FIELD PERFORMANCE OF PECAN ROOTSTOCKS FOR RESISTANCE TO *MELOIDOGYNE PARTITYLA* IN THE SOUTHEASTERN UNITED STATES[1]

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ABSTRACT

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Two open pollinated commercial pecan seedling rootstocks were evaluated for resistance to *Meloidogyne partityla* in field microplots. Rootstocks tested included seedlings derived from open pollinated seed of 'Curtis' and 'Elliott' parent trees. 'Elliott', a susceptible pecan seedling rootstock for *M. partityla*, also served as the identifiable control. Both commercial pecan rootstocks supported nematode reproduction as indicated by number of egg masses per plant, number of eggs per plant, and number of eggs per gram dry root and were not significantly different between rootstocks 30 months after inoculation. Differences in tree growth, as measured by trunk diameter and dry root weight, were not found between 'Elliott' and 'Curtis' rootstocks, but growth suppression of both stocks was influenced in the presence of *M. partityla*. These results provide useful insights into *M. partityla* being a potentially economically important pathogen to the pecan industry in the southeastern United States and that the search for an IPM strategy for control of *M. partityla* on pecan is warranted.

Key words: Carya illinoinensis, host parasitic relationship, management, *Meloidogyne partityla*, pecan, resistance, root knot nematode, rootstock, susceptibility.

RESUMEN

Nyczepir, A. P. 2013. Resistencia en campo de portainjertos de pecano a *Meloidogyne partityla* em el sureste de Estados Unidos. Nematropica 43:63-67.

Se evaluó la resistencia de campo a *Meloidogyne partityla* de dos portainjertos de pecano comerciales de polinización abierta. Los portainjertos evaluados incluyeron plántulas derivadas de semilla de polinización abierta de los padres 'Curtis' y 'Elliott'. El portainjertos 'Elliott', susceptible a *M. partityla*, también se utilizó como control positivo. Ambos portainjertos comerciales sostuvieron reproducción del nematodo, medida como masas de huevo por planta, cantidad de huevos por planta y cantidad de huevos por gramo de raíz seca. No se observaron diferencias significativas entre los portainjertos 30 meses después de la inoculación. No se encontraron diferencias en el crecimiento de los portainjertos 'Elliott' y 'Curtis', medido como diámetro del tronco y peso seco de raíces, pero el nematodo afectó el crecimiento de ambos. Estos resultados brindan evidencia de *M. partityla* como patógeno de importancia económica en la industria de pecano en el sureste de Estados Unidos e indican que es necesario encontrar estrategias de manejo integrado pare el control de de esta especie en pecano.

Palabras clave: Carya illinoinensis, manejo, *Meloidogyne partityla*, nematodo agallador, pecano, portainjertos, relación hospedante-patógeno, resistencia, susceptibilidad.

[1]Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

INTRODUCTION

Pecan (*Carya illinoinensis*) is North America's most valuable native tree-nut crop, with worldwide cultivation and substantial production in both the United States and Mexico (Wood, 1994; Wood *et al*., 1990). United States kernel production alone was approximately 136,000 MT in 2011 (Anonymous, 2012). Pecan is a highly heterozygous species which shows wide variation when propagated from seed. Pecan cultivars are clonally propagated by budding or grafting onto seedling rootstocks which are then dug and sold as bare root trees. Pecan trees are impaired by a wide variety of diseases, insect pests, and nematodes that can reduce tree productivity if not properly managed.

Root-knot nematodes (M*eloidogyne* spp.) are recognized as causing serious limitations to intensive crop production systems worldwide. Perennial crops, such as fruit and nut trees, all suffer economic losses due to root-knot nematodes. *Meloidogyne* spp. that attack young peach trees often cause below-ground root galls, stunted growth of above-ground plant parts within the first two years following orchard establishment, early defoliation, reduced tree vigor, and occasionally tree death (Nyczepir and Becker, 1998; Nyczepir *et al*., 1999; Nyczepir and Thomas, 2009).

Reports of *Meloidogyne* spp. parasitizing pecan throughout the world are limited. Prior to 1996, the three species of *Meloidogyne* reported parasitizing pecan roots included *M. incognita* (Kofoid and White) and *M. arenaria* (Neal) Chitwood from the United States (Hendrix & Powell, 1968; Carithers, 1978; Johnson, 1986) and *M. partityla* from South Africa (Kleynhans, 1986). In 2002, the pecan root-knot nematode, *M. partityla*, was found for the first time on pecan in Georgia and was associated with stressed trees exhibiting dead branches in the upper canopy and/or typical mouse-ear (ME) associated foliar symptoms (Nyczepir *et al*., 2002). This was the third report of this nematode outside South Africa; with the first report of *M. partityla* on pecan within the United States reported by Starr *et al.* (1996) in Texas. Since 2002, further investigations in the southeastern and southwestern United States have revealed i) the increased severity of ME leaf symptoms, and thus Ni deficiency, in pecan trees in the presence of *M. partityla* (Nyczepir *et al*., 2006; Thomas *et al*., 2011) and ii) the first experimental proof of pathogenicity for *M. partityla* on pecan (Nyczepir and Wood, 2008); which explained the above-ground stunting of pecan trees observed growing in *M. partityla* infested soil. In 2003-04, a survey was conducted in the major pecan growing regions of Georgia where *M. partityla* was found to be the dominant root-knot nematode species associated with pecan (Nyczepir *et al*., 2004).

There are presently no recommended nematode resistant rootstocks, effective chemical nematicides, or biological control strategies available for managing *M. partityla* on pecan. In a previous short-term study, open-pollinated pecan seedling rootstocks were evaluated for resistance to *M. partityla, M. arenaria,* and *M. incognita* under greenhouse conditions (Nyczepir and Wood, 2012). All nine pecan seed sources were rated as good hosts (susceptible) to *M. partityla* infection, including 'Curtis' and 'Elliott' the most commonly used seed stock used for rootstocks in the southeastern United States. To further access the susceptibility and impact *M. partityla* has on these two commercial pecan rootstocks, the objective of this study was to conduct a long-term field evaluation (1-2 years) study to determine if 'Curtis' or 'Elliott' tree growth is impaired due to *M. partityla* infection.

MATERIAL AND METHODS

Nematode source and inoculum

A population of *M. partityla* isolated from pecan in Cobb, Georgia was maintained on pecan (*Carya illinoinensis* cv. 'Desirable') in the greenhouse. Identification of the root-knot nematode as *M. partityla* was confirmed using the esterase phenotype technique (Esbenshade and Triantaphyllou, 1985). Root-knot nematode egg inoculum was extracted from pecan roots using NaOCl solution (Hussey and Barker, 1973).

Field microplot experiment

Approximately 37-week-old open-pollinated 'Curtis' or 'Elliott' pecan seedlings were planted singly in bucket microplots (Barker, 1985) (25-cm-diam × 31-cm-deep) containing 15,000 cm^3 of steam pasteurized soil (86% sand, 10% silt, 4% clay, pH 6.1, 0.54% organic matter). 'Elliott' (known susceptible) was also included to verify *M. partityla* infectivity. Microplots were established in a shaded area (30% shade) in a field in Byron, Georgia. Approximately 27 days later, after seedling survival was evident, the soil in 20 microplots containing 10 'Elliott' or 10 'Curtis' seedlings was infested with 15,000 *M. partityla* eggs/15,000 cm^3 soil; which is equivalent to 100 *M. partityla* eggs/100 cm^3 soil. Approximately 7,500 eggs were pipetted directly into each of two holes (2.5 cm-deep), one on either side of the plant stem. The holes were covered and additional water applied to settle the soil around the eggs. Twenty other uninoculated microplots containing 10 'Elliott' or 10 'Curtis' seedlings served as controls. Treatments were replicated 10 times in a randomized complete block with a split plot design. Rootstock represented the main plot treatment and nematode the subplot treatment. Plants were watered and fertilized with Osmocote (14-14-14) as needed. Tree-trunk diameters were measured 8.0 cm above the soil line at 15 (March) and 25 (February) months after soil infestation. The experiment was terminated approximately 30 months after soil infestation and nematode population densities in roots were quantified by recording the following data, which included: number of egg masses per plant (up to 101 egg masses), number of eggs per plant , number of root galls per plant (up to 101 galls), and dry root weight. *Meloidogyne partityla* eggs in roots were estimated by cutting a 5-gram fresh weight portion of the root system and extracting eggs with a NaOCl solution as mentioned above. After collecting the eggs from the roots, the dry root weight (dried to a constant weight at 70°C in a drying oven) of each tissue extraction sample was determined. The remaining root systems were dried on greenhouse benches to a constant weight and then combined with the tissue extraction sample weights for total dry weight.

Statistical analysis

Nematode data were subjected to analysis of variance using the generalized linear models (GLM) procedure of SAS (SAS Institute, Cary, NC). Analysis of variance was also performed to determine treatment effect on trunk diameter and number of eggs per gram dry root. Means were compared using Fisher's protected least significant difference (LSD) test following a significant F test.

Table 1. Trunk diameter and dry root weight of 'Elliott' and 'Curtis' pecan seedlings grown in field microplots with *Meloidogyne partityla* and sampled 15 and 25 months after inoculation (MAI) and 30 MAI , respectively.

	Trunk diam. (mm)		Dry root weight (g)
Treatment	15 MAI	25 MAI	30 MAI
Rootstock[y]			
Curtis	8.43 a	10.78 a	124.62 a
Elliott	7.33 a	10.58 a	106.41 a
Nematodey [z]			
M. partityla -	7.92 a	11.53 a	150.30 a
M. partityla +	7.85 a	9.55 b	60.09 b

Data are means of 10 replications, except on 25 MAI which had seven and eight replicates for the 'Elliott' and 'Curtis' with *M. partityla* treatments, respectively and on 30 MAI which had six and nine replicates for the 'Elliott' with *M. partityla* and 'Elliott' control treatments, respectively and 5 and 8 replicates for the 'Curtis' with *M. partityla* and 'Curtis' control treatments, respectively. The interaction between rootstock and nematode was nonsignificant for trunk diameter and dry root weight.
[y]Means within a main effect and column followed by the same letter are not different ($P < 0.01$) according to the Fisher Protected LSD test.
[z]Initial population density of *Meloidogyne partityla* = 100 eggs/100 cm^3 soil.

RESULTS

Because the interaction between rootstock and nematode was not significant for all parameters, only main effect values are reported. Both 'Curtis' and 'Elliott' commercial seed sources were hosts to *M. partityla*. Reproduction by *M. partityla* on 'Curtis' and 'Elliott' rootstocks, as indicated by number of egg masses per plant (93 vs. 64 egg masses; $P = 0.10$), number of eggs per plant (10,875 vs. 10,067 eggs; $P > 0.15$), and number of eggs per gram of dry root (177 vs. 244 eggs/gram root; $P > 0.15$) was not significantly different between rootstocks 30 months after inoculation (MAI), respectively. Comparable results ($P > 0.15$) were also observed for number of root galls per plant on 'Curtis' (101 galls) vs. 'Elliott' (87 galls) rootstocks.

Differences in tree growth, as measured by trunk diameter and dry root weight did not differ between the two rootstocks, but was influenced by nematode treatment (Table 1). At 25 and 30 MAI, trunk diameter and dry root weight for both rootstocks were lower ($P < 0.01$) in the presence of *M. partityla* as compared to the untreated control, respectively.

DISCUSSION

The pecan root-knot nematode, *M. partityla*, was first reported on pecan in the United States in 1996, where it was detected in several counties in Texas (Starr *et al*., 1996). Since its detection in Texas, *M. partityla* has been found on pecan in New Mexico, Georgia, Florida, Arizona, and Oklahoma (Thomas *et al*., 2001; Nyczepir *et al*., 2002; Brito *et al*., 2006; Heerema *et al*., 2010). Further investigations of pecan in the southeastern and southwestern United States revealed this nematode's association with enhanced severity of twig die-back and/or ME leaf symptoms, and thus Ni deficiency (Nyczepir *et al*., 2006; Thomas *et al*., 2011). It was later reported by Nyczepir and Wood (2008) that above-ground tree growth was less with trees (cv. Desirable) growing in the presence of *M. partityla*. This was the first experimental proof of pathogenicity for *M. partityla* on pecan. This work helped to explain the above-ground stunting of pecan observed in commercial orchards in the southeastern United States. It should however, be noted that the 'Desirable' pecan seedlings used in this study was not a commercial rootstock commonly utilized by pecan growers in the Southeast. The two predominant pecan rootstocks used in the southeastern United States include 'Elliott' and 'Curtis'; the ones evaluated in the current study.

Results from this study show that differences in tree growth, as measured by trunk diameter and dry root weight, did not differ between 'Elliott' and 'Curtis' rootstocks. Furthermore, even though plant shoot weight was not recorded in this study, root weight is generally known to be proportional in size to plant shoot weight (root:shoot ratio) (Harris, 1992). Growth suppression was observed at the same level in both rootstocks in the presence of *M. partityla*, because both stocks were relatively similar in their susceptibility to this nematode. One may speculate that growth differences between the two rootstocks may have been similar because the initial inoculum level (Pi) was too low. However, in a previous field microplot study the presence of *M. partityla* at Pi = 4,000 eggs/15,000 cm^3 soil was sufficient enough to reduce ($P < 0.05$) mean trunk diameter in pecan (Nyczepir and Wood, 2008). The Pi in the current study was 15,000 *M. partityla* eggs/15,000 cm^3. These results also substantiate the susceptibility of 'Curtis' and 'Elliott' rootstocks to *M. partityla* as previously reported in greenhouse trials (Nyczepir and Wood, 2012) and further demonstrate the pathogenicity of the nematode toward these two primary commercial pecan rootstocks used in the southeastern United States. Additionally, the potential damage to the commercial pecan industry could result in reduced nut yields as a consequence of a reduced root system from *M. partityla* parasitism. In apple, mechanical root pruning with a sharpened subsoiler caused a reduction in yield and trunk cross-sectional area over a nine year period (Ferree and Knee, 1997).

In summary, the two commercial pecan rootstocks used in the southeastern United States are not only good hosts (susceptible) to *M. partityla*, but this nematode is an economically important pathogen to the pecan industry in the Southeast. Georgia is ranked number one in pecan production within the United States. The 3-year average value of the utilized pecan crop (budded, grafted or top-worked varieties only) in Georgia alone (2009-2011) was in excess of $176 million (Anonymous, 2012). Further research is needed to determine if other potential germplasms differ in resistance, tolerance or susceptibility of pecan to *M. partityla* and/or to develop an IPM management strategy for control of *M. partityla* on pecan and its effect on orchard profitability.

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LITERATURE CITED

Anonymous. 2012. U.S. Department of Agriculture, National Agricultural Statistics Service. Noncitrus Fruits and Nuts 2011 Summary. National Technical Information Service, Springfield, VA.

Barker, K. R. 1985. Design of greenhouse and microplot experiments for evaluation of plant resistance to nematodes. Pp. 107-113 *in* B. M. Zuckerman, W. F. Mai, and M. B. Harrison, eds. Plant Nematology Laboratory Manual, Massachusetts: University of Massachusetts Agricultural Experiment Station.

Brito, J. A, R. Kaur, D. W. Dickson, J. R. Rich, and L. A. Halsey. 2006. The pecan root-knot nematode, *Meloidogyne partityla* Kleynhans, 1986. Florida Department of Agriculture & Consumer Services, Division of Plant Industry, Nematology Circular No. 222, Gainesville, FL.

Carithers, P. A. P. 1978. Investigations of a *Meloidogyne* species isolated from pecan. M.S. thesis, The University of Georgia, Athens.

Esbenshade, P. R. and A. C. Triantaphyllou. 1985. Use of enzyme phenotypes for identification of *Meloidogyne* species. Journal of Nematology 17:6-20.

Ferree, D. C. and M. Knee. 1997. Influence of root pruning and rootstock on growth and performance of 'Golden Delicious' apple. HortScience 32:64-648.

Harris, R. W. 1992. Root-shoot ratios. Journal of Arboriculture 18:39-42.

Heerema, R., N. Goldberg, and S. Thomas. 2010. Diseases and other disorders of pecan in New Mexico. New Mexico State University Extension Service Bulletin Guide H-657, Las Cruces, NM.

Hendrix, F. F., Jr. and W. M. Powell. 1968. Nematode and *Pythium* species associated with feeder root necrosis of pecan trees in Georgia. Plant Disease Reporter 52:334-335.

Hussey, R. S. and K. R. Barker. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp., including a new technique. Plant Disease Reporter 57:1025-1028.

Johnson, J. D. 1986. Current status of root-knot nematodes on pecans and their control. Proceedings of the Annual Conference for the Texas Pecan Growers Association 64:37-38.

Kleynhans, K. P. N. 1986. *Meloidogyne partityla* sp. nov. from pecan nut [*Carya illinoinensis* (Wangenh.) C. Koch] in the Transvaal Lowveld (Nematoda: Meloidogynidae). Phytophylactica 18:103-106.

Nyczepir, A. P. and O. J. Becker. 1998. Fruit and citrus trees. Pp. 637-684 *in* K. R. Barker, G. A. Pederson, and G. L. Windham, G. L. eds. Plant nematode interactions, American Society of Agronomy Monograph Series, No. 36, Madison, WI Publishers.

Nyczepir, A. P., T. G. Beckman, and G. L. Reighard. 1999. Reproduction and development of *Meloidogyne incognita* and *M. javanica* on Guardian peach rootstock. Journal of Nematology 31:334-340.

Nyczepir, A. P., C. C. Reilly, and B. W. Wood. 2004. Incidence and association of *Meloidogyne partityla* with mouse-ear disorders of pecan in Georgia. Journal of Nematology 36:338.

Nyczepir, A. P., C. C. Reilly, B. W. Wood, and S. H. Thomas. 2002. First record of *Meloidogyne partityla* on pecan in Georgia. Plant Disease 86:441.

Nyczepir, A. P. and S. H. Thomas. 2009. Current and future management strategies in intensive crop production systems, Pp. 412-443 *in* R. N Perry, M. Moens, and J. L. Starr, eds. Root-knot nematodes. United Kingdom: CABI.

Nyczepir, A. P. and B. W. Wood. 2008. Interaction of concurrent populations of *Meloidogyne partityla* and *Mesocriconema xenoplax* on pecan. Journal of Nematology 40:221-225.

Nyczepir, A. P and B. W. Wood. 2012. Assessment of selected pecan and peach rootstocks for resistance to *Meloidogyne partityla*. Nematropica 42:281-286.

Nyczepir, A. P., B. W. Wood, and C. C. Reilly. 2006. Association of *Meloidogyne partityla* with nickel deficiency and mouse-ear of pecan. HortScience 41:402-404.

Starr, J. L., E. K. Tomaszewski, M. Mundo-Ocampo, and J. G. Baldwin. 1996. *Meloidogyne partityla* on pecan: Isozyme phenotypes and other hosts. Journal of Nematology 28:565-568.

Thomas, S. H., J. M. Fuchs, and Z. A. Handoo. 2001. First report of *Meloidogyne partityla* on pecan in New Mexico. Plant Disease 85:1030.

Thomas, S. H., J. M. Trojan, and R. J. Heerema. 2011. *Meloidogyne partityla*-induced changes in pecan growth and nutrient sequestration. Journal of Nematology 43:288-289.

Wood, B. W. 1994. Edible tree nuts: Pecan and other hickories. Encyclopedia of Agricultural Science 2:1-8.

Wood, B. W., J. A. Payne, and L. J. Grauke. 1990. The rise of the United States pecan industry. HortScience 25:721-723.

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