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Root-knot Nematode Populations Infecting Resistant Tomatoes

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Background

California is by far the largest producer of processing tomatoes in the US, representing approximately 95% of the nationwide acreage. In 2021 the value of this crop in California was close to $1 billion. Root-knot nematodes (*Meloidogyne* species) are the most important nematode parasites of tomato, not just in California but wherever tomatoes are grown.

Fortunately, there are tomato varieties that are resistant to the most important root-knot nematode species. Such varieties can be identified by the letter "N" following the variety name (for example Hypeel VFF**N**P). The majority of processing tomato varieties that are grown in California are nematode resistant.

The resistance to nematodes is based on the presence of the "*Mi-1*" gene. This gene was originally found in a wild relative of tomato. A cross was made between the wild tomato and a commercial tomato in the 1950's, and through many years of conventional breeding a large range of nematode-resistant tomato varieties are now available. Nematode-resistant processing tomato varieties have been used very successfully to manage nematode problems for the last 60 years. However, because all resistant plants can be traced back to the same original cross, and because the resistance in these plants is based on the same single gene, there is the risk that nematodes develop that can break the resistance. In other tomato growing areas, reports on resistance-breaking of tomato started to appear in the 1970's and 1980's. In California, it was not until 1996 that the first report on the breaking of nematode resistance in tomato was published. Since then, there have been many observations by growers and UCCE farm advisors of fields with nematode-resistant processing tomato still showing nematode symptoms. This seems to be increasing, although there are no hard data to support this.

It was also not known if the nematode populations that are able to break the resistance are all of the same root-knot nematode species, if they are all equally aggressive on resistant tomato, and if there are any differences between the resistant tomato varieties when they are exposed to these nematodes. This was studied in a series of experiments in pots in a greenhouse at UC Riverside.

Description of experiments

Over 2-year period, several UCCE Farm Advisors collected root and soil samples from processing tomato fields where resistant varieties became infected with nematodes. A total of 16 fields were identified. The fields were located in Colusa (2x), Fresno (3x), Kern (3x), San Joaquin (1x), Solano (1x), Sutter (1x), and Yolo (5x) Counties.

The samples were sent to UC Riverside, the nematodes were extracted from the samples, and added to a pot with a nematode-resistant tomato 'Celebrity' plant. Eight weeks later, the roots of the resistant 'Celebrity' tomatoes were examined. The nematodes from all 16 locations caused obvious symptoms on these roots, confirming that they were able to infect resistant tomato.

The nematodes were then identified through morphology and PCR-based techniques. All were identified as the Southern root-knot nematode *Meloidogyne incognita* except one sample from Kern County which contained the Javanese root-knot nematode *M. javanica*. Nematodes from this sample and from four *M. incognita* samples were grown further on tomato to increase the nematode numbers and were then used in experiments.

For the experiments, the *M. javanica* isolate and four *M. incognita* isolates were added to five nematode resistant processing tomato varieties. A “standard” California *M. incognita* root- knot nematode isolate (MI-CTRL), a susceptible tomato ‘Daniela’, and the resistant tomato ‘Celebrity’ were included in the trial as controls. The trial was done twice in a greenhouse at UC Riverside.

Figure 1. Greenhouse pot experiment set-up at UC Riverside.

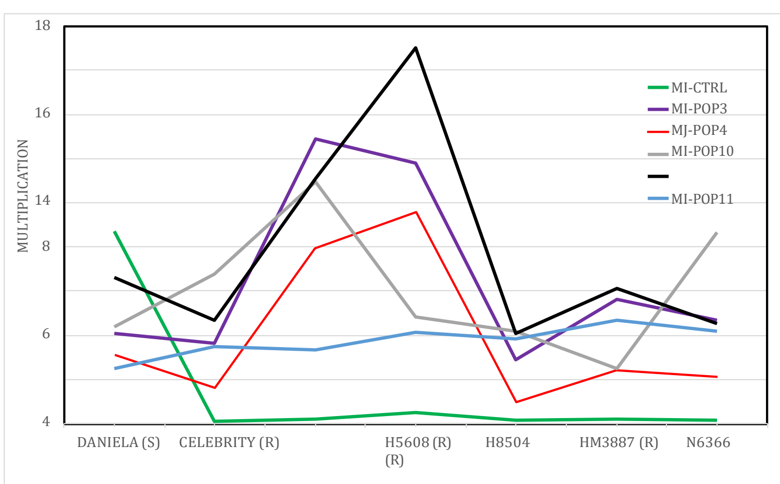
Results

Galling on the tomato roots at the end of the trial was very obvious on almost all of the “tomato variety - nematode population” combinations. Only the standard *M. incognita* population (MI-CTRL) did not cause galling when it had been added to a nematode-resistant tomato variety. The average galling on the tomato roots after inoculation with a resistance breaking nematode population was 5.8 (0 = no galling, 10 = 100% of root system with galls).

Figure 2. Root-galling on nematode-resistant tomato eight weeks after inoculation with a resistance-breaking population.

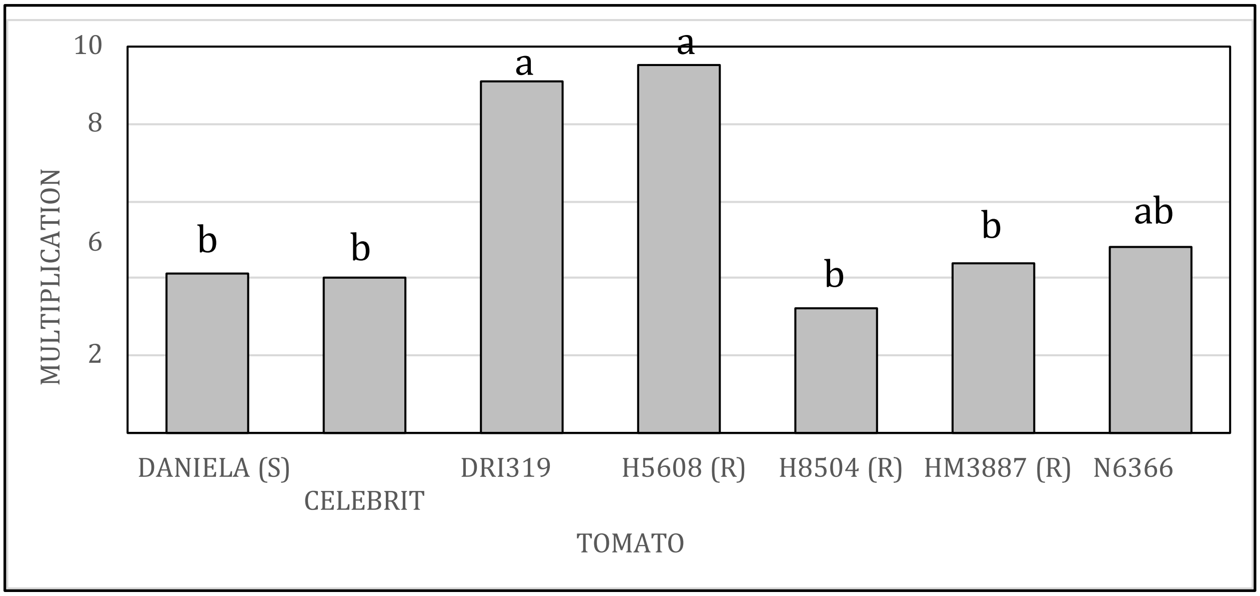
As expected, the standard root-knot nematode population (Mi-CTRL) multiplied very well on the susceptible tomato Daniela, but not on any of the resistant tomato varieties. The five resistance-breaking nematode populations multiplied on the susceptible Daniela, and also on each of the six resistant tomato varieties. With each tomato cultivar, there were some differences between the nematode populations. For example, on the variety ‘H5608’ nematode population number “11” multiplied to a much higher level than number “10”. On the tomato ‘N6366’ the opposite occurred and number “10” multiplied more than “11” (Figure 3).

Figure 3. Nematode multiplication factor (number of nematodes at harvest/number of nematodes inoculated) of an avirulent root-knot nematode population (MI-CTRL, green line) and five resistance-breaking populations on a susceptible (Daniela) and six resistant tomato varieties.



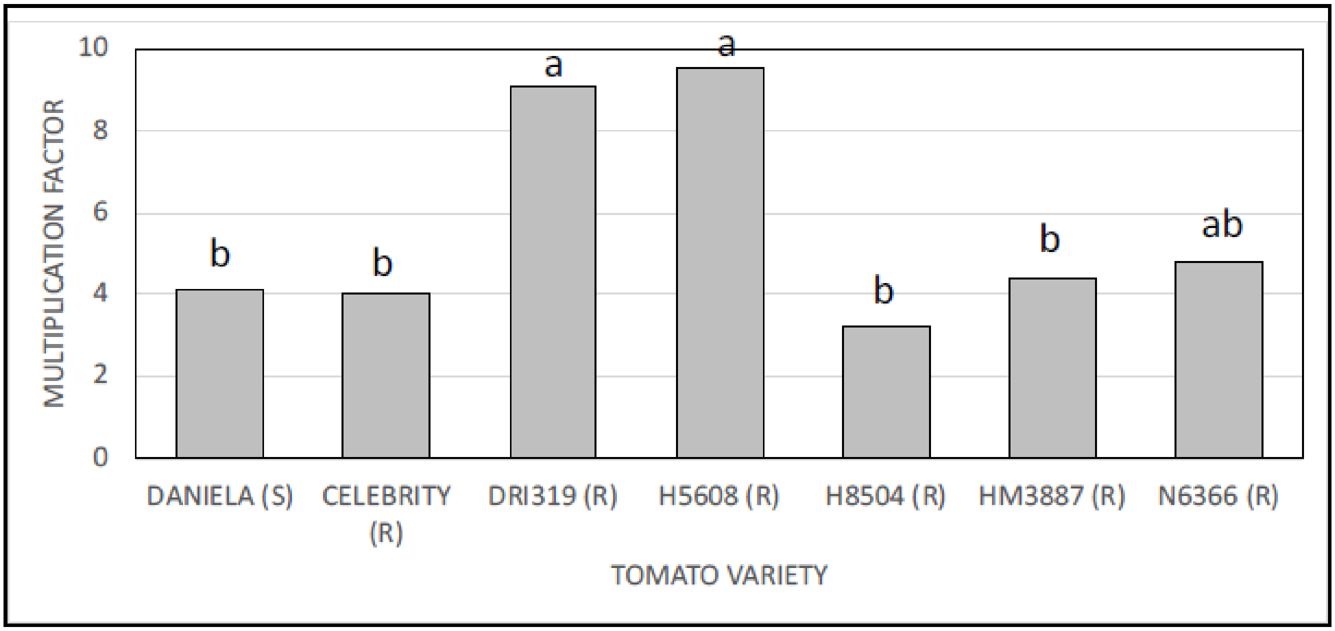
Comparing the multiplication of the resistance breaking nematodes on the different tomato varieties showed that on average the nematodes more than tripled on each of the tomato varieties. The resistant varieties DRI319 and H5608 were the best host plants. On both these varieties the resistance breaking nematodes increased more than 9-fold.

Figure 4. Nematode multiplication factor on seven tomato varieties (averaged over five resistance-breaking root-knot nematode populations). Different letters above bars represent significant differences (P σ; 0.05).



Looking at differences between the five resistance breaking nematode populations averaged over all the tomato varieties, showed that each population increased by a factor of >3.5, and that the populations 3, 10, and 11 were more virulent than populations 4 and 12.

Figure 5. Multiplication factor of five resistance-breaking root-knot nematode populations on tomato (averaged over seven tomato varieties). Different letters above bars represent significant differences (P σ; 0.05).



Conclusion

Root-knot nematodes that were able to infect resistant tomato varieties were isolated from samples collected from 16 tomato fields in seven counties in California's Central Valley. The most Northern sample was from Colusa County, the most Southern from Kern County. Fifteen of the samples contained the Southern root-knot nematode *M. incognita,* and one sample the Javanese root-knot nematode *M. javanica*.

Of the 16 samples, the nematodes from five samples were used for further greenhouse pot experiments and added to five nematode resistant processing tomato varieties.

Although there were some differences between these tomato varieties, they all showed obvious root galling symptoms and each variety resulted in an increase in nematode levels. There were also some differences between the nematode populations, but all five populations were able to infest, cause symptoms and multiply on the resistant tomatoes.

Thus, it can be concluded that once a resistance-breaking population develops in a field, it is likely that it will cause symptoms and multiply on any resistant processing tomato variety.
Currently there are no methods (yet) to identify the presence of resistance-breaking nematodes other than adding them to a resistant tomato and checking the roots for symptoms and nematode infestation 6-8 weeks later in a greenhouse pot test. However, research efforts are on-going to develop molecular tools that will allow such populations to be easily and reliably identified.

It is unknown if nematodes that are able to overcome the resistance in tomato, are also able to break resistance in other nematode-resistant crop varieties. This information is needed to know if other resistant crop varieties are also at risk of becoming susceptible or if they could be used in a rotation to manage these resistance-breaking populations.

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