METHYL BROMIDE ALTERNATIVES, FOCUS ON ROOTSTOCKS

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ABSTRACT

We have known since 2008 that spirotetramat as a foliar spray is nematicidal and that this attribute can improve yields of a variety of nematode infested tree/vine crops if applied with attention to avoiding post-treatment irrigation for 9 days and not applying more than one treatment per year. We have been concerned that *P. vulnus* destroys walnut feeder roots so much that delivery of the nematicide via roots may not provide nematicide access to enough of the nematode targets. Three sprays of spirotetramat beginning in 2010 provided our first evidence that trees already having a large root system, because of MB treatment, followed by spirotetramat were uniform in yield whether they had nematode resistance or not. Lesser root systems due to poorer soil fumigation had been showing significantly reduced yield depending on their level of nematode resistance. In 2012 it appeared there was no longer significant separation of yields whether produced on the more susceptible or more resistant paradox seedlings. Following the fourth spirotetramat treatment in spring 2013 the yields across all pre-plant and rootstock treatments were further increased by as much as 15 to 30%. These data improvements are likely a benefit due to spirotetramat but to prove the correlation we would need an untreated comparison which was not possible at this site given at least three rows of buffer zone will be required between treated and untreated due to spirotetramat drift as the orchard trees reach 35 feet in height. The values of Garlon plus one year of fallow is that it kills all nematode life stages within walnut roots and provides slightly greater remedy to root rejection than an untreated. It provides visible remedy when no other treatments are available including switching to a walnut rootstock of completely different species or a fumigant is to be used. These data indicate the value of Garlon plus one year of waiting can be mostly hidden by any fumigation including Vapam but would have value if only softer products were to be utilized. Mechanisms of nematode resistance are summarized in this report.

OBJECTIVES

1) Maintain the Rio Oso trial for yield data, rates of nematode return and tree growth with and without Movento applications.
2) Explore at our KAC trial site the value of Garlon + one year, Vapam drench and/or non-hosts as methods for reducing soil populations of *P. vulnus*.
3) Summarize what is known about mechanisms of nematode resistance in Juglans.

SIGNIFICANT FINDINGS

1) Three years totaling 4 Movento treatments improved yields across all treatments regardless of rootstock susceptibility to *P. vulnus* or pre-plant fumigation history, as long as all treatments were at least fumigated with Telone strip, MB broadcast or Vapam drench to avoid root rejection.
2) Aerial photos five years after replanting Juglans rootstocks indicated growth after Garlon + one year fallow was visibly improved compared to the untreated control but pre-plant treatments with Vapam drench produced larger trees whether Garlon was applied or not.

3) Nematode resistance mechanisms visible within the terminus 12 inches of Juglans root systems include: 1) a mechanism that deters *P. vulnus* feeding and hatching within roots of VX211, 2) a mechanism, gaseous and/or soluble in agar, in *J. cathayensis* #21 that halts nematode travel toward roots except those at least one inch or more in length where they also lay eggs. 3) a mechanism in Serr that provides resistance against root knot but not root lesion nematodes.

PROCEDURES

Objective 1. The Rio Oso site involved 8 acres with every other tree being NX or DN paradox down each row. These rows have been planted over soil that received either methyl bromide delivered to the 6-foot depth, Telone II at 50 gallons per acre stripped with delivery to the 4.5-foot depth or a broadcast application of Metam sodium delivered to the 4-foot depth. As tree yields failed to improve at 9th and 10th leaf the entire 8 acres was treated with 7 oz/acre Movento in fall 2010 and also in spring 2011 then 9 oz /acre in spring 2012 and 2013. Yields were collected annually from 8th until 12th leaf.

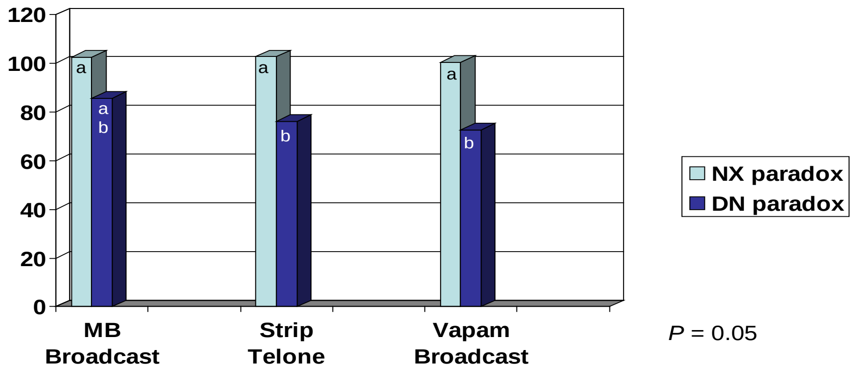
Objective 2. A rootstock_trial completed in third year after half of the rootstocks showed tolerance to root rejection in the presence of *J. hindsii* was maintained as a source of long term nematode host status. Half the trees were removed diagonally across the field to reduce shading due to the close planting. Aerial photographs were collected at this site in 2013 and 2014 using Near Infrared as well as regular photography. These photos provided for walnuts evidence that mimicked data from almonds where Roundup and one year of waiting could be compared to fumigated or untreated controls as pre-plant treatments.

Objective 3. There appears to be a need for phenotypic information to compliment genotypic information as the SCRI grant moves forward. Pathologists refer to such information as resistance mechanisms. We will summarize herein several of these resistance mechanisms.

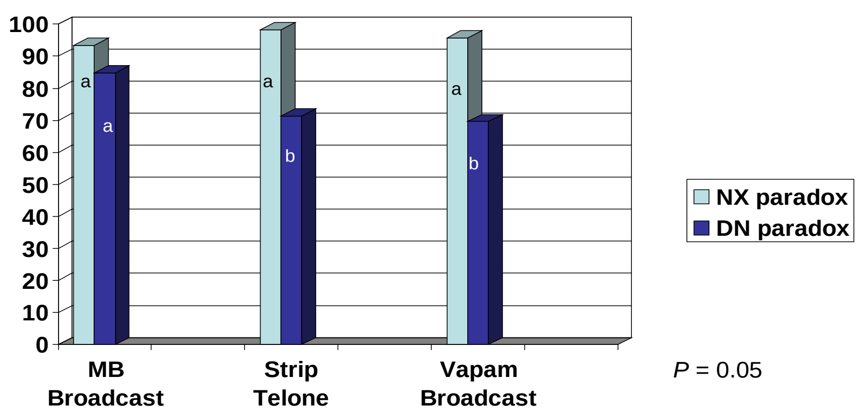
RESULTS AND DISCUSSION

Objective 1. An 8-acre soil fumigation experiment at Rio Oso, CA provided an opportunity to compare partially resistant NX paradox seedlings with mostly susceptible DN paradox seedlings. Yields collected from these rootstocks in 2010 showed the DN seedlings were beginning a significant decline particularly if the pre-plant history did not involve methyl bromide. This history of yield data has provided the first information ever available on yield impacts associated with three fumigation histories. Five days after collecting the 2010 yield data Movento at 7 oz/ac was applied. This treatment was repeated in May 2011. Yield improvements due to Movento were not notable in 2011. In May 2012 a third application was applied at 9 oz /acre. In 2012 we observed for the first time no significant yield differences between NX and DN rootstocks regardless of the soil treatment histories. Farm gate values of the harvested nuts were most improved among DN rootstocks. It was the yield improvements of 2013 that were most remarkable. Trees planted following lesser soil treatments appeared slower to improve their yields but when they did it was across the entire plot. Yields for individual treatments each of five years indicate MB treated trees began to improve yields in their fourth year while all others improved in their fifth year.

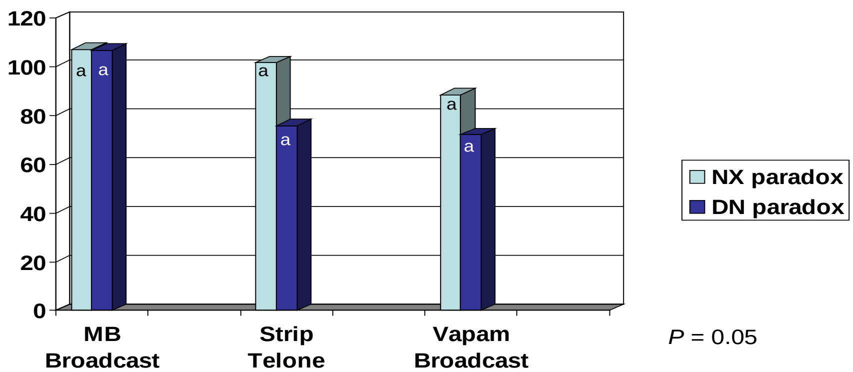
Ninth-leaf yield (lb/tree) of Chandler on Two Rootstock Seedlings



Tenth-leaf (lb/tree) of Chandler on Two Rootstock Seedlings following Movento in fall 2010 and spring 2011

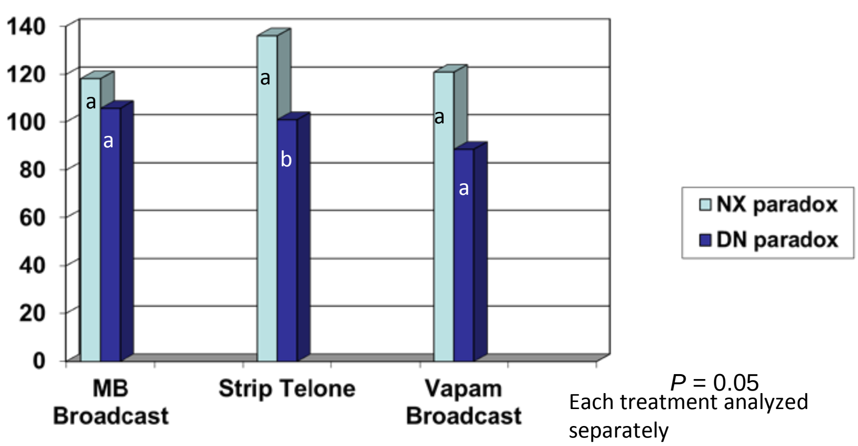


Eleventh-leaf yield (lb/tree) of Chandler on Two Rootstock Seedlings following 3 Movento treatments

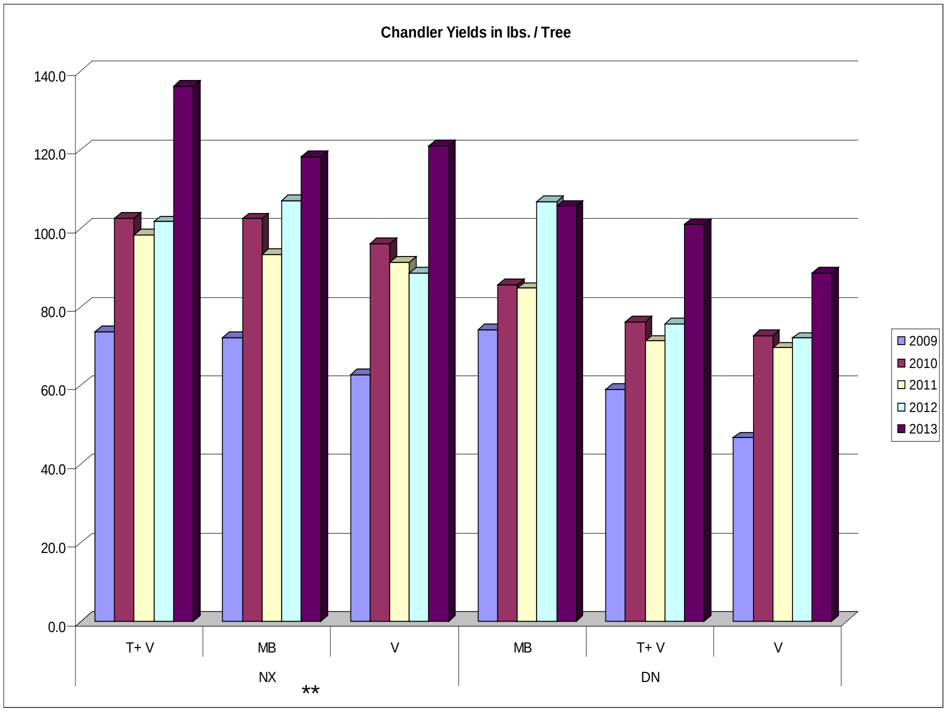


P = 0.05

Twelfth-leaf yield (lb/tree) of Chandler on Two Rootstock Seedlings following 4 Movento treatments

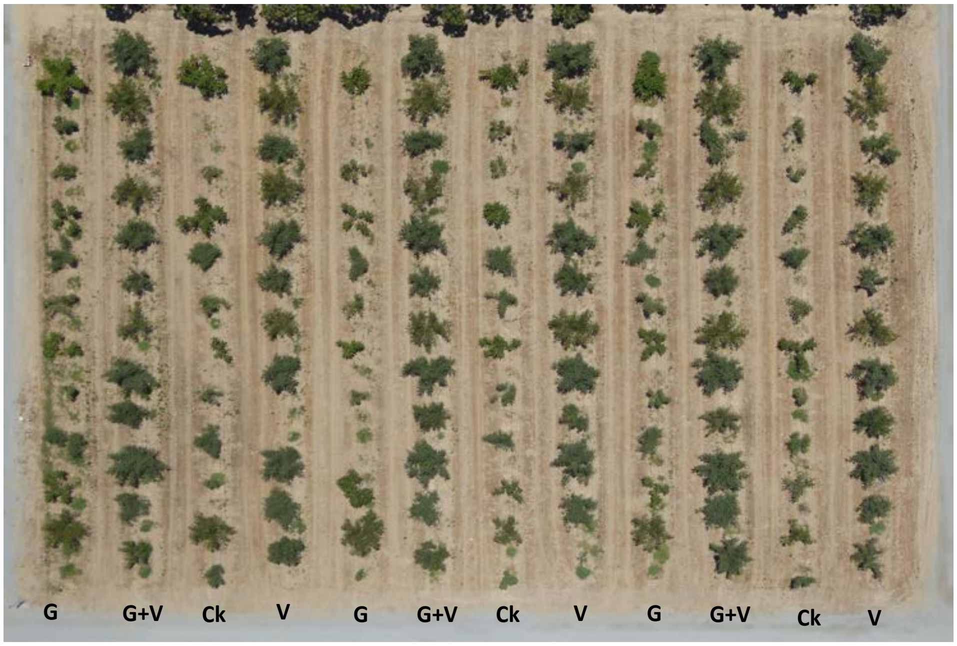


P = 0.05
Each treatment analyzed separately

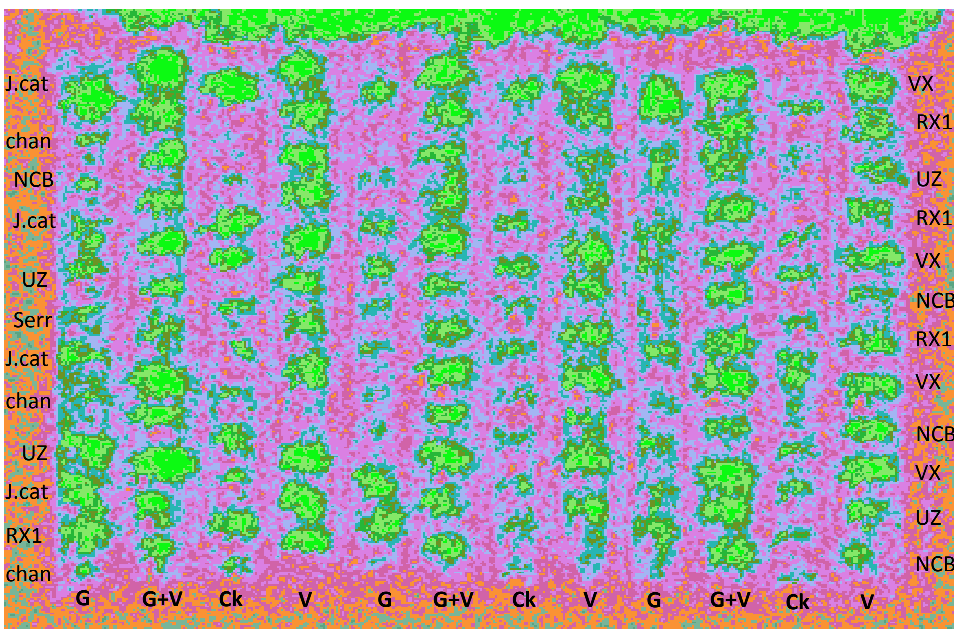


Garlon herbicide is a tool that kills all roots best as a fall treatment to decapitated walnut trunks. Root killing power of this product when mixed with MorAct adjuvant can kill all roots. Unlike Prunus rootstocks, Juglans trees when treated with the herbicide result in root death that is not visible for almost a full year except the nematode eggs and adults are at least 99.5% reduced after one year. One value of Garlon is that any biocidal agents applied before planting do not need to penetrate the root system to be totally effective.

S&S walnuts replanted after 25 yr NCB walnuts, June 2013 in 4th leaf



S&S walnut replants after 25 yr NCB , June 2013, 4th leaf near infrared

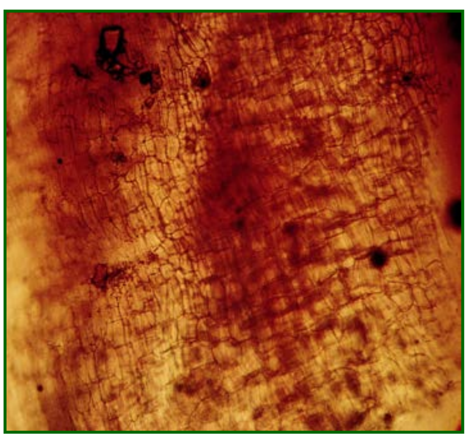


Mechanisms of nematode resistance (=phenotypic sources of nematode resistance)

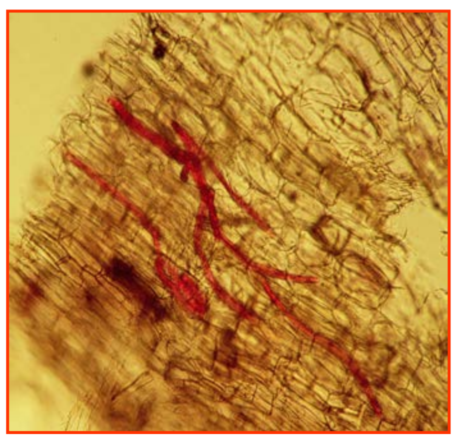
Species of the Juglans genus are known to possess allelopathy which impacts young seedlings growing nearby but they also possess nematicidal properties except in youngest tissues which are mostly the terminus 6 to 12 inches of young roots. Basically, visible lesions caused by root lesion nematode feeding are confined to wood at 1 year of age or more. It is the youngest roots that support very high populations of nematodes. However, VX211 is currently the single rootstock that also possesses a mechanism that keeps the nematode from living and hatching within the walnut root terminus. Rather, they feed from outside the root tips after being in the ground several years and therefore cause less vascular damage to VX211 roots. This also results in fewer nematodes per gram of young root and we refer to the nematicidal value of this single mechanism as a source of nematode tolerance.

Juglans cathayensis provides a very different source of resistance that is effective against root lesion and root knot nematodes for at least 3 to 5 years after planting. This resistance is a result of perhaps gaseous or liquid leakage emanating from older roots that can actually reduce nematode populations within soil during this three year period. Then, nematodes find their way into the plant, probably in the terminus 1 inch of terminal roots, where they enter and reproduce within the root. *Juglans cathyensis* #21 and #27 are currently the best sources of available nematode resistance. Both are relatively low vigor.

Pratylenchus vulnus does not prefer to live or reproduce **within** VX211

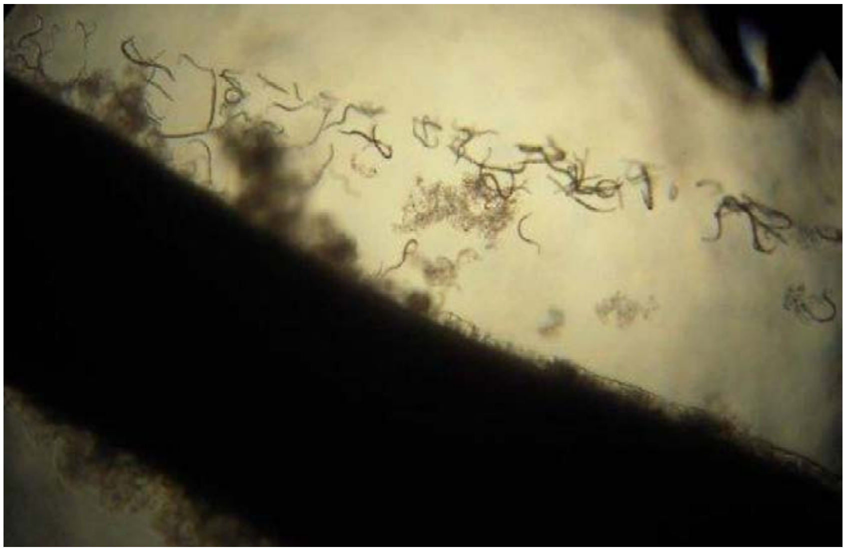


VX211 Paradox hybrid clone



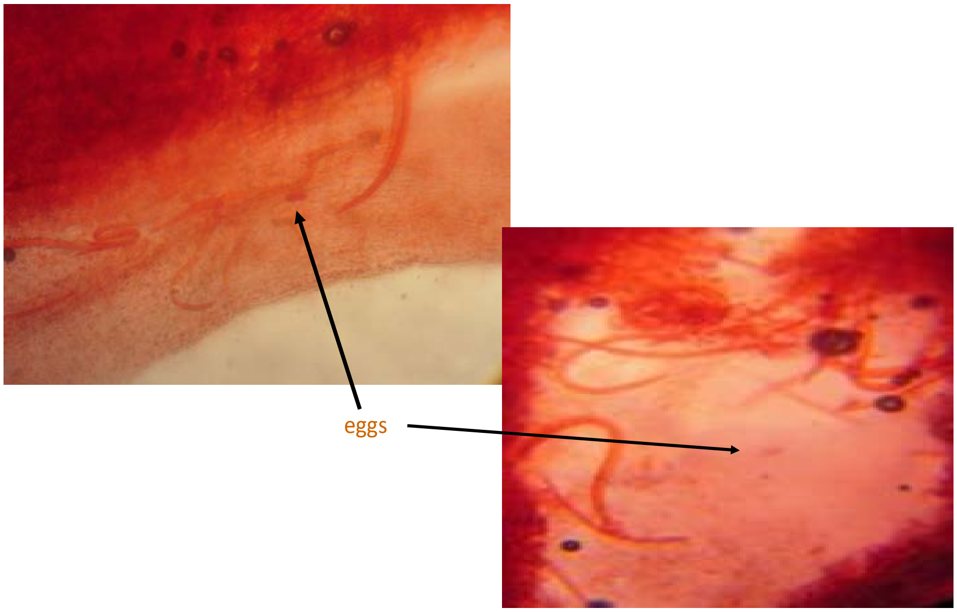
AX1 Paradox hybrid clone

Root tips of J. cathayensis #21 are attractive to *P. vulnus* but death usually occurs trying to enter



Death and degradation can rapidly appear on the agar surface of a petri dish.

However, successful entry and reproduction by *P. vulnus* is possible in J. cat #21



*P. vulnus/*250 cc soil during first-leaf

Selection	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	mean
11.03 B:2-12 J.cat #21	25	24	7	0	27	16.6 a
11.03 B:2-12	652	436	944	491	484	601 b
PI 159568	748	1444	274	1188	1312	993 b

P = 0.01

J.cat #21 collected 2005 O.P.

Other J.cat collected 2007 O.P.

P.vulnus/gram of root, five years later

J. cathayensis	Pv pops. 45 and 30	P.v./gr root
Shen xi #1 0833A1-T1		16.9
Shen xi #3 0835M1-T12		13.7
Shill in #5 0837R2 -T27		10.9
Shill in #6 0838A2-T30		10.3
Shill in #6 0838F2-T31		11.2 **12.6**

Rootstock	History	P.v/gr root
RX1 rep7 (T18)	Vapam soil	25.5
RX1 rep11 (T18)	Vapam soil	87.8
RX1 rep7 (T18)	Garlon/Vapam	38.2
RX1 rep3 (T18)	Garlon/Vapam	13.5
		41.3
VX211 rep7 (T16)	Vapam soil	23.1
VX211 rep11 (T16)	Vapam soil	57.6
VX211 rep7 (T16)	Garlon/Vapam	30.8
VX211 rep3 (T16)	Garlon/Vapam	17.5
		33.9

A third source of nematode resistance is J. regia, cv Serr which provides resistance to root knot nematode but minimal impact to root lesion nematode. Another source of J. regia which may provide useful breeding material is the cultivar Waterloo.