Use of Resistant Carolina Cayenne Pepper as a Rotational Crop to Manage Southern Root-knot Nematode

J. A. Thies, J. D. Mueller, and R. L. Fery
USDA Vegetable Laboratory
Charleston, SC 29414

Introduction

The southern root-knot nematode, *Meloidogyne incognita*, causes severe yield losses in bell peppers (*Capsicum annuum*) in the southern United States and world-wide. Currently, methyl bromide is used by U.S. pepper growers as a pre-plant soil fumigant to control root-knot nematodes. However, the pending withdrawal of methyl bromide from the United States market, combined with the loss of many other nematicides from use due to environmental concerns and costly re-registration, has resulted in a need for effective alternative root-knot nematode management measures. The development of vegetable crop rotation schemes that utilize resistant cultivars would provide a cost effective and environmentally benign tool for managing root-knot nematodes. This paper reports the results of a multi-year field study designed to evaluate the potential of using a *M. incognita* resistant cayenne pepper cultivar as a rotation crop for managing *M. incognita* in a subsequent bell pepper crop.

Materials and Methods

This multi-year field study was conducted at the Clemson University Edisto Research and Education Center, Blackville, SC. The pepper genotypes used in the study were Carolina Cayenne--PA-136, Keystone Resistant Giant, and California Wonder. Carolina Cayenne is a well-adapted cultivar that is highly resistant to *M. incognita*. PA-136 is a sibling line of Carolina Cayenne--that is susceptible to *M. incognita*. Keystone Resistant Giant and California Wonder are bell-type peppers; Keystone Resistant Giant has an intermediate type of response to *M. incognita* and California Wonder is susceptible.

The study was conducted in a field that was artificially infested with *M. incognita* race 3. The field was infested in July 1993 by inoculating a planting of susceptible PA-136 cayenne pepper with approximately 7000 eggs of *M. incognita* race 3 per plant. A winter cover crop of hairy vetch (*Vicia villosa* Roth) was sown over the pepper plants in Dec. 1993 to maintain *M. incognita* populations over winter. The experimental design was a randomized complete block with treatments in a split-plot arrangement with nine replications. On 2 June 1994, main plots were planted to either the highly resistant Carolina Cayenne or its susceptible sibling line PA-136. Main plots were nine row beds established on 1-m centers with 46-cm in-row plant spacing and 15 plants per row. In 1995, Carolina Cayenne and the susceptible bell cultivars Keystone Resistant Giant and California Wonder were grown as sub-plots in each of the original main plots. Sub-plots were three row beds established on 1-m centers with 60-cm in-row plant spacing and 10 plants per row.

Seeds of all the entries were planted in the greenhouse on 7 Apr. 1995 in an artificial growing medium. The seedlings were transplanted on 21 Apr. and the transplants were moved outdoors to harden on 10 May. The herbicide trifluralin [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine] was pre-plant incorporated in the field at 2.5 kg a.i. ha^{-1} on 19 May. The transplants were planted in the field on 22 May. Mature pepper fruit from the two bell-type cultivars were harvested weekly from 31

July to 31 August from all plants in each plot. Mature red fruit were harvested from five plants of the cayenne cultivar on 22 August and 31 August; all mature red and green fruit were harvested from these plants on 6 September. Five plants were removed from each sub-plot on 6 September. The root system of each plant was washed, scored for galling using a 1 to 5 scale (1 = 0 to 3% root system galled; 2 = 4 to 25%, 3 = 26 to 50%, 4 = 51 to 79%, and 5 = greater than 80% root system galled), and *M. incognita* eggs were extracted from a 20-g subsample of roots using 1% NaOCl. Data were subjected to analysis of variance using SAS System for Windows, Release 6.12, and means were separated using Duncan's multiple range test.

Results and Discussion

The 1994 planting of Carolina Cayenne effectively suppressed development of soil populations of *M. incognita*. Numbers of *M. incognita* second stage juveniles present in soil samples collected on 19 Oct. 1994 from main plots where Carolina Cayenne had been grown were only 3% ($P < 0.05$) of those of main plots where susceptible PA-136 had been grown (<1 second stage juvenile per cm^3 soil and 83 second stage juveniles per cm^3 soil, respectively).

The performance of the Carolina Cayenne plants in the 1995 season was unaffected by the previous crop. Carolina Cayenne exhibited a highly resistant response to *M. incognita* when it was grown following its susceptible sibling line, PA-136, or when it was grown in the same plots for two consecutive years; i.e., roots of Carolina Cayenne were not galled and reproduction of *M. incognita* was very limited (Table 1). Likewise, fruit yields and fruit numbers of Carolina Cayenne were not different when grown after susceptible PA-136 or when grown in the same plots for two successive years. There was no significant interaction between the rotation crop treatment (1994) and the subsequent pepper cultivars grown in 1995 with regard to gall index, numbers of eggs per g fresh root, fruit yield, and fruit number.

Previous cropping history had a significant impact on the performance of the bell cultivars with respect to *M. incognita*. Although the response of the individual bell cultivars did not differ within crop rotation treatments (there was no interaction between crop rotation treatments and cultivars), the mean gall index of Keystone Resistant Giant and California Wonder (averaged over cultivars) was less ($P<0.01$) when grown in rotation with resistant Carolina Cayenne (gall index = 3.1) than when grown in rotation with susceptible PA-136 (gall index = 3.6) (Table 1). Likewise, mean fruit yield of the bell cultivars was 2.9 times greater ($P<0.01$) and mean fruit numbers were 2.5 times greater ($P<0.01$) when the bell cultivars were grown in rotation with Carolina Cayenne than when grown in rotation with PA-136.

Cultivar differences between California Wonder and Keystone Resistant Giant were significant ($P<0.05$) for root galling and *M. incognita* reproduction when averaged over the main plot rotation crop treatments (Carolina Cayenne and PA-136) (Table 1). California Wonder plants exhibited a susceptible response to *M. incognita*; mean root gall ratings were 3.5 and *M. incognita* reproduction was 1.7 times greater than those for Keystone Resistant Giant. Keystone Resistant Giant plants exhibited an intermediate response to *M. incognita*; roots were moderately galled with mean root gall ratings of 3.1. Nematode reproduction was intermediate between that of resistant Carolina Cayenne and susceptible California Wonder plants.

Conclusions

Integration of a resistant cultivar, such as Carolina Cayenne, into vegetable crop rotation schemes should allow successful crop production in soils that are heavily infested with root-knot nematodes, while simultaneously suppressing nematode population densities in the soil to levels that allow production of a subsequent susceptible crop. Furthermore, host resistance is one of the most cost

effective and environmentally compatible alternatives to using methyl bromide or other nematicides for managing plant-parasitic nematodes. Resistant pepper cultivars such as Carolina Cayenne should be considered highly useful as rotation crops in the development of strategies for managing southern root-knot nematode in susceptible vegetable crops. Further research will be necessary to determine the compatibility of nematode management strategies with other disease management strategies in vegetable crops.

Table 1. Gall index, numbers of *Meloidogyne incognita* eggs extracted from roots, fruit yield, and fruit number of three pepper cultivars grown in rotation with two cayenne pepper genotypes (PA-136 and Carolina Cayenne) differing in resistance to *M. incognita.*

Rotation crop/pepper cultivar[z]	Gall index[y]	No. eggs g^{-1} fresh root	Fruit yield (kg ha^{-1})	Fruit (no. ha^{-1})
PA-136 (S)[x]				
Carolina Cayenne	1.0[w]	254[w]	7328[w]	521,288[w]
Keystone Resistant Giant[v]	3.4	11,174	2534	13,296
California Wonder	3.8	21,710	1683	7,793
Carolina Cayenne (R)[u]				
Carolina Cayenne	1.0	738	6407	610,691
Keystone Resistant Giant	2.8	10,859	4571	21,859
California Wonder	3.3	15,822	611	29,879
		Rotation crop mean (avg. over bell cultivars)		
PA-136	3.6**	9,140	2108**	10,544**
Carolina Cayenne	3.1	11,046	6091	25,869
		Cultivar mean (avg. over rotation crops)		
Carolina Cayenne	1.0 a[t]	496 a	6868[s]	565,990[s]
Keystone Resistant Giant	3.1 b	11,017 b	3552 a	17,578 a
California Wonder	3.5 c	18,766 c	4647 a	18,836 a

[z]Rotation crop (main plots) grown in 1994; pepper cultivars (sub-plots) grown in 1995.

[y]Gall index: 1 = 0 to 3% root system galled; 2 = 4 to 25%, 3 = 26 to 50%, 4 = 51 to 79%, and 5 = greater than 80% root system galled.

[x]S = susceptible to *M. incognita.*

[w]Rotation crop treatment x cultivar interaction F-test was not significant; therefore means were not separated.

[v]Susceptible bell cultivars.

[u]R = resistant to *M. incognita.*

[t]Mean separation within columns by Duncan's multiple range test ($P<0.05$).

[s]Means for Carolina Cayenne were not compared with those for bell pepper cultivars.

**Significantly different from values for Carolina Cayenne by ANOVA ($P < 0.01$).