	1.5	0	0	
15K_278	(Bx6 x HM) x (8483B x 9256B)	F3	40980	118863	2.6	3	1	1	
15K_279	SFF x Uberlandia	F4	4SCJ157	119416	0.2	3	2	7	
15K_280	SFF x Uberlandia	F4	4SCJ157	119417	0.7	2.5	3	3	
15K_281	SFF x Uberlandia	F4	4SCJ158	119418	1.2	3	2.5	2.5	
15K_282	SFF	F2MS4	4SCJ243	119427	0.0	1	0	0	
15K_283	Nb8483B x 9256B	F4MS2	4SCJ249	119428	2.2	1	1	7	
15K_284	Nb8483B x 9256B	F7	4SCJ250	119431	3.3	1	1	1	
15K_285	Nb8483B x 9256B	F7	4SCJ250	119432	2.2	0	0	0	
15K_286	Nb6526B	F4MSMSMS2	4SCJ302	119436	1.0	1	0	0	
15K_287	Nb8524B x (FN2-9 x 2302)	F4	4SCJ341	119437	2.1	2.5	3	7	
15K_288	Nb8483B	F3MSM4S2	4SCJ303	119446	2.0	1	0	0	
15K_289	HM x (Bx6) x (Smts x EFM)	F4	4SCJ347	119452	1.6	1.5	0	0	
15K_290	L9786B x HM	F4	4SCJ356	119456	1.4	0	0	0	
15K_291	L9786B x HM	F4	4SCJ356	119457	2.3	0	0	0	
15K_292	PD x WR	F3MS3	4SCJ391	119465	3.8	1	1	7	
15K_293	9782B x (9256B x Nb8483B)	F2MS	4SCJ402	119467	3.2	5.5	5.5	5.5	
15K_294	9782B x (9256B x Nb8483B)	F2MS	4SCJ402	119469	2.4	3	3	3	
15K_295	Nb8503B x (FN2-9 x 2302)	F4	4SCJ411	119472	3.4	5	6	7	
15K_296	(Nb8483B x 9256B) x HM	F2MS	4SCJ418	119473	4.3	0	1	1	
15K_297	SFF x HM	F4MS	4SCJ429	119476	1.0	0	0	0	
15K_298	(PD x PI326011) x WR	F3MSMS	4SCJ461	119480	1.7	0	1	1	
15K_299	HM x (Nb8483B x 9256B)	F3M	4SC124	119495,96	2.7	1	1	7	
15K_300	HM x (Nb8483B x 9256B)	F3M	4SC124	119496,95	2.6	1	2	2	
15K_301	(FN2-9 x 2302) x HM	F4	4SC136	119506	1.0	3	3.5	3.5	
15K_302	(Nb8483B x 9256B) x HM	F4	4SC144	119514	2.1	4.5	2	2	
15K_303	(Nb8483B x 9256B) x HM (out of order)	F4	4SC144	119513	0.0	3	1	6.5	
15K_304	SFF x ?	F4	4SC149	119515	2.8	0	0	0	
15K_305	HM x SFF	F4	4SC153	119522	0.7	1	0	0	
15K_306	HM x SFF	F4	4SC154	119525	2.1	1.5	0	0	
15K_307	HM x SFF	F4	4SC154	119526	1.3	1	0	6.5	
15K_308	(Bx6) x PD	F6	4SC161	119534	0.9	1	0	0	
15K_309	WR x PD	F3M2S2	4SC171	119542	1.5	0	0	0	
15K_310	WR x PD	F3M2S2	4SC171	119543	0.7	1	0	0	
15K_311	HM x (Bx6)	F2MS5	4SC174	119546	1.6	3.5	1	7	
15K_312	PD x PI326011	F1M2SMS2MS2	4SC1204	119567	0.6	1	1	1	

Table 1. 2015 Carrot Nematode Trials

Entry	Root				Seed		M. javanica		M. incognita	
	No.	Pedigree	Gen.	Source	Source	Rem.	Entry score	Check score	Entry score	Check score
15K_313	SFF	F1XMS2MS4	4SCI212	119574	0.7	1.5	0		0	
15K_314	(PD x PI326011) x WR	F3MS2	4SCI225	119586	1.4	1	1		1	
15K_315	HM	XXMS2M2SMS2	4SCI232	119587	0.0	1	1	7	1	7
15K_316	HM	XXMS2MS2	4SCI237	119594	1.9	3	2		2	
15K_317	Nb8483B x 9256B	F7	4SCI255	119609	0.8	1	0		0	
15K_318	Nh0252B	XXMS2M2SMS2	4SCI259	119612	0.7	1	0		0	
15K_319	Nb1386B	F4MS2	4SCI263	119614	0.3	1.5	1	7	1	7
15K_320	Nb1386B	F4MS2	4SCI263	119615	1.1	0	0		0	
15K_321	Nb2205B	F2MSMS2MS2	4SCI282	119629	0.6	1.5	1		1	
15K_322	Nb8483B	F3MSM4S2	4SCI303	119648	1.4	2	2		2	
15K_323	Nb8483B	F3MSM4S2	4SCI303	119649	0.8	0	0	6.5	1	5.5
15K_324	Nb8524B	F3M8	4SCI308	119655	3.2	3.5	2		2	
15K_325	Nb9324B	F5M2S2	4SCI325	119665	0.0	2	3.5		3.5	
15K_326	Nb8524B x (FN2-9 x 2302)	F4	4SCI341	119675	0.2	3	4		4	
15K_327	Nb8524B x (FN2-9 x 2302)	F4	4SCI341	119676	0.4	NS	NS		NS	
15K_328	HM x (Bx6) x (Snts x EFM)	F4	4SCI347	119678	2.6	1.5	1	7	1	7
15K_329	HM x (Bx6) x (Snts x EFM)	F4	4SCI347	119680	1.2	1	1		1	
15K_330	HM x (Bx6) x (Snts x EFM)	F4	4SCI347	119681	0.9	0	1		1	
15K_331	HM x (Bx6) x (Snts x EFM)	F4	4SCI347	119682	1.4	0	1		1	
15K_332	L9786B x HM	F4	4SCI355	119686	1.5	3	3.5	7	3.5	7
15K_333	L9786B x HM	F4	4SCI356	119687	0.0	NS	NS		NS	
15K_334	(8483B x 9256B) x HM	F4	4SCI360	119690	0.4	1	1		1	
15K_335	(8483B x 9256B) x HM	F3M	4SCI360	119692,94	0.2	1	0		0	
15K_336	(8483B x 9256B) x HM	F3M	4SCI363	119694,92	0.6	1	1	7	1	7
15K_337	(8483B x 9256B) x HM	F4	4SCI363	119695	2.4	0	0		0	
15K_338	PD x WR	F3MS3	4SCI390	119704	1.1	0	0		0	
15K_339	(SFF x HM) x (FN2-9 x 2302)	F2MS	4SCI406	119714	2.3	4	5		5	
15K_340	(9256B x Nb8483B) x (FN2-9 x 2302)	F2MS	4SCI408	119717	0.5	5.5	6	7	6	7
15K_341	SFF	F1XMS2MS4	4SCI441	119731	1.1	0	0		0	
15K_342	(PD x PI326011) x WR	F5	4SCI446	119735	2.3	5	3		3	
15K_343	(PD x PI326011) x WR	F3M2S	4SCI449	119738	1.1	1	1.5		1.5	
15K_344	(PD x PI326011) x WR	F3M2S	4SCI449	119739	2.3	3	0	7	0	7
15K_345	(PD x PI326011) x WR	F3MSMS	4SCI461	119744	3.0	0	1		1	
15K_346	(PD x PI326011) x WR	F3MSMS	4SCI461	119745	2.5	0	1		1	
15K_347	HM x FS	F3	4SCI469	119747	2.3	5	6		6	
15K_348	HM x FS	F3	4SCI469	119749	3.1	5	5.5	7	5.5	7
15K_349	SFF x (FN2-9 x 2302)	F3	4SCI474	119753	0.6	3	6		6	
15K_350	(FN2-9 x 2302) x SFF	F3	4SCI478	119757	1.0	1.5	1		1	
15K_351	((Bx6) x (PD x PI326011)) x (FN2-9 x 2302)	F3	4SCI492	119761	0.0	3.5	4		4	
15K_352	Nb2155B	F2MSMS6	4SCI502	119771	0.6	3.5	3	7	3	7
15K_353	Nb12306B	F7	4SCI515	119781	1.6	2	1.5		1.5	
15K_354	(Nb8483B x 9256B) x (SFF)	F3	3K161	114073	2.6	5	2		2	
15K_355	(Nb8483B x 9256B) x HM	F3	3K163	114074	0.9	1	0		0	
15K_356	(Nb8483B x 9256B) x HM	F3	3K163	117075	1.7	1	1	9	1	7
15K_357	SFF x ?	F3	3K169	114079	1.6	3	1		1	

Table 1. 2015 Carrot Nematode Trials

Entry	Root			Seed			M. javanica		M. incognita	
	Gen.	Source	Rem.	Entry score	Check score	Entry score	Check score			
15K_358	F3	3K169	0.9	1.5		0				
15K_359	F3	3K169	3.9	1		0				
15K_360	F3	3K169	3.8	1	7	1	7			
15K_361	F1MS	3K172	0.3	1.5		0				
15K_362	F1MS	3K172	0.9	1		1				
15K_363	F1MS	3K172	0.5	0		0				
15K_364	F3	3K175	3.3	1.5	7	1	7			
15K_365	F3MS2S	3K208	0.9	0		1				
15K_366	F3MS2S	3K208	1.0	0		1				
15K_367	F3MS2S	3K208	3.0	1		1				
15K_368	F2MS4	3K209	0.6	1	6.5	0	8			
15K_369	F2MS4	3K209	3.8	0		0				
15K_370	F2MS4	3K209	0.6	1		1				
15K_371	F5MS	3K216	0.2	2		0				
15K_372	F5MS	3K216	0.9	1.5	7	2	7			
15K_373	F5MS	3K216	0.4	1.5		2				
15K_374	F5MS	3K216	2.9	5.5		1				
15K_375	F5MS	3K216	0.3	0		2.5				
15K_376	F5MS	3K216	0.8	3	7	0	7			
15K_377	F5	3K232	0.4	1		0				
15K_378	F5	3K232	0.7	0		1				
15K_379	F5	3K232	0.5	0		1				
15K_380	F5	3K232	0.2	0	7	0	8			
15K_381	F3MS2	3K234	0.2	0		1				
15K_382	F3MS2	3K234	0.6	2		1				
15K_383	F3MS2	3K234	0.0	1	7	0	7			
15K_384	F1M2SMS2MS	3K251	1.7	1		0				
15K_385	F4MS2	3K251	2.9	1.5		1				
15K_386	F1XMS2MS3	3K257	0.7	1		2				
15K_387	F1XMS2MS3	3K257	0.6	1	7	1	8			
15K_388	F1XMS2MS3	3K257	0.7	1		0				
15K_389	F2MS6	3K258	1.0	0		1				
15K_390	F2MS6	3K258	1.7	1.5		0				
15K_391	F6	3K263	0.2	NS	7	1	7			
15K_392	F6	3K263	0.6	0		0				
15K_393	F3MS	3K287	0.8	1		0				
15K_394	F3MS	3K287	2.7	1		1.5				
15K_395	F3MS	3K287	0.6	2	6.5	2	7			
15K_396	XXMS2MS	3K290	1.1	1		2				
15K_397	XXMS2MS	3K290	0.4	1		2				
15K_398	XXMS2MS	3K290	3.0	1		1				
15K_399	XXMS2MS	3K290	1.2	1	7	1	7			
15K_400	XXMS2MS	3K290	3.3	1		1				
15K_401	F1MSMS	3K294	1.0	2		2				
15K_402	F1MSMS	3K294	2.2	1.5		1.5	0			

Table 1. 2015 Carrot Nematode Trials

Entry	M. javanica			M. incognita		
	Gen.	Root	Seed	Rem.	Entry score	Check score
15K_403	F1MSMS	3K294	114204	2.0	2	7
15K_404	HM x (Br 1091)	3K295	114207	1.3	4	3.5
15K_405	HM	3K295	114208	0.9	4	5
15K_406	HM	3K295	114210	1.8	5	3.5
15K_407	SFF	3K304	114211	0.5	1.5	7
15K_408	SFF	3K304	114212	2.8	1.5	1.5
15K_409	SFF	3K304	114214	1.6	0	1
15K_410	SFF	3K304	114215	2.2	1	0
15K_411	SFF	3K306	114217	0.9	0	7
15K_412	SFF	3K306	114218	2.3	1	1
15K_413	SFF	3K306	114220	4.2	1.5	2.5
15K_414	Nb8483B x 9256B	3K317	114221	1.9	1	0
15K_415	Nb8483B x 9256B	3K317	114222	3.3	0	7
15K_416	Nb8483B x 9256B	3K321	114225	2.1	0	6.5
15K_417	Nb8483B x 9256B	3K321	114227	1.8	1	0
15K_418	Nb8483B x 9256B	3K321	114228	0.7	2	1
15K_419	Nb8483B x 9256B	3K322	114231	4.6	1	7
15K_420	Nb8483B x 9256B	3K322	114233	1.9	0	0
15K_421	Nb8483B x 9256B	3K322	114234	0.6	1.5	0
15K_422	Nb8483B x 9256B	3K322	114235	0.2	0	0
15K_423	Nb1386B	3K374	114242	2.0	1	7
15K_424	Nb1386B	3K374	114243	2.5	0	0
15K_425	Nb1386B	3K374	114245	2.0	0	0
15K_426	Nb1386B	3K374	114248	1.6	0	0
15K_427	Nb1386B	3K374	114249	1.7	0	7
15K_428	Nb1391B	3K375	114251	1.5	1	0
15K_429	Nb1391B	3K375	114252	1.0	1	0
15K_430	Nb1393B	3K378	114260	0.1	2	0
15K_431	Nb1393B	3K378	114263	0.5	1	1.5
15K_432	Npw2191B	3K391	114274	2.2	1	7
15K_433	Npw2191B	3K391	114275	0.9	1	0
15K_434	Npw2191B	3K391	114276	0.7	0	1
15K_435	Npw2191B	3K391	114277	2.8	0	7
15K_436	Npw2191B	3K391	114279	2.0	0	0
15K_437	Nbh2306B	3K401	114287	1.4	1	1
15K_438	Nbh2306B	3K401	114289	2.3	1	1
15K_439	Nbh2306B	3K401	114290	3.8	2	1.5
15K_440	Nb4002B	3K419	114307	1.4	1	7
15K_441	Nb4002B	3K419	114308	1.2	0	2.5
15K_442	Nb4002B	3K419	114310	2.3	1.5	0
15K_443	Nb4002B	3K419	114311	1.2	1	0
15K_444	Nb8503B	3K439	114332	1.4	5	7
15K_445	Nb8503B	3K439	114336	0.4	4	4
15K_446	Nb8503B	3K439	114337	1.7	1	1
15K_447	Nb9297B	3K453	114357	0.6	0	2
						1

Table 1. 2015 Carrot Nematode Trials

Entry	Root			Seed			M. javanica		M. incognita	
	Gen.	Source	Source	Rem.	Entry score	Check score	Entry score	Check score		
15K_448	Nb9297B	3K453	114359	1.9	1	7	2	7		
15K_449	Nb9297B	3K453	114360	0.7	0		0			
15K_450	Nb9297B	3K453	114362	2.6	1		1			
15K_451	Nb9297B	3K453	114363	1.0	0		0			
15K_452	Nb9297B	3K453	114364	1.8	0	7	1	6.5		
15K_453	Nb9297B	3K453	114365	0.5	1.5		2.5			
15K_454	Nb9297B	3K453	114366	2.6	0		0			
15K_455	Nb9297B	3K453	114367	2.3	0		0			
15K_456	Nb9324B	3K455	114368	1.7	4	7	5	7		
15K_457	Nb9324B	3K455	114371	1.0	3.5		3			
15K_458	Nb9324B	3K455	114372	1.9	3		3.5			
15K_459	(FN2-9 x 2302) x Nb8503B	3K103	114470	0.8	5		5			
15K_460	Nb8503B x (FN2-9 x 2302)	3K115	114479	1.4	3.5	7	5.5	6.5		
15K_461	Nb8503B x (FN2-9 x 2302)	3K117	114493	1.8	1		1			
15K_462	Nb8524B x (FN2-9 x 2302)	3K119	114504	2.3	1.5		1.5			
15K_463	Nb8524B x (FN2-9 x 2302)	3K119	114506	2.1	2		1			
15K_464	Nb8524B x (FN2-9 x 2302)	3K119	114508	1.7	2	7	5	7		
15K_465	Nb8524B x (FN2-9 x 2302)	3K119	114509	1.0	3		1			
15K_466	Nb8524B x (FN2-9 x 2302)	3K119	114512	1.9	1		1.5			
15K_467	L9786B x HM	3K155	114541	1.4	1.5		2			
15K_468	L9786B x HM	3K155	114547	0.3	1.5	7	1	7		
15K_469	L9786B x HM	3K155	114548	0.8	1.5		0			
15K_470	(Nb8483B x 9256B) x HM	3K168	114554	4.0	4		3.5			
15K_471	(Nb8483B x 9256B) x HM	3K168	114555	2.6	1		1			
15K_472	(Nb8483B x 9256B) x HM	3K168	114557	1.0	1	7	2	7		
15K_473	(Nb8483B x 9256B) x HM	3K168	114558	1.8	3.5		1.5			
15K_474	(Nb8483B x 9256B) x HM	3K168	114559	4.9	0		0			
15K_475	(Nb8483B x 9256B) x HM	3K168	114560	0.8	0		0			
15K_476	(Nb8483B x 9256B) x HM	3K168	114563	1.2	4	7	3.5	8		
15K_477	(Nb8483B x 9256B) x HM	3K168	114564	0.9	1.5		1.5			
15K_478	SFF x HM	3K187	114582	1.6	0		2			
15K_479	SFF x HM	3K187	114583	0.7	1		2			
15K_480	SFF x HM	3K187	114584	0.5	0	7	1	7		
15K_481	SFF x HM	3K187	114585	1.1	1		1			
15K_482	SFF x HM	3K187	114586	3.1	1.5		2			
15K_483	SFF x HM	3K187	114588	1.5	1		2			
15K_484	SFF x HM	3K187	114589	0.1	0	7	2	7		
15K_485	SFF x HM	3K187	114590	2.2	0		2			
15K_486	SFF x HM	3K187	114591	0.6	0		2			
15K_487	SFF x HM	3K187	114592	1.3	1.5		1.5			
15K_488	SFF x HM	3K187	114594	3.7	1	7	5	9		
15K_489	SFF x HM	3K187	114595	1.5	1		4			
15K_490	SFF x HM	3K187	114596	3.0	0		3.5			
15K_491	PD x WR	3K191	114606	2.9	0		5			
15K_492	PD x WR	3K191	114607	3.5	0	7	2	7		

Table 1. 2015 Carrot Nematode Trials

Entry	Pedigree	Gen.	Root	Seed	M. javanica		M. incognita	
					Rem.	Entry score	Check score	Entry score
15K_493	PD x WR	F3MS2	3K191	114608	0.5	0	0	0
15K_494	PD x WR	F3MS2	3K191	114609	0.1	0	2	2
15K_495	PD x WR	F3MS2	3K192	114610	1.9	1	1.5	7
15K_496	Bx6 x PD	F5	30193	113071	0.2	2	2.5	7
15K_497	(Nb8483B x 9256B) x HM	F2M	2SCJ166	111600	2.4	1	1	1
15K_498	(Nb8483B x 9256B) x HM	F2M	2SCJ167	111602	10.7	0	1	1
15K_499	(Nb8483B x 9256B) x HM	F2M	2SCJ168	111604	11.2	1	6.5	7
15K_500	(Nb8483B x 9256B) x HM	F2M	2SCJ169	111606	13.0	0	3	3
15K_501	(Nb8483B x 9256B) x HM	F2M	2SCJ170	111608	12.9	0	3	3
15K_502	SFF x ?	F2M	2SCJ174	111612	9.6	1	2	2
15K_503	NF x HM	F2M	2SCJ180	111614	1.0	1	7	9
15K_504	HM x SFF	F4M	2SCJ252	111620	1.1	1	1	1
15K_505	HM x SFF	F4M	2SCJ257	111622	12.4	3	4	4
15K_506	SFF x HM	F4M	2SCJ260	111624	10.9	0	0	0
15K_507	SFF x HM	F4M	2SCJ261	111626	8.9	0	7	1
15K_508	(PD x PI326011) x WR	F3MSM	2SCJ266	111628	3.5	2	0	6.5
15K_509	(PD x PI326011) x WR	F3MSM	2SCJ267	111630	9.3	0	0	0
15K_510	(PD x PI326011) x WR	F3MSM	2SCJ271	111632	7.6	1	0	0
15K_511	PD x PI326011	F1M2SM2M2SM	2SCJ312	111634	14.1	1	7	7
15K_512	PD x PI326011	F1M2SM2M2SM	2SCJ314	111636	9.8	0	0	0
15K_513	Nb8483B x 9256B	F4MS2	2SCJ334	111646	5.8	1	0	0
15K_514	SFF	F1XMS2MS3	2SCJ342	111652	0.4	0	0	0
15K_515	HM x (Bx6)	F2MS4	2SCJ367	111668	5.5	1	7	7
15K_516	(PD x PI326011) x WR	F5	2SCJ397	111678	3.1	0	1	1
15K_517	WR x HM	F3M	2SCJ423	111680	0.9	4.5	1	1
15K_518	(PD x PI326011) x WR	F4	2SCJ459	111684	3.2	3	3.5	3.5
15K_519	(PD x PI326011) x WR	F4	2SCJ460	111686	6.0	1.5	1	1
15K_520	HM x SFF	F3M	2SCJ491	111688	18.7	3	4	4
15K_521	(PD x PI326011) x WR	F3M2	2SCJ496	111690	9.1	0	0	0
15K_522	SFF x HM	F3M	2SCJ521	111692	15.0	2.5	3	3
15K_523	Nb6526B	F4M5MSMS	2SCJ601	111706	12.0	1	8	0
15K_524	(Nb8483B x 9256B) x HM	F2M	2SCJ169	111606	15.5	1	2	2
15K_525	SFF x ?	F2M	2SCJ174	111612	14.6	1	1.5	1.5
15K_526	(PD x PI326011) x WR	F3MSM	2SCJ267	111630	8.8	0	1	1
15K_527	PD x PI326011	F1M2SM2M2SM	2SCJ314	111636	6.3	0	7	7
15K_528	Bx6	F2MSMS4M	2SCJ324	111638	12.0	5	4	4
15K_529	(PD x PI326011) x WR	F3M2	2SCJ496	111690	11.4	1	1	1
15K_530	SFF x HM	F3M	2SCJ521	111692	15.1	1.5	4.5	4.5
15K_531	Brasilia	Embrapa '07	2SCJ539	111694	8.9	6.5	7	7
15K_532	(PD x 326011) x WR	F3MSM	-	S303-1	880.0	0	1	1
15K_533	Horns	XMMS3M3	-	S304-1	490.0	1	2	2
15K_534	SFF	F1XMS2MS2M	-	S303-2	150.0	0	1.5	1.5
15K_535	Nb1391B	F4M2	-	S304-2	150.0	0	0	0
15K_536	Nb8483B x 9256B	F4M2	-	S303-3	1000.0	1	1.5	1.5
15K_537	Nb8483B x 9256B	F4M2	-	S304-3	1100.0	1	0	0

Table 1. 2015 Carrot Nematode Trials

Entry	Root			Seed			M. javanica		M. incognita	
	Gen.	Source	Source	Source	Source	Rem.	Entry score	Check score	Entry score	Check score
15K_538	Nb1175B	4772	B120-1	B120-1	50.0	6	5.5		5.5	
15K_539	S.C. x Nb1175B	4773	B120-2	B120-2	40.0	6	7	6.5	7	8
15K_540	S.C. x Nb1175B	-	B120-3	B120-3	50.0	6.5	7		7	
15K_541	Nb1175B	2775	256-1	256-1	9.4	5	7		7	
15K_542	Nb1175B	3895	310-1	310-1	39.2	7	6		6	
15K_543	Nb1386B	1386	109-1	109-1	7.3	1	1.5	7	1.5	7
15K_544	S.C. x Nb1386B	1705	109-2	109-2	13.6	3.5	1		1	
15K_545	Nb1393B	3681	110996	110996	7.1	6.5	7		7	
15K_546	Nb2155B	3901	111424	111424	1.8	2	1		1	
15K_547	S.C. x Nb2155B3	3902	111425 x 424	111425 x 424	0.7	2	1	7	1	7
15K_548	Nb2157A	4784	415-2	415-2	3.7	2	4		4	
15K_549	Nb2159B	3905	314-1	314-1	4.1	6	5		5	
15K_550	Nb2160B	2160	233-1	233-1	11.2	1	1		1	
15K_551	Npw2191B	OSC 598	90691-94	90691-94	3.9	1	0		0	
15K_552	Npw2191B	3917	111452	111452	3.8	0	0	7	0	7
15K_553	Npw2191B	4796	417-1	417-1	11.1	0	1		1	
15K_554	S.C. x Npw2191B3	4797	417-2	417-2	3.6	1	3		3	
15K_555	S.C. x Npw2191B	4803	117343	117343	14.5	1	2		2	
15K_556	(S.C. x Nb2201B) x Nb2195B	3922	111457 x 456	111457 x 456	4.4	2	1.5	7	1.5	7
15K_557	S.C. x Nb2201B3	4805	117349	117349	1.3	3	3		3	
15K_558	Nb2205B	4806	117352	117352	2.6	4.5	3.5		3.5	
15K_559	Nb2205B	4806	117354	117354	0.7	1	2		2	
15K_560	(S.C. x Nb2246B) x Nb2205B2	4807	117355	117355	6.9	1	2	6.5	2	7
15K_561	(S.C. x Nb2246B) x Nb2222B	3926	111465 x 464	111465 x 464	10.3	3	5		5	
15K_562	Nbh2306B	2306	96368	96368	7.0	1.5	1		1	
15K_563	Nbh2306B	3930	111486	111486	4.6	1	4		4	
15K_564	(S.C. x Nb6509B) x Nbh2306B	3933	111487 x 486	111487 x 486	2.7	3.5	6	7	6	7
15K_565	Nb3271B	3271	329-1	329-1	18.1	3	3		3	
15K_566	Nb3271B	4821	428-1	428-1	39.7	3.5	3.5		3.5	
15K_567	(S.C. x Nb4000B) x Nb3271B2	4822	117379	117379	1.0	2	3		3	
15K_568	Nb3284B	4823	B101-1	B101-1	-	1	1	7	1	7
15K_569	Nb3353B	4826	334-1	334-1	11.3	6	6		6	
15K_570	Nb3999B	4827	431-1	431-1	0.6	4	3.5		3.5	
15K_571	Nb4001B	-	S434-1	S434-1	-	6.5	6		6	
15K_572	(Nb4001A x Nb4002B) x Nb4001B	-	N110102	N110102	-	0	0	7	0	7
15K_573	Nb4002B	-	B104-1	B104-1	-	1	1		1	
15K_574	(Nb4001A x Nb4002B) x Nb4002B	-	N111042	N111042	-	2.5	3		3	
15K_575	Nb4216B	9157	85372	85372	2.2	1	2.5		2.5	
15K_576	Nb4216B	4216	433-1	433-1	1.1	1	2	7	2	7
15K_577	Npw4217B	OSC 598	90695-97,	90695-97,	0.9	1	2		2	
			703M	703M						
15K_578	Ns4222B	F1XMS3MS	85C195;	85C195;	6.1	1	3		3	
			Plot42	Plot42						
15K_579	Ns4450B	F2M2	4450	441-1	5.0	2	2		2	
15K_580	(L7550A x 7808B) x Ns4450B	F1	4947	441-2	6.7	5.5	5	7	5	7

Table 1. 2015 Carrot Nematode Trials

Entry	No.	Pedigree	Gen.	Root		Seed	M. javanica		M. incognita	
				Source	Source		Rem.	Entry score	Check score	Entry score
15K_581	Npw4458B	F3MSM2	4458	444-1	11.0	0	1	1		
15K_582	(7262A x P6279B) x Npw4458B	F1	4913	444-2	1.7	1	0	2		
15K_583	Ns4467B	F1XMS2MSM3	4467	445-1	1.2	0	3	3		
15K_584	(8233A x L7553B) x Ns4467	F1	4933	445-2	2.1	7	7	6	7	
15K_585	Nb6509B	F2MSMS	3932	111490	0.8	1	3.5	6		
15K_586	Ns6520B	F1XMS2M2S2	4837	117384	3.8	5.5	6.5	3.5		
15K_587	(L7550A x 1111B) x Ns6520B	F1	4921	117385	4.9	8	6	6		
15K_588	Ns6520B	F1XMS2M2S2	4837	117386	2.4	4.5	7	6	6.5	
15K_589	Nb6526B	F4MSMSM2M	3941	349-1	8.6	1.5	1	1		
15K_590	Nb6526B	F4MSMSM3M	4484	463-1	2.5	1	0	0		
15K_591	S.C. x Nb6526B	F1	4936,57	463-2, 3 Mix	12.2	6	4	4		
15K_592	(6366A x 5238B) x Nb6526B	F1	4943	117391	3.2	4	7	3	6.5	
15K_593	Nb8483B	F3MSM3SM3	3510	375-1	5.9	7	6	6		
15K_594	Nb8483B	F3MSM3SM	-	S435-1	-	7	6	6		
15K_595	Nb8495B	F3MS2	9758	86782	0.8	4.5	2	2		
15K_596	S.C. x Nb8495B3	BC2	3943	111505 x 498	2.9	3	7	4.5	7	
15K_597	Nb8524B	F3M6	-	B115-1	-	2.5	4	4		
15K_598	Nb8524B	F3M7	-	N11481	-	1	5	5		
15K_599	Nb8524B	F3M6	-	B115-1	-	1.5	3	3		
15K_600	Nb9297B	F3M	-	B117-1	-	0	7	1	7	
15K_601	Nb9297B	F4M2	-	B111-1	-	1.5	1.5	1.5		
15K_602	Nb9297B	F3M2	4852	474-1	6.9	1.5	1	1		
15K_603	S.C. x Nb9324B2	BC1	4855	117405	3.3	1.5	2	2		
Inbreds for Release										
15K_604	Nb4002B	F3M4	-	N111041	-	0	7	1.5	7	
15K_605	Ns5154B	F1XMS3M	-	B310-1	-	0	0	0		
15K_606	Nb4001B	F3M4	4831-32	N110101	-	1	0	0		
15K_607	Nb6526B	F4M5MSM	-	S277-1	-	0	7	0	7	
Industry Production										
15K_608	Horns	M4SMSM	-	B119-1	-	1	2	2		
15K_609	Horns	M4SMSM	-	S278-1	-	3	3.5	3.5		
15K_610	PD x 1326011	F1X3M	-	B309-1	-	2.5	3	3		
15K_611	SFF	F1XMS3M	-	S433-1	-	0	7	1	7	
15K_612	Nb4001B	F3M3	-	B101-1	-	3.5	4.5	4.5		
15K_613	Nb4001B	F3M2SM3	-	B102-1	-	2	1	1		
15K_614	Nb4001B	F3M2SM3	-	B103-1	-	1.5	1	1		
15K_615	Nb4001B	F3M2SM2 OR -	-	S261-1	-	1	7	1	7	
15K_616	Nb4001B	F3M4	-	S276-1	-	2	1	1		
15K_617	Nb4001B	F3M2SM2 OR -	-	S434-1	-	6	5	5		
15K_618	Nb4002B	F3M4	-	S263-1	-	3.5	1.5	1.5		
15K_619	Nb6526B	F4M5MSM	-	2011 C 104	-	1	7	1	7	

Table 1. 2015 Carrot Nematode Trials

Entry	Pedigree	Root		Seed	M. javanica		M. incognita	
		Gen.	Source		Rem.	Entry score	Check score	Entry score
15K_620	Nb8483B	F3MSM3SM	-	B106-1	-	6	7	7
15K_621	Nb8483B	F3MSM3SM or F3MSM5	-	S435-1	-	6	5	5
15K_622	Nh8502B	XMxMSM	-	B113-1	-	4.5	2	2
15K_623	Nb8524B	F3M6	-	V104068-2	-	3.5	3.5	7
15K_624	Nb8524A	BC3	-	V104069-2	-	4.5	3.5	3.5
15K_625	Nb8542B	F3M6	-	V104070-2	-	1	0	0
15K_626	Nb8542A	BC4	-	V104071-2	-	2.5	1.5	1.5
15K_627	Nb9296B	F3M	-	N111031	-	4	3	3
15K_628	(Nb4001A x Nb4002B) x 9296	F1	-	N111032	-	3.5	2	2
15K_629	Nb9296B	F3M	-	B116-1	-	5	2.5	2.5
15K_630	Nb9297B	F3M	-	12-HC44-1	-	2.5	3	3
15K_631	Nb9324B	F5M2	-	B118-1	-	6	1.5	1.5
15K_632	HM x (Bx6)	F5M	-	B246-1	-	1	0	0
15K_633	HM x (Bx6)	F5M	-	B247-1	-	1	0	0
15K_634	HM x (Bx6)	F5M	-	B248-1	-	0	0	0
15K_635	HM x (Bx6)	F5M	-	N111021	-	0	0	0
15K_636	S.C. x (HM x (Bx6))	F1	-	N111022	-	1	0	0
15K_637	S.C. x (HM x (Bx6))	F1	-	N111023	-	1	3	3
15K_638	HM x (Bx6)	F5M	-	S267-1	-	1	1	1
15K_639	Nb8483 x 9256	F4M	-	B107-1	-	2	3.5	3.5
15K_640	Nb8483 x 9256	F4M	-	B108-1	-	1	3	3
15K_641	Nb8483 x 9256	F4M	-	B109-1	-	1	3	3
15K_642	Nb8483 x 9256	F4M	-	B110-1	-	1	1	1
15K_643	Nb8483 x 9256	F4M	-	B111-1	-	1	1	1
15K_644	Nb8483 x 9256	F4M	-	B112-1	-	1	1	1
15K_645	Nb8483 x 9256	F4M	-	B307-1	-	1	1	1
15K_646	Nb8483 x 9256	F4M	-	B308-1	-	1	2.5	2.5
15K_647	Nb8483 x 9256	F3M	-	S265-1	-	1	0	0
15K_648	Nb8483 x 9256	F3M	-	S274-1	-	0	1	1
15K_649	Nb8483 x 9256	F3M	-	S275-1	-	1	3	3
15K_650	HM x 0568B	F2	20132	97379	-	3	5	5
15K_651	(Bx6) x (PD x 1326011)	F4	2172-25	97254-25	-	3	5	5
15K_652	PD	XMxMS2M2SM	2200	96140	-	2	3.5	3.5
15K_653	(Snts x EFM) x ((Bx6) x FS)	F4	1K1159	94564	-	1	0	0
15K_654	HM x SFF	F4	1K1174	94597	-	0	1	1
15K_655	HM x (B x 6)	F2MS3	1K1339	94984	-	0	0	0
15K_656	SFF x HM	F4	OSC 804	91227	-	0	1	1
15K_657	SFF x HM	F4	OSC 805	91232	-	0	1	1
15K_658	HM x SFF	F3	OSC 521	91682	-	3.5	4	4
15K_659	HM x SFF	F3	OSC522	91686	-	2	1	1
15K_660	(Bx6) x (PD x 1326011)	F3	OSC 544	90552	-	1.5	1.5	1.5
15K_690	(8542 x 8524) x 8524	F1	-	N110392	-	1	4.5	4.5
15K_691	(8542 x 8524) x 8524	F1	-	N11482	-	1.5	3.5	3.5
15K_692	(4001 x 4002) x 8524	F1	-	N110512	-	2	3	3

Table 1. 2015 Carrot Nematode Trials

Entry	Pedigree	Root		Seed		M. javanica		M. incognita		
		Gen.	Source	Source	Source	Rem.	Entry score	Check score	Entry score	Check score
15K_693	(8524 x 8483) x 8524	F1	-	N110393	-	-	4.5	-	7	-
15K_694	(MJS.C. x 8542) x 8524	F1	-	N110394	-	-	1.5	-	5.5	-
15K_695	(8542 x 8524) x 8524	F1	-	N110502	-	-	1	-	3.5	-
15K_696	(8542 x 8524) x 4002	F1	-	117-3	-	-	0	6.5	4	7
15K_726	(8542 x 8524) x 8524	F1	-	N110392	-	-	2	-	4	-
15K_727	(8542 x 8524) x 8524	F1	-	N111482	-	-	2.5	-	5	-
15K_728	(4001 x 4002) x 8524	F1	-	N110512	-	-	1.5	7	4	7
15K_729	(8524 x 8483) x 8524	F1	-	N110393	-	-	3	-	6	-
15K_730	(MJS.C. x 8542) x 8524	F1	-	N110394	-	-	3	-	4	-
15K_731	(8542 x 8524) x 8524	F1	-	N110502	-	-	1.5	-	5.5	-
15K_732	(8542 x 8524) x 4002	F1	-	117-3	-	-	1.5	7	3	7

Key:

Score: 0 to 8 scale; 0=resistant, 8=susceptible

NS: No stand

(B x 6): Brasilia 1252 x 6274

HM: Horns

NF: Nantes Fancy

PD: Ping Ding

SFF: Scarlet Fancy x Favourite

WR: Western Red

Shaded entries are resistant (score of 2 or less) to both incognita and javanica

Table 2 - Carrot genotypes used in multi-isolate greenhouse tests and their 2014 and 2015 seed source (M. incognita)

Carrot Genotype	Pedigree	Other ID	2014 test Seed Source	2015 test Seed Source
UCR 40	Br x 6274	3999B	UCR 40	UCR 40
UCR 4	Br x 6274	3999B (Mj-1 only)	UCR 4	119355-376
4001B	Br x 6274		Nun 110101	119201-219
SEM	Br x 6274	8483 x 9256	Sem 274-1	119313-329
F4 (2014) F5 (2015)	BR1091 x Homs BR1091 x Homs		68679-9 -	- 114642-643
Homs 1	Homs		87298	119259-273
Homs 2	Homs		90818	119284-310
H x B	Homs x (BR1252 x 6274)		Nun 111021	119383-414
SFF	Scarlet Fancy x Favorite		Bejo 310-1	119333-342
WR	Western Red		84158	119190-194
PD	PD x PI326011		90830	119346-350
Imp. 58	Imperator 58	Sus. Check	Commercial	Commercial

Note: 2014 test used 25 M. incognita isolates; 2015 test used same 25 + 4 additional = 29 isolates