Measuring Soybean Cyst Nematode Populations Using Remote Sensing

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Introduction

The soybean cyst nematode (SCN) (Heterodera glycines Ichinohe) is an economically important pathogen of soybean throughout the United States (Wang, et al., 2003). This nematode caused annual losses of 152 million bushels in the United States during 1996-2010 (Wrather and Koenning). Phenotypic characterization of genotypic resistance to SCN is labor intensive. Remote sensing technologies have the potential to characterize plant stress. These technologies may provide powerful tools for monitoring plant growth and development and for detecting plant disease caused by SCN in soybean (Nutter, et al., 2002).

Objective

Characterize differences in soybean cyst nematode (SCN) reproduction on soybean genotypes using remote sensing.

Materials and Methods

Experimental Design:

- The experiment was conducted at three locations in N.E. KS in 2012 and 2013. Two SCN resistance genotypes, KS5502N, KS5004N and two susceptible genotypes, 5002T, 5601T were planted in four-rows plots, 3.4m long, spaced 76 cm apart, in a randomized complete block design with 10 replications.

Measurements:

- Soil samples were collected from each plot at planting and harvest in 2012. SCN cysts were extracted from 100 cm^3 subsamples using wet-sieving. Eggs and infective juveniles (J2) were recovered from mechanically-ruptured cysts and counted under a microscope X40 magnification (Fig. 2a-b).
- Root samples were collected at the R2 stage (Fehr et al., 1971) and sprayed with pressurized water to dislodge cysts. Cyst and egg counts were standardized per gram of root.
- Spectral data were collected four times during the growing season from R1 through R6 using an ASD Field Spec3 spectroradiometer (Fig. 1a-b).
- Canopy temperature (CT) was measured using a FLIR BCAM infrared camera on each day that spectral data were collected (Fig. 2c).
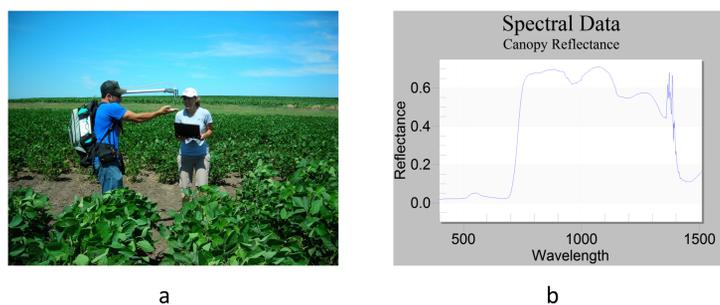

Fig. 1. a) ASD Field Spec3 spectroradiometer being used for reflectance measurements, b) Spectral reflectance characteristic of a plant canopy for the wavelength interval 400-1500 nm (ViewSpec Pro, 2008).

Data Analysis:

- SCN counts were log_{10} transformed to reduce heterogeneity of variance.
- Mean comparisons were done among the genotypes for SCN soil and root population densities using SAS (SAS institute, 2005) Proc Mixed.
- Principal component (PC) scores were obtained for spectral data within seven specified reflectance regions: green (495-605nm), red and red edge (685-775nm), and five from near infrared (NIR) (785-945nm, 955-1005, 1015-1125nm, 1135-1235, 1235-1305nm).
- Overall correlations between principal component scores, CT, and SCN soil and root population densities were obtained at different growth stages by pooling over genotypes, and using Proc Corr.
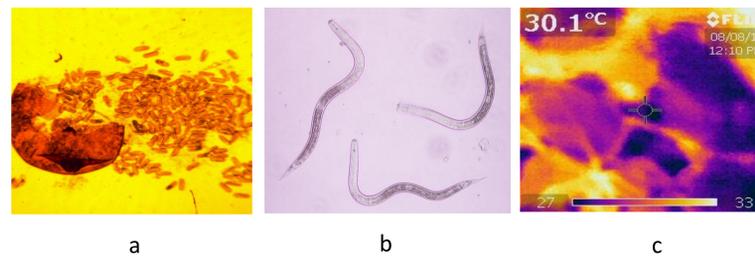
Materials and Methods (Cont.)

Fig. 2 a) Ruptured SCN cyst showing released eggs , b) Hatched J2, c) infrared image of the canopy (QuickReport 1.1, 2007).

Results

- There were significant differences (p≤ 0.01) among genotypes for final SCN soil population densities (cyst per 100 cm^3 soil, and egg per 100 cm^3 soil), reproductive factor (RF), SCN root population densities (cyst per gram of root, and egg per gram of root).
- KS5502N had a lower final SCN soil population densities (Pf), RF and SCN root population densities than the other genotypes. KS5004N was not resistant to the SCN population at Rossville in 2012 (Fig. 3a-b).
- There were significant (p≤ 0.01) differences among genotypes for canopy reflectance and temperature in three locations (data not shown).
- In 2013, there were significant differences (p≤0.01) among genotypes for SCN root populations densities. KS5004N was not resistant to the SCN population in both locations as well.
- At growth stage R6, there were significant negative correlations between PC scores of NIR (785-945nm) with Pf (r=-0.36, p≤0.05), and CT was positively correlated with RF (r=0.29, p≤0.1) in Rossville 2012 (Table 1a).
- At growth stage R6, there were significant negative correlations between PC scores of NIR (785-945nm) with cyst/gram (r= -0.41, (p≤0.01), and egg/gram (r=-0.42, p≤0.01), and CT was positively correlated with cyst/gram (r=0.40, p≤0.01), and egg/gram (r=0.39, p≤0.05) in Rossville in 2013 (Table 1b in red).
- Results have also shown there were significant negative correlations between PC score of NIR (785-945nm) with egg/gram (r=-0.42, p≤0.01), and positive correlations between CT and cyst/gram (r=0.35, p≤0.05) at growth stage R6 in Manhattan in 2013 (Table 1b in blue).
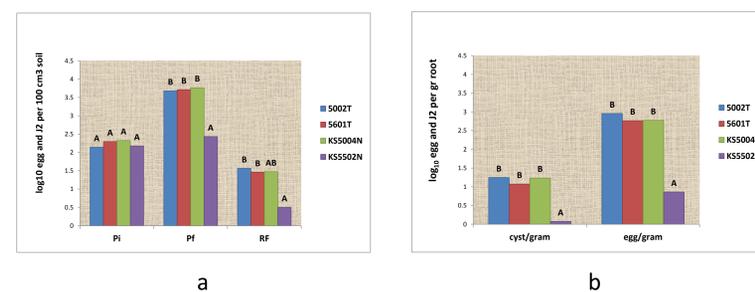

Fig. 3 a) Effect of soybean genotypes on SCN soil population densities at planting (Pi), and at harvest (Pf), and on reproductive factor (RF=Pf/Pi).
b) Effect of soybean genotypes on SCN root population densities at growth stage R2 at Rossville (2012).
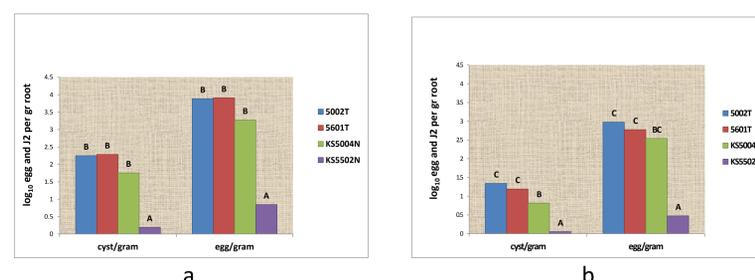

Fig. 4 a) Effect of soybean genotypes on SCN root population densities at growth stage R2 in Rossville (a) and Ashland (b) in 2013.

Results (Cont.)

	Pf	RF	Cyst/gram	Egg/gram	CT
RF	**0.77****				
Cyst/gram	**0.68****	**0.54****			
Egg/gram	**0.72****	**0.53****			
CT	0.25	**0.29†**	0.24	0.24	
NIR	**-0.36***	-0.21	-0.26	-0.24	-0.07

a

	Cyst/gram	Egg/gram	CT	NIR
Cyst/gram		0.91**	0.35*	-0.25
Egg/gram	**0.973****		0.22	-0.42**
CT	**0.40****	**0.39***		-0.16
NIR	**-0.41****	**-0.42****	**-0.67****	

b

Table 5 a) Pearson's correlation coefficients (r) between principle component scores based on spectral reflectance data in the NIR region and SCN root population densities, Pf, and RF at Rossville in 2012. b) Pearson's correlation coefficients (r) between principle component scores based on spectral reflectance data in the NIR region and SCN root population densities at Rossville (in red), and Ashland (in blue) in 2013.

†p≤ 0.1, *p≤ 0.05, and **p≤ 0.01

Conclusions

- KS5502N was resistance to the SCN root populations in three locations had a lower cyst/gram and egg/gram.
- In 2012 at Rossville, as canopy reflectance increased in the NIR region (785-945nm), Pf tended to decrease. As CT increased RF tended to increase.
- In the second year of evaluation, SCN root population densities were associated with canopy reflectance and canopy temperature. When canopy temperature increased, SCN root population densities increased. When canopy reflectance decreased in the NIR region (785-945nm), SCN root population tended to increase.
- Results indicate that it may be possible to characterize soybean cyst nematode reproduction in the field using spectral reflectance and canopy temperature measurements.

References

- Wang, J., Niblack, T. L., Tremain, J. A., Wiebold, W. J., Tylka, G. L., Marett, C. C., Noel, G. R., Myers, O., and Schmidt, M. E. 2003. Soybean cyst nematode reduces soybean yield without causing obvious aboveground symptoms. Plant Dis. 87:623-628.
- Wrather, J. A., and Koenning, S. Soybean disease loss estimates for the United States, 1996-2010. Retrieved April 5, 2013 from http://aes.missouri.edu/delta/research/soyloss.stm.
- Nutter, F.W., Jr., G. L. Tylka, J. Guan, A. J. D. Moreira, C. C. Marett, T. R. Rosburg, J. P. Basart, and C. S. Chong. 2002. Use of remote sensing to detect soybean cyst nematode-induced plant stress. Journal of Nematology, 34(3):222-231.
- Fehr, W.R., Caviness, C.E., Burmood, D.T., Pennington, J.S. 1971. Stages of development descriptions for soybeans, *Glycine max* (L.) Merrill. Crop Sci. 11:929-932.
- ViewSpec Pro. 2008. Version 6.0. ASD Inc., Boulder, CO.
- SAS Institute. 2007. Release 9.2 ed. SAS Inst., Cary, NC.
- FLIR Systems QuickReport 1.1. 2007. FLIR Systems Inc., Wilsonville, OR.

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