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Managing Root-knot Nematode (*Meloidogyne* spp.) in Grafted Watermelon

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Fusarium wilt of watermelon is a serious and expanding disease in many watermelon producing areas of the southeast United States. Grafted watermelons have been reported to provide control of Fusarium wilt. Unfortunately, the rootstocks currently utilized for Fusarium control are very susceptible to root-knot nematodes (RKN), which are also common in many production areas infested with Fusarium wilt. Two non-fumigant nematicides (abamectin, fluensulfone) were compared with a fumigant nematicide [1,3-dichloropropene (1,3-d)] in grafted and non-grafted watermelon. None of the nematicide treatments significantly reduced root gall index (RGI). The use of 1,3-d improved watermelon yield when compared with fluensulfone and the non-treated control. Grafted plants had significantly greater RGI and significantly lower yield compared with non-grafted plants. These data illustrate a significant hindrance to the adoption of grafted watermelons in commercial production areas that are infested with RKN.

Fusarium wilt of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a soilborne fungal disease caused by *Fusarium oxysporum* f. sp. *niveum*. This disease has widespread distribution throughout the southern United States and other watermelon producing regions of the world (Kurt et al., 2008; Keinath and Hassell, 2014a). Fusarium wilt has traditionally been managed with multi-year crop rotation or soil fumigation. Demands on agricultural lands have reduced the availability of rotational land and the costs associated with soil fumigation have increased beyond economic feasibility for watermelon, leaving producers searching for Fusarium management options. Fusarium wilt is of great concern because there are no diploid or triploid cultivars available that possess adequate resistance to race 2, a very widespread and virulent race of Fusarium. Although there are no available watermelon cultivars with resistance, other cucurbitaceae, such as bottle gourd (*Lagenaria siceraria* (Molina) Standl.) and interspecific hybrid squash (*Cucurbita maxima* Duch. ex Lam. x *Cucurbita moschata* Duch. ex Poir), have reported resistance to multiple races of Fusarium wilt (Yetisir et al., 2003). These genetic resources may eventually be deployed in watermelon through traditional breeding but currently grafting, the physical combination of two different species or varieties, is being used to exploit these traits in watermelon. Scions of susceptible watermelon cultivars are being grafted to rootstocks of resistant species to manage Fusarium wilt. This practice has been shown to significantly reduce losses from Fusarium wilt and improve watermelon yield (Keinath and Hassell, 2014; Miguel et al., 2004). Unfortunately, the most common type of rootstocks used to manage Fuasrium wilt have been shown to be very susceptible to root-knot nematodes [RKN (*Meloidogyne* spp.), Theis et al., 2010]. Root-knot nematode infestation has traditionally been managed with host plant resistance, nematicides, or crop rotation, but a lack of these management options are the primary reason for the use of grafting. Widely distributed in many watermelon producing regions, RKN has been shown to significantly reduce watermelon yield (Davis, 2007). The use of grafting may not be beneficial if, although yield losses from Fusarium wilt are prevented, there are still yield losses to RKN. This experiment was performed to examine the effect of two non-fumigant nematicides (abamectin, fluensulfone) and a fumigant nematicide [1,3-dichloropropene (1,3-d)] in grafted and non-grafted watermelon.

Materials and Methods

This experiment was conducted at the University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS) North Florida Research and Education Center (NFREC) in Quincy, FL. The soil type at NFREC is a Dothan fine sand with pH 6.9. Experimental plots were arranged in a split-plot design with six replications. Main plot treatments were nematicide and sub-plot treatments were grafting. The experiment was located in a field with a history of southern root-knot nematode (*Meloidogyne incognita*) infestation. Soil was cultivated to 12-inch depth and pre-plant fertilizer was applied at a rate of 152-52-100 lb/acre of N-P-K. Raised beds 8 inches tall x 30 inches wide were established and covered with black polyethylene mulch. Rows were spaced 8 feet apart and plants were spaced 3 feet within the row. Experimental plots consisted of a single row containing 12 plants. Nematicide treatments included fluensulfone, abamectin, 1,3-d, and a non-treated control. Prior to bed establishment, fluensulfone was applied to the soil at a broadcast rate of 112 oz/acre and incorporated to a depth of 8 inches. During bed establishment a 63:35 w:w mixture of 1,3-d and chloropicrin was applied at a broadcast rate of 336 lb/acre. Fumigant was delivered through three backswept shanks and released 8 inches below the bed

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Table 1. Yield, fruit quality, and root gall index (RGI) from watermelons as affected by grafting and pre-plant nematicide treatment. Experiments were conducted at NFREC in Quincy, FL, during Spring 2014.

Factor	Yield[z] (lb/acre)	Avg. wt (lb)	HS[y]	HH[x]	°Brix[w]	RGI[v]
Nematicide						
1,3-d	61021 a	16.3 ns	8.0 ns	0.5 ns	12.2 ns	3.0 ns
Abamectin	48959 ab	16.8	8.8	0.0	11.8	4.0
Untreated	43407 b	15.6	6.3	0.5	12.3	4.4
Fluensulfone	40135 b	16.1	9.3	0.5	12.0	4.4
Entry						
Grafted	41354 b	16.7 ns	8.7 ns	0.1 b	12.1 ns	6.3 a
Non-grafted	54957 a	16.0	7.7	0.7 a	12.1	1.9 b

[z]Yield estimates are based on a plant population of 1815 plants per acre.

[y]HS = Hard Seed, number of hard seed were counted on 4 faces of cut fruit using a 4 fruit subsample from each plot.

[x]HH = Hollow Heart, Based on a 0–5 scale with 0 being no hollow heart and 5 being severe hollow heart. Ratings of 4 and 5 would be considered unmarketable.

[w]The °Brix was measured using a hand held digital refractometer. Flesh samples were removed from the heart of 4 fruit per plot.

[v]RGI = Root Gall Index, Based on a 0–10 scale with 0 being no galling to 10 being severe galling of primary root system. Data were obtained using a five-plant subsample per plot.

Values not followed by the same letter are significantly different at $P \leq 0.05$ by LSD.

ns = not significant

surface. Abamectin was applied as a seedling drench at a rate of 0.6 g a.i. per plant two days prior to field transplanting. Trickle irrigation tubing was deployed 2 inches below the bed surface at bed formation. Grafting treatment consisted of the seedless watermelon ‘Fascination’ non-grafted or ‘Fascination’ grafted onto the interspecific hybrid (*C. maxima* x *C. moschata*) rootstock ‘Carnivor’. ‘Fascination’ was grafted to ‘Carnivor’ using the one cotyledon method (Hassell et al., 2008). Five-week-old seedlings of grafted and non-grafted entries were field transplanted on 21 Apr. 2014. Watermelon plant health was maintained using UF/IFAS recommendations (Freeman et al., 2014). Harvests of ripe watermelons were made on 10 and 24 July. During the first harvest, 4 fruit per plot were cut and examined for the presence of hard seed, hollow heart, and soluble solids content. Hard seed was counted on four interior surfaces of cut fruit. Hollow heart severity was rated using a 0–5 scale with ratings of 3–5 being unmarketable. Soluble solids content was measured with a hand held refractometer and is reported as °Brix. After termination of the second harvest, five plants per plot were dug up and roots were examined for galling caused by RKN using the root gall index (RGI), a 0–10 scale with 0 = no galling and 10 = plant and roots are dead (Zeck, 1971). Experimental data were analyzed using the GLM procedure in SAS and means separation was performed with LSD, when appropriate.

Results and Discussion

There was no significant interaction between grafting and nematicide treatments. Non-grafted ‘Fascination’ produced significantly greater yield than grafted ‘Fascination’ while average fruit size was not significantly different (Table 1). There was no significant difference in hard seed content or °Brix between grafted and non-grafted entries while hollow heart was more severe in non-grafted entries. Hollow heart in both grafted and non-grafted entries was not severe enough to result in unmarketable fruit. RGI was significantly greater in grafted ‘Fascination’ compared to non-grafted ‘Fascination’. Experimental plots treated with 1,3-d produced greater fruit yield than those treated with fluensulfone and the non-treated control (Table 1). The abamectin treatment resulted in yields similar to those from 1,3-d, fluensulfone, and non-treated control plots. There were no significant differences in average fruit weight, hard seed content, hollow heart rating, °Brix, or RGI between nematicide treatments.

These data confirm what has been reported by Theis et al., (2010) with respect to the sensitivity of interspecific cucurbit rootstocks to RKN. Grafted plants had severe root galling on about 50% of the roots while non-grafted plants had few small galls. All nematicides employed in this experiment failed to protect the sensitive rootstocks. Though there was no difference between 1,3-d and other nematicides it was noted that root systems from fluensulfone and abamectin plots had begun to decay, likely from fungal organisms, while those from 1,3-d had not. This may indicate that 1,3-d protected roots for a longer period, but nematodes re-infested treated soil and damaged roots later in the season. This is not known for certain because roots were not evaluated at mid-season. These data indicate a potential hindrance to the adoption of grafted cucurbits in certain geographic areas. It is unclear what the market price of grafted watermelons may be and whether the economics of production would allow for a protective nematicide treatment, though those used in this experiment did not appear sufficient. Another question that remains is whether the Fusarium wilt resistance will persist when resistant rootstocks are infested and damaged by RKN.

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