The Potential of Nematode-Resistant Carrots to Reduce Soil Fumigation and VOC Emissions

Project PI and Co-PI:

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California Carrot Processors and Growers

Funding: UCIPM (field tests)

CFCAB (Screening/selection)

Pre-plant soil fumigation-1,3-dichloropropene (Telone II) or Metam-Na (eg Vapam)

Carrot Production, Soil Fumigation and VOC Emissions in 2002 May-Oct. season:

NAA 2 (San Joaquin Valley)

NAA 3 (Southeast Desert)

		NAA 2	NAA 3
Primary AI:	**#1 Metam-Na**	**26.9**	**57.3**
	#2 1,3-D	**14.2**	**13.2**
Application site			
	#1 Carrots	**19.2**	**28.2**
	#2 Cotton (Peppers)	**13.3**	**14.0**
	#3 Almonds (Strawbs)	**7.7**	**6.1**

Values are % of all pesticide emissions (Data from F Spurlock, DPR memo to J. Sanders, DPR, May 17, 2004)

Sources for resistance to root-knot nematodes (*Meloidgyne* spp.) in carrot

Brasilia-1252

-F_2 population 3838 (gene *Mj-1*)

-F_2 population 3839

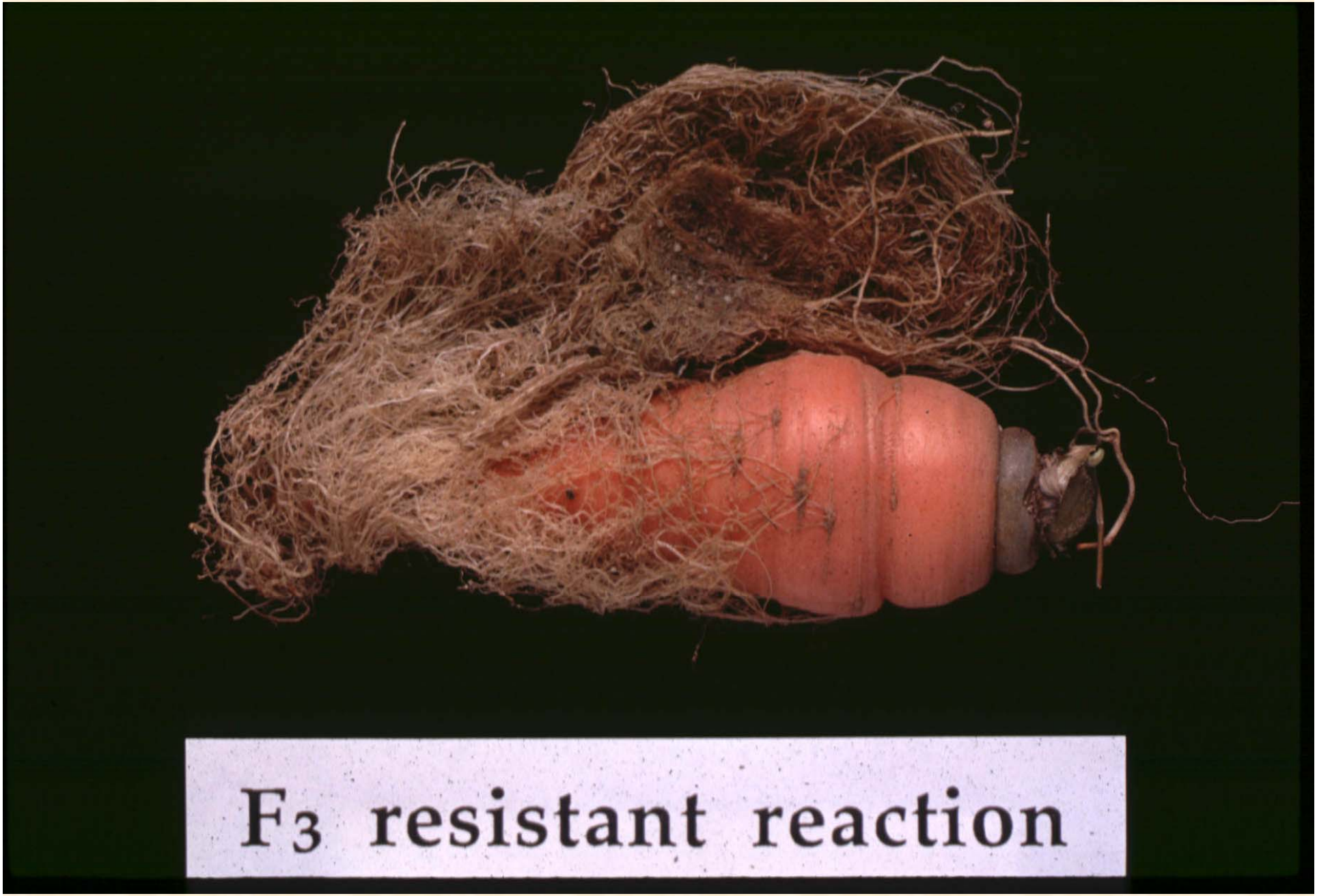
Brasilia-1091

Non-Brasilia (Homs, Ping Ding, etc.)

Greenhouse Resistance Screening

Greenhouse pot tests to assess resistance

- **Fibrous root galling**
- **Egg production**
  - **-total eggs per plant**
  - **-eggs/gm root**


F3 resistant reaction

Reproduction of *Meloidogyne javanica* on F3 carrots segregating for gene *Mj-1*

Gall Rating	Total Eggs	Eggs/Gram Root
8	249.2 a	23.2 a
6	248.8 a	29.3 a
1	27.1 b	8.5 b
0	3.9 c	1.4 c

Genetic characterization of *Mj-I*

- Resistance is highly effective against *M. javanica*.
- Resistance is more variable to isolates of *M. incognita*.
- *Mj-1* strongest in homozygous condition (gene dosage effect).
- *Mj-1* resistance is weakened at high temperature..

UC field sites to evaluate carrot progenies for nematode resistance (1996 - 2006)

Site	Location	Root-knot isolate
Kearney Agricultural Center (KAC)	Parlier (Fresno County)	***M. incognita* race 3**
Kearney Ag. Center	Parlier (Fresno County)	***M. javanica***
South Coast Research and Extension Center (SCREC)	Irvine (Orange County)	***M. incognita* race 3**
Coachella Valley Ag. Research Station (CVARS)	Thermal (Riverside County)	***M. incognita* race 1**
Shafter Research Station	Shafter (Kern County)	***M. incognita* race 3**

Number of Br1252 x 6274 (F_2 = 3838) derived entries in field evaluations

Year	Sites	Generation(s)	Number of Entries	% Selected
1997	KAC	F_3M	30	0
1998	Kearney	F_3, F_3M, F_3M_2, F_3MS, F4	75	10
1999	KAC + CVARS	As in 1998 +inbreds	93	10
2000	SCREC	As in 1999, BC_1,BC_2	> 150	20
2001	**KAC + CVARS**	As in 2000	> 300	**60**
2002	**CVARS + SCREC**	As in 2001	> 150	**75**
2003	**KAC**	As in 2002 + others	> 150	**75**
2004	**KAC**	As in 2003 + others	168	**50**
2005	**KAC**	As in 2004 + others	199	**30**
2006	**KAC**	As in 2005 + others	150	**35**

Field tests to assess tolerance conferred by resistance genes

Scale →

0 Clean

1

2

3

4

5

6

7

8

9

10 Rotted or

M. incognita Field Screen

Imperator 58 (Sus)

8524B (Res)

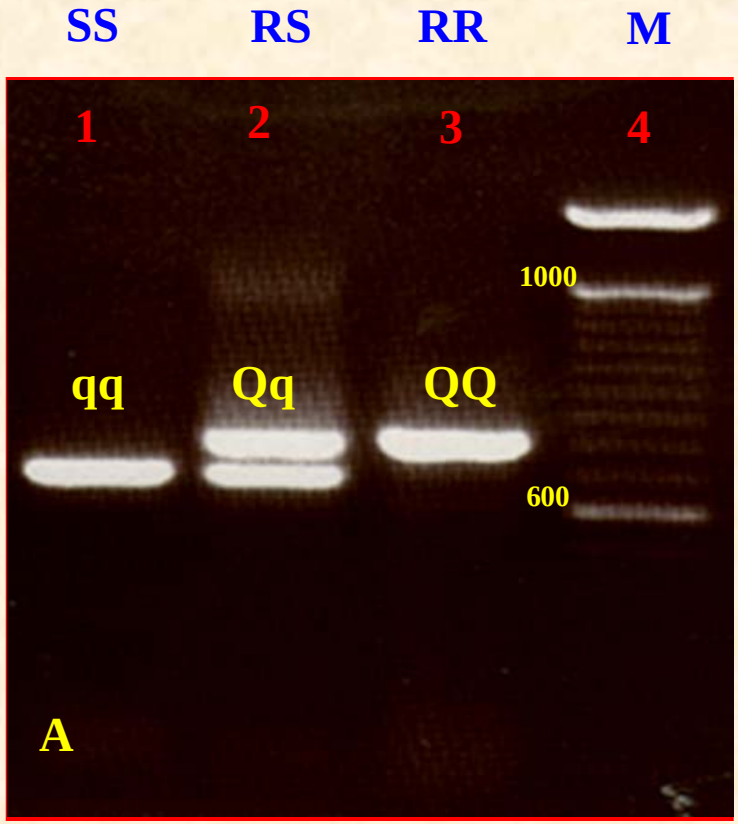
Field Selection

Table 1. 2006 KAC field trials of multi-year carrot selections with *M. incognita* and *M. javanica*.

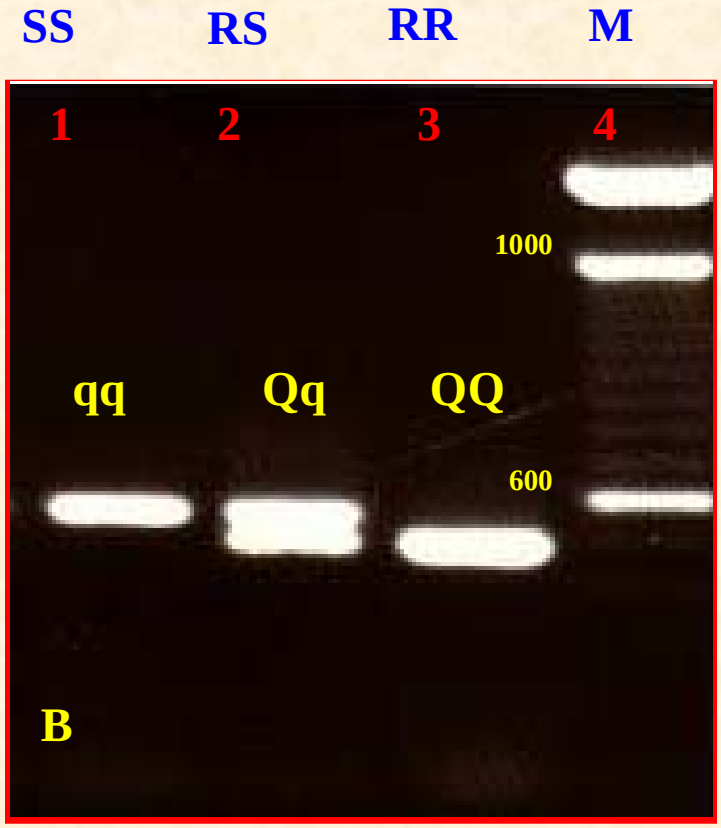
Pedigree	Seed Source	Generation	Root Source 2N - 2002 / 3N - 2003 / 4N - 2004	*M. incognita* race 3 or <race 1> * Plot #	2005 Plot Score	Source Score	*M. javanica* ** Plot #	2005 Plot Score	Source Score
I. BR x 6274 (Selections from 2002 CVARS, 2003 KAC, and 2004 KAC)									
BR x 6274	54815	F_3M_2	2N420	5N235	2.5	<1.46>	N.T.	-	-
BR x 6274	54796	F_3M_2	2N434	5N237	1.5	<2.96>	N.T.	-	-
BR x 6274	73980 cg981	F_3MS	3N113	5N184 5N584	0 0	2	5N384	0	4
BR x 6274	73992	F_3MS		5N186 5N586	0 1		5N386	4	
BR x 6274	73994	F_3MS		5N187 5N587	2 1		5N387	5.5	
BR x 6274	73996	F_3MS		5N188 5N588	2.5 0		5N388	2	
BR x 6274	74000	F_3MS		5N189 5N589	0 0		5N389	0	
BR x 6274	74002	F_3MS		5N190 5N590	2 5		5N390	6	

Agarose gel electrophoresis of the flanking codominant STS markers developed for the *Mj*-1 resistance locus in carrot

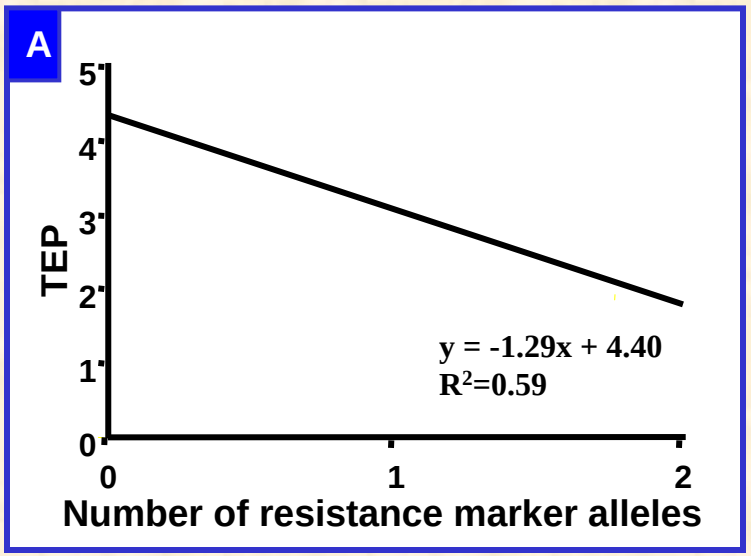
SQ1 (800R, 700S)

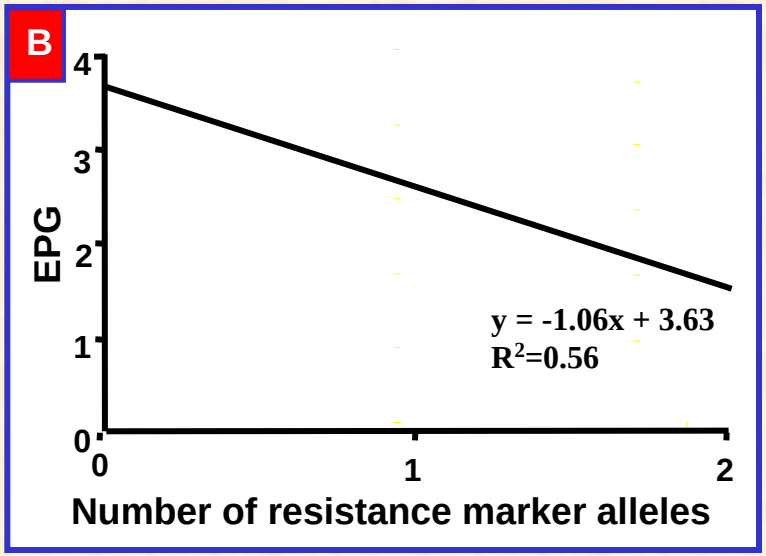


SQ6 (500R, 590S)



Effect of flanking marker dosage from resistant parent on resistance phenotypes for egg production (A, B) and root galling (C) for SQ 1.

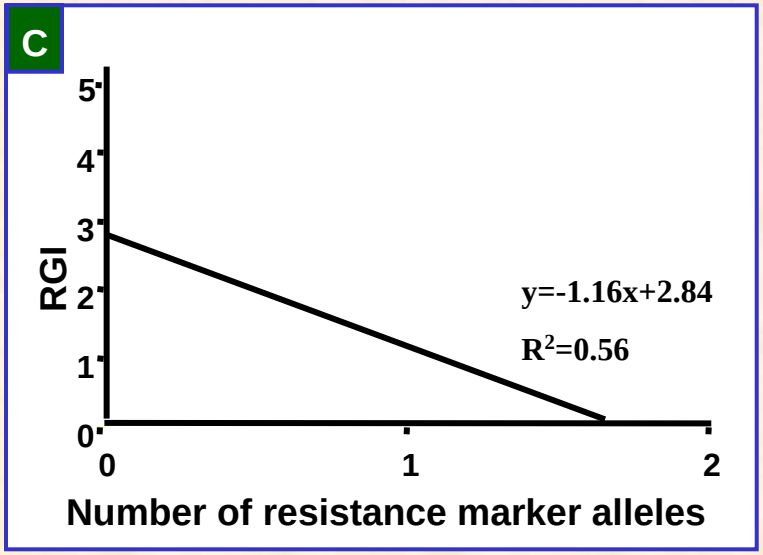




TEP: Log_{10}Total Eggs

EPG: Log_{10}Eggs/Gram of Root

RGI: Root Galling Index



Grower field sites used to evaluate Resistance and Fumigation

2005-6: 5 Fields (Bolthouse and Grimmway) in Kern Co.

Treatments: Standard Telone II fumigation

Half-rate Telone II fumigation

No fumigation

Each with Susceptible and Resistant carrots

5-fold Replication

Assays: Yield

Nematode damage (forking/galling)

Nematode soil populations

Root pathogen symptoms (cavity spot)

Funding: UC IPM Program

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Treatment	% Forked		Nematodes / Kg soil	
	Number	Weight	Pi	Pf
Res / Fum	5 b	6 b	2	0b
Res / Non	7 b	8 b	84	17b
Sus / Fum	6 b	9 b	0	0b
Sus / Non	18 a	25 a	126	177a

Standard Telone II treatment; LSD (P = 0.05)

Grower field sites used to evaluate Resistance and Fumigation

Treatment	% Forked	Gall Index	Nematodes / Kg soil	
			Pi	Pf
Res / Fum	12 b	0.2 b	3 b	1 b
Res/Half Fum	12 b	0.3 b	4 b	1 b
Res / Non	13 b	0.2 b	28 a	5 b
Sus / Fum	18 ab	1.0 a	10 b	4 b
Sus/Half Fum	24 a	1.1 a	8 b	15 b
Sus / Non	24 a	1.2 a	24 a	28 a

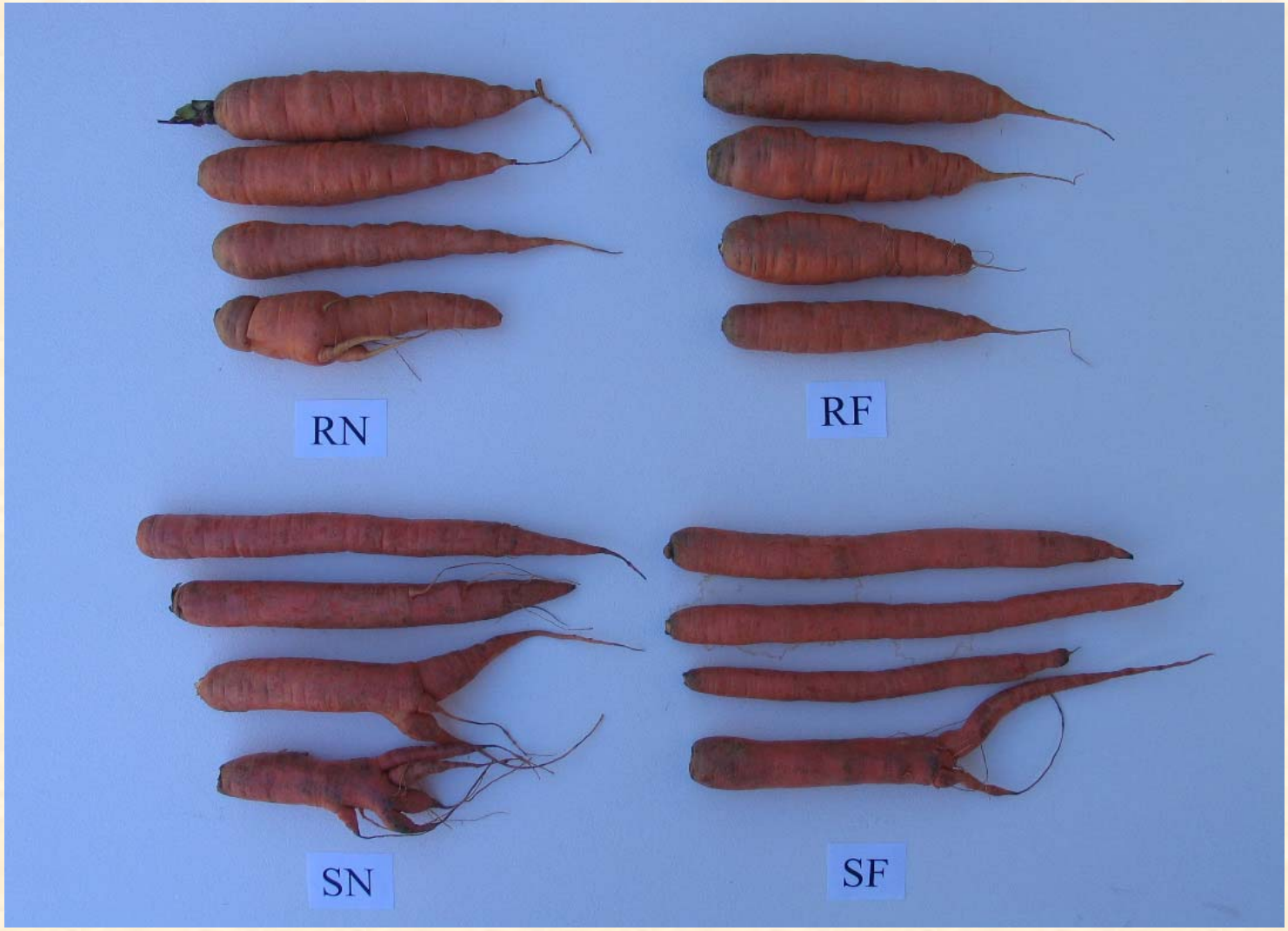
Telone II treatment; LSD ($P = 0.05$)

Grower field sites used to evaluate Resistance and Fumigation

Treatment	Cavity Spot (% Roots w/ Cavities)		
	% with 0	% with 1	% with >1
Res / Fum	**83**	**10**	**7**
Res / Non	**79**	**9**	**13**
Sus / Fum	**80**	**11**	**9**
Sus / Non	**78**	**9**	**13**

Standard Telone II treatment; LSD (P = 0.05) No significance

Grower field sites used to evaluate Resistance and Fumigation



Rotation/Plant Date: Early Planted Carrots

S Tom/ S Carrot

S Tom/ R Carrot

R Tom/ S Carrot

R Tom/ R Carrot