Host Suitability and Yield Response of Three Cotton Varieties to *Meloidogyne incognita*

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ABSTRACT

One susceptible (Deltapine 90) and two resistant (LA 887 and NemX) cultivars were evaluated in field microplots for host suitability and yield loss to an isolate of Meloidogyne incognita. Five replications of seven initial population densities (Pi) of M. incognita (0, 0.5, 1, 10, 50, 100, 500 eggs/500 cm^3soil) were established for each cultivar in the 1997 growing season in South Carolina. Deltapine 90 was an excellent host for M. incognita. Severity of galling (G) and reproduction, as measured by the final larvae population density of juveniles in the soil (Pf), responded in a positive linear manner to Pi as predicted by the models $G = 1.28 \log_{10}(Pi + 1) - 0.278$, ($r^2 = 0.82$) and $Pf = 822.5 \log_{10}(Pi + 1) - 253.3$, ($r^2 = 0.61$). NemX and LA 887 were both poor hosts. Severity of galling and Pf for these two varieties responded in a positive linear manner to Pi and could be predicted by the following models: $G = 0.239 \log_{10}(Pi + 1) - 0.013$, ($r^2 = 0.27$) and $Pf = 111.78 \log_{10}(Pi + 1) - 4.80$, ($r^2 = 0.05$) for NemX; $G = 0.34 \log_{10}(Pi + 1) - 0.186$, ($r^2 = 0.39$) and $Pf = 42.62 \log_{10}(Pi + 1) - 3.51$, ($r^2 = 0.25$) for LA 887. Yield response of the cultivars to Pi did not fit a linear model. In a similar experiment utilizing the same Pi's, greater yield suppression of DP 90 was observed. The negative linear relationship between Pi and yield fit the model $y = - 9.30 \log 10 (Pi + 1) + 60.05$, ($r^2 = 0.13$). Generally, LA 887 yielded the highest across Pi's and had smaller Pf's at harvest.

Introduction

Nematodes are a major factor in reducing U.S. cotton yields. In 1997, it was estimated that nematodes caused a $300 million dollar loss in the USA (Blasingame, 1998). Currently *M. incognita* control relies heavily on the use of nematicides at-planting which reduce yield losses but require significant economic inputs. Nematicides applied at-planting provide control only for 4-6 weeks, so nematode populations may increase later in the growing season. One major method of control with great potential is the use of resistant cultivars. Resistant cultivars typically reduce both yield losses and residual populations for subsequent crops. Currently there are resistant breeding lines with high levels of resistance to *M. incognita* but they lack the agronomic traits needed for commercial cultivars (Jeffers and Roberts, 1993). Current work aims to incorporate resistance into acceptable commercial cotton cultivars (Kirkpatrick *et al.*, 1995). In 1995, the cultivar NemX was released by the California Planting Cotton Seed Distributors as a *M. incognita* resistant cultivar (Ogallo *et al.*, 1997; Oakely, 1995). NemX exhibits greater yields than susceptible cultivars in *M. incognita* infested fields and suppresses population development across varying initial population densities (Ogallo *et al.*, 1997). For other new resistant cultivars to be acceptable for commercial production, they must exhibit this type of durability and favourable agronomic traits.

A damage threshold is the population density at which a yield loss is observed (Abdel-Momen and Starr, 1997). Accurate damage thresholds are necessary to determine when specific management practices need to be implemented. Damage thresholds may differ for cultivars, site locations, species isolates, and environmental conditions (McSorley and Phillips, 1993). Utilizing damage thresholds developed for specific genotypes and environmental conditions will allow implementation of the most cost effective and sustainable agricultural systems. Damage thresholds for many of the current sources of resistance are not known but it is expected that they will be higher than the thresholds for susceptible cultivars. The objective of this study was to determine the damage thresholds for cultivars which are highly resistant (NemX), moderately resistant (LA 887) (Jones *et al*, 1991.), and susceptible (DP 90) and also to evaluate the ability of these cultivars to suppress nematode reproduction.

Materials and Methods

Field microplot experiments were established to determine damage thresholds and reproduction of *M. incognita* populations on cotton. Microplots consisted of metal cylinders 60-cm-diam x 45-cm deep located in a sandy-loam soil. Microplots were fitted with plastic covers and fumigated with methyl bromide (90-ml/4 m^2). Covers were removed after one week and soil within each microplot was mixed three times to ensure that phytotoxic levels of methyl bromide were not present at the time of planting.

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A single *M. incognita* race 3 population ('Musen') was selected, based on its virulence in field plots and the high levels of galling present on greenhouse cultures. Inoculum was prepared by chopping infected tomato roots into fragments and mixing them with the infested soil from which they were obtained. Eggs and J2 densities were estimated for the inoculum by extracting eggs from root pieces using sodium hypochlorite (Hussey and Barker, 1973) and J2 from soil by elutriation and centrifugation. Pasteurized soil was added proportionately to ensure an equal amount of soil was added to each microplot. Soil inoculum was added to the upper 25 cm of soil in each microplot at specified levels (0, 0.5, 1, 10, 50, 100, 500 eggs/500 cm^3 soil). Microplots were infested and the cotton cultivars were planted on 28 May 1997. Twelve seeds were planted in each microplot and thinned to 6 plants on June 25. The experimental was a 7x3 factorial design in 5 randomized complete blocks with 7 Pi's and 3 cultivars. Microplots were fertilized with 10-10-10 fertilizer according to recommendations received from soil analysis on June 5 and July 7.

At harvest, on October 21, four 2.54-cm diameter. cores were taken 15-cm deep in each microplot to determine final *M. incognita* population densities (Pf). Elutriation and centrifugation were used to extract J2 nematodes from the soil and eggs were extracted from the root fragments collected during the elutriation using sodium hypochlorite (Hussey and Barker, 1973). Pf = eggs and J2 at harvest and Rf (reproductive factor) = Pf/Pi.

Cotton was harvested by hand on October 19 and October 30. Each cotton plant was removed from the microplot and the root system was rated for galling on a scale of 0-5 where: 0= no galls; 1= 1-20%; 2= 21-40%; 3= 41-60%; 4= 61-80%; and 5= 81-100% of root surface galled.

Analysis of variance and regression analysis used a simple linear regression in the Statistical Analysis System (SAS).

Results and Discussions

Deltapine 90 was an excellent host for *M. incognita* with an Rf of well above 1 at all Pi levels (Fig. 1.). Severity of galling (G) and Pf responded in a positive linear manner to Pi as predicted by the models:

$G = 1.28 \log_{10} (Pi + 1) - 0.278$, ($r^2 = 0.82$); and

$Pf = 822.5 \log_{10} (Pi + 1) - 253.3$, ($r^2 = 0.61$).

NemX and LA 887 were both poor hosts with low Rf values. Rf values for LA 887 were slightly above 1 only for Pi levels greater than 1 (Fig. 1.). Rf values for NemX were slightly above 1 only for Pi levels greater than 10 (Fig. 1.). At Pi's of 100 and 500 for LA 887 and at a Pi of 500 for NemX, Rf's were less than 1. In general Rf values for LA 887 and NemX decreased as Pi's exceeded 1. This decline in Rf values is probably due to high infection levels leading to restricted root systems and therefore fewer feeding sites and fewer nutrients available at each site. Severity of galling and Pf for these cultivars responded in a positive linear manner to Pi and could be predicted by the following models:

$G = 0.239 \log_{10} (Pi + 1) - 0.013$, ($r^2 = 0.27$) and
$Pf = 111.78 \log_{10} (Pi + 1) - 4.80$, ($r^2 = 0.05$)
for NemX; and

$G = 0.34 \log_{10} (Pi + 1) - 0.186$, ($r^2 = 0.39$) and
$Pf = 42.62 \log_{10} (Pi + 1) - 3.51$, ($r^2 = 0.25$)
for LA 887.

Severity of galling was higher on DP 90 than on LA 887 or NemX for Pi's of 10 or more.

There was no linear yield response of the three cultivars to increasing Pi's. Generally, LA 887 yielded the highest across Pi's (Fig. 2). The lack of a linear yield response prevented an accurate assessment of the damage thresholds for each cultivar. However, by increasing the Pi levels in future experiments we may observe a more linear response in all three cultivars. In a separate experiment utilizing the same Pi's greater yield suppression of DP 90 was observed. In this experiment, the negative linear relationship between Pi and yield fit the model

$y = - 9.30 \log_{10} (Pi + 1) + 60.05$, ($r^2 = 0.13$).

Conclusions

Relatively high levels of resistance to *M. incognita* are present in breeding lines and are being incorporated into commercially acceptable cotton cultivars. NemX and LA 887 are examples of new, highly resistant cultivars. However, the durability of resistance and agronomic traits of these cultivars must be assured before they are recommended to producers. They are highly resistant but not immune so yield losses may occur if *M. incognita* populations are high or if environmental conditions favour disease development. Damage thresholds must be accurately defined for higher levels of resistance so that growers may incorporate other control measures such as nematicides when necessary. Yield losses did not respond in a linear manner to Pi for LA 887 or NemX. However, yield loss on DP 90 did respond in a linear manner in the second experiment. Higher Pi's are probably needed to consistently produce yield losses on the resistant cultivars.

References

Abdel-Momen, S.M. and J.L. Starr. (1997): Damage functions for three *Meloidogyne* species on *Arachis hypogaea* in Texas. J. Nematology 29(4):478-483.

Blasingame, D. (1998): Cotton disease loss estimate committee report. In: Proc. Beltwide Cotton Conf. P. Dugger and D.A. Richter (Ed.) National. Cotton Council, Memphis TN. Pp 119.

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 59:1025-1028.

Jeffers, D.P. and P.A. Roberts. (1993): Effect of planting date and host genotype on the root-knot nematode-*fusarium* wilt disease complex of cotton. Ecology and Epidemiology 83(6):645-654.

Jones, J.E., J.I. Dickson, W. Aguillard, W.D. Caldwell, S.H. Moore, R.L. Hutchinson and R.L. Rogers. (1991): Registration of 'LA 887' cotton. Crop Science 31:1701.

Kirkpatrick, T.L., P.D. Colyer and T.A. Wheeler. (1995): Interactions with *fusarium* diseases. In: Proc. Beltwide Cotton Conf., D.A. Richter and J Amour (Ed.). Nat. Cotton Council Memphis, TN:.Pp 199.

McSorley, R., and M.S. Phillips. (1993): Modelling population dynamics and yield losses and their use in nematode management. In: Plant-Parasitic Nematodes in Temp. Agric. K. Evans, D.L. Trudgill, and J.M. Webster, (Eds.). Wallingford, UK:CAB International. Pp. 63-85.

Noe, J.P. (1993): Damage functions and population changes of *Hoplolaimus columbus* on cotton and soybean. J. Nematology 25(3):440-445.

Oakley, S.R. (1995): CPCSD Acala C-225: a new nematode-resistant Acala variety for California's San Joaquin Valley. In: Proc. Beltwide Cotton Conf.: D.A. Richter and J Amour (Ed.). Nat. Cotton Council. . Memphis, TN. Pp 39.

Ogallo, J.L., P.B. Goodell, J. Eckert, and P.A. Roberts. (1997): Evaluation of NemX, a new cultivar of cotton with high resistance to *Meloidogyne incognita*. J. Nematology 29 (4): 531-537.

Figure 1. Effects of *M. incognita* Pi densities on the reproductive factor of cotton.

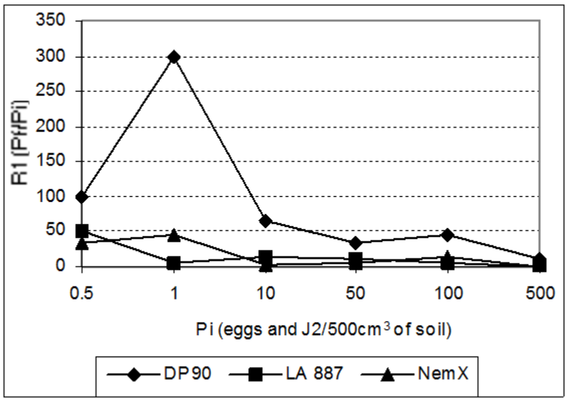

Figure 2. Effects off Pi *M. incognita* on yield of three cotton cultivars.