ASSESSING THE BENEFITS OF RADISH AS A COVER CROP

M.M. Chawner, M.D. Ruark, F. Arriaga, A.E. MacGuidwin, and J.K. Stute
University of Wisconsin, Madison, Wisconsin

Abstract

Oilseed radish (*Raphanus sativus L)* is a popular cover crop for no-till farmers in Wisconsin, especially among those that include winter wheat in rotation since radish can accumulate large amounts of nitrogen (N). However, previously presented research in Wisconsin has not shown a clear N credit for a subsequent corn crop. Additionally, there is a lack of information that quantifies other benefits of radish, including compaction reduction and nematode suppression. The objective of this project was to determine the effects of radish as a cover crop on optimum N rate, soil compaction, and nematode populations. Radish cover crops were planted in mid-August at two field sites located in Southern and Northeast Wisconsin. Each radish treatment was accompanied by a no cover crop treatment, and all treatments were split into increasing amounts of nitrogen fertilizer. Radish biomass and volunteer winter wheat was collected within each whole plot in the fall prior to radish winterkill and analyzed for total nitrogen uptake. Soil nitrate samples were collected pre-plant and pre-sidedress to determine any potential N credit. During the growing season, soil samples were collected for each plot and analyzed for root lesion and soybean cyst nematodes. Soil compaction was measured in each plot using a portable constant-rate cone penetrometer. Results have shown that while radish N uptake can be quite substantial, we have not been able to determine an N credit across six site years. However, in some cases, soil nitrate samples would suggest an N credit. Soil penetrometer indicated differences in soil compaction in the upper profile early in the season, as well as differences in the lower profile later in the season. Soybean cyst nematodes were detected in only a few plots so the data were not analyzed. Biofumigation from radish appeared to have an effect on root lesion nematodes earlier in the season.

Introduction

Radish has become a popular cover crop option throughout the United States within the past decade. Among its touted benefits are N scavenging, compaction reduction, and pest suppression. The bulk of the scientific research on radish has been performed in the Chesapeake Bay region in Maryland. Dean and Weil (2009) demonstrated that radish was able to take up N, as well as reduce residual nitrate found in the soil. This same paper also provided a summary of eight other studies that showed a positive impact by radish on capturing soil nitrate or improving crop yields. In 2011, Chen and Weil proved that radish planted in the fall prior to corn resulted in a significant yield increase as compared to plots with no cover crop. The following year, O'Reilly et al. demonstrated that radish used as a cover crop increased yield in sweet corn, especially in plots where less than optimal N rates were applied. The same paper also suggested that cover crops were more effective at preventing N loss. The Weil lab was also involved in investigating the effects of radish on soil compaction. In 2004, Williams and Weil proved that root channels left behind by radish may have provided soybean roots with low resistance paths to water contained in the subsoil. Chen and Weil (2010) found that under high and medium soil compaction, radish had significantly more roots break through the soil than either rapeseed and rye, other common cover crops. Radish has also been documented as having a biofumigant effect on soil. An in-depth review by Matthiessen and Kirkegaard (2006), explains the mechanisms of biofumigation. In 2003, Zasada et al. found that the citrus nematode was consistently suppressed by Brassica amendments. In 2004, Zasada and Ferris demonstrated that Brassica amendments added to the soil could be applied to achieve consistent and repeatable nematode suppression. This study focused on the chemistry of the Brassica amendment material. The objectives of this study were to (i) quantify the amount of N taken up by radish, (ii) evaluate radish's potential for N credit, (iii) determine the timing of radish N release, and (iv) evaluate the effect of radish on soil compaction and nematode populations.

Materials and Methods

The experiment was established at the Rock County Farm in Janesville, WI. The Rock County Farm had a long history of no-tillage management practices, 5 years or more, depending on the field. The crop rotation for the experiment included one year of corn (*Zea mays*), followed by one year of soybean (*Glycine max*), then followed by one year split between winter wheat (*Triticum aestivum*) and radish (*Raphanus sativus*).

The experimental design was a randomized complete block, split plot with four replications. Each block contained three whole plot treatments: (i) no cover crop (No Radish), (ii) radish with no N added at planting (Radish), and (iii) radish with 60 lb N ac^{-1} added at planting (Radish 60N). Radish was planted on 15 August 2011, and 30 August 2012 using a no-till drill, with a seeding rate of 10 lb ac^{-1}. On the planting dates of both years, 60 lb N ac^{-1} as ammonium nitrate was broadcast surface applied to Radish 60N. Each whole plot contained six split plots, which were N rates of 0, 40, 80, 120, 160, and 200 lb ac^{-1}. Four rows of corn were planted per plot with a no-till planter on 15 May 2012, and 16 May 2013.

In the fall, biomass from radish and volunteer winter wheat was sampled on 1 November 2011, and 16 November 2012, before any frost damage had occurred. Soil samples were collected at two depths (0-1' and 1-2') both at radish planting and at the same time as biomass collection.

During the summer growing season, soil was sampled at two depths (0-1' and 1-2') prior to corn planting. In 2012, no more soil samples were collected for the rest of the growing season. In 2013, soil samples were collected after planting at the following four physiological points; V4, V10, tassel, and harvest. Soil was sampled at one depth (0-1'). Soil samples (0-1') were collected for each plot and analyzed for nematodes. Nematodes were isolated from the soil by a series of washings through increasingly smaller sized sieves. The samples were then counted for both root lesion nematodes and soybean cyst nematodes. Soil penetrometer measurements were collected using a portable constant-rate cone penetrometer (FieldScout SC 900 Soil Compaction Meter; Spectrum Technologies, Inc., Aurora, IL). Soil moisture was measured with the FieldScout TDR 300 Soil Moisture Meter (Spectrum Technologies, Inc., Aurora, IL). Both soil penetrometer and soil moisture measurements were collected at two physiological points in 2013: V4 (3 June 2013) and tassel (16 August). After planting, all penetrometer and moisture measurements were collected in the 160N subplot treatments. Corn grain was harvested by a two-row combine in October of 2012 and 2013.

Results and Discussion

In 2011, there was no significant difference in N uptake between the radish treatments (Table 1). This indicated that in ideal growing conditions; extra N might not be necessary for good establishment and growth of radish. The following year, 2012, all treatments exhibited lower N uptake than in 2011, most likely due to the drought conditions throughout the summer and fall of 2012. However, the radish treatments did show a statistically significant difference with Radish 60N having greater N uptake than Radish.

Over the course of the 2011-2012 growing season, treatment, date, and their interaction effect are all statistically significant for soil NO_3-N concentrations (Figure 1). However, when the data is analyzed by date alone, only two of the sampling dates are significant: April 2012 and May 2012. In April of 2012, Radish 60N had the highest soil NO_3-N concentration, followed by Radish 0N and then No Radish, but only No Radish and Radish 60N were statistically different. May 2012 demonstrated the most dramatic differences between the treatments. Radish 60N had the highest soil NO_3-N concentration, followed by Radish 0N and No Radish. While the radish treatments were not statistically different from each other, No Radish was statistically different from both Radish and Radish 60N. These significant differences in early spring indicated that radish was releasing decomposed N into soil at these time points; this was also supported by the fact that No Radish did not increase in nitrate concentrations from April to May.

In the second growing season, 2012-2013, the levels of soil NO_3–N were about half of those seen in the previous year, due to the smaller N uptakes seen in the previous spring as a result of drought conditions (Figure 2). When the data was analyzed at each date separately, none of the treatments were statistically different from each other. Since there were low N uptakes by the radish in the fall, the spring nitrate concentrations were similarly low. However, when the data was analyzed over the course of the growing season, both Treatment and Date were significant but their interaction was not.

In 2012, all of the effects used to analyze corn yield were not significant at $\alpha = 0.10$ level. This result was due to drought conditions. In 2013, both cover crop and N rate were statistically significant, but their interaction effect was not at $\alpha = 0.10$ level. When yield was averaged across all N rates, the cover crop treatment means were as follows: No Radish- 161 bu ac^{-1}, Radish- 159 bu ac^{-1}, Radish 60N- 173 bu ac^{-1}. Radish 60N had a significantly greater yield than Radish, but not No Radish. Radish and No Radish were also not significantly different in yield. Using regression analysis, No Radish was best described with a quadratic model ($R^2 = 0.978$), while both Radish ($R^2 = 0.960$) and Radish 60N ($R^2 = 0.980$) were best described with a linear model (Figure 3). The statistically significant higher yield seen in Radish 60N indicated that extra N applied to radish may have had an effect on yield under ideal growing conditions.

All three treatments exhibited the same pattern of soil resistance with depth in June 2013 (Figure 4). At 1.97 in and 2.95 in, Radish was statistically different from No Radish, while Radish 60N was not significantly different from either. At 3.94 in, Radish 60N was different from both No Radish and Radish, but these treatments were not different from each other. At 12.8 in, No Radish and Radish 60N were different from each other but neither was different from Radish. The average moisture for the soil, measured as volumetric water content (VWC), in June 2013 was 37%. In August 2013, however, the pattern of resistance among treatments did separate from each other further down the soil profile (Figure 5). It is important to note that although it appears as though there was a large difference in soil resistance values between the two time points in 2013, this was mostly due to differences in soil moisture, not soil compaction. The average moisture for the soil in August 2013 was 24.6%. At 6.89 in, No Radish was statistically different than Radish 60N, but neither were different from Radish. From 7.87 in through 11.8 in, No Radish was different from both radish treatments; however, the radish treatments did not differ from each other. At 16.7 in, both No Radish and Radish were statistically similar to each other, but different from Radish 60N. At 17.7 in, Radish was different from both No Radish and Radish 60N, which were not different from each other. Earlier in the growing season, there were fewer differences between treatments and mostly in the upper 4 in of the soil profile. However, later in the season, differences between treatments are more apparent and occur deeper in profile. Radish appeared to affect soil penetrometer readings at depths below 6.89 in indicating that its tap root had grown below this depth and was influencing soil conditions deeper in the soil profile.

In July 2013, the 0N treatment and the 160N treatment demonstrated different patterns of nematode suppression (Figure 6). At the 0N rate, both of the radish treatments had significantly less root lesion nematodes than the No Radish treatment. However, at the 160N rate, this effect appeared to reverse itself, possibly due to the accelerated growth of corn which is a host for root lesion nematodes. In August 2013, halfway through the growing season, the effects of radish on nematode populations appeared to be waning (Figure 7). At the 0N and 160N rate, both of the radish treatments have more root lesion nematodes than the No Radish treatment; however, these results are not significantly different. Perhaps at this point, the biofumigation potential of radish was too diminished to suppress nematodes.

References

Chen, G., and R.R. Weil. 2010. Penetration of cover crop roots through compacted soils. Plant Soil 331:31-43.

Chen, G., and R.R. Weil. 2011. Root growth and yield of maize as affected by soil compaction and cover crops. Soil and Tillage Research 117:17–27.

Dean, J.E., and R.R. Weil. 2009. Brassica cover crops for nitrogen retention in the Mid-Atlantic coastal plain. J. Environ. Qual. 38:520–528.

Matthiessen, J.N., and J.A. Kirkegaard. 2006. Biofumigation and enhanced biodegradation: opportunity and challenge in soilborne pest and disease management. Critical Reviews in Plant Sciences 25:235-265.

O'Reilly, K.A., Lauzon, J.D., Vyn, R.J., and L.L. Van Eerd. 2012. Nitrogen cycling, profit margins and sweet corn yield under fall cover crop systems. Can. J. Soil Sci. 92: 353-365.

Williams, S.M., and R.R. Weil. 2004. Crop cover root channels may alleviate soil compaction effects on soybean crop. Soil Sci. Soc. Am. J. 68:1403–1409.

Zasada, I.A., Ferris, H., Roncoroni, J.A., MacDonald, J.D., Bolkan, L.R., and L. E. Yakabe. 2003. Field application of brassicaceous amendments for control of soilborne pests and pathogens. Plant Health Progress.

Zasada, I. A., and Ferris, H. 2004. Nematode suppression with brassicaceous amendments: application based upon glucosinolate profiles. Soil Biology & Biochemistry 36:1017–1024.

Table 1. Radish and volunteer winter wheat N uptake before the first frost. Mean values (in columns and within years) followed by different letters indicate statistically significant differences at α = 0.05 level.

Year	Treatment	Material	Plant Parts	N Uptake	C:N
				lb ac^{-1}	
2011	Radish	Radish	whole	180	11.9
	Radish 60N	Radish	whole	180	16.5
	P > F			0.098	
2012	Radish	Radish	whole	38.8 a	15.7
	Radish 60N	Radish	whole	70.2 b	13.0
	P > F			0.0003	

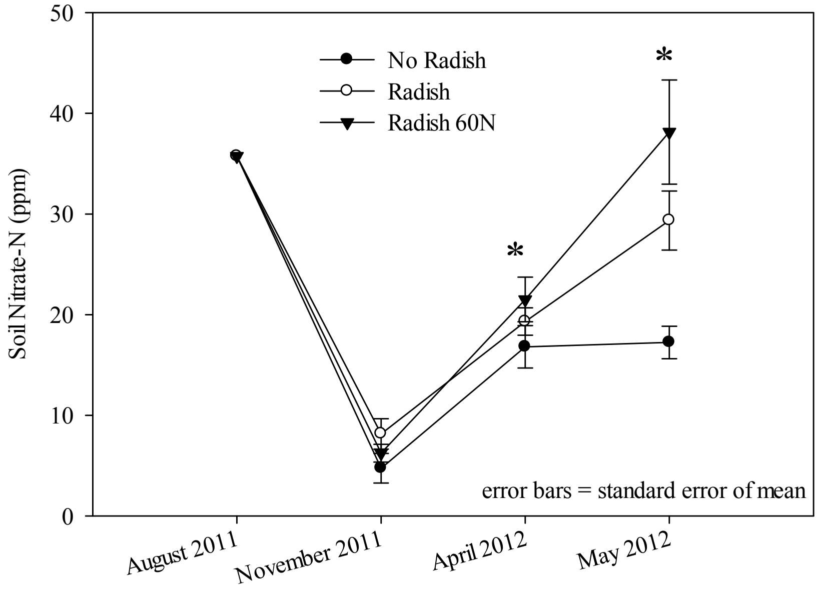

Figure 1. Soil NO_3–N concentrations for 0-1' from 2011 to 2012.
*Statistically significant differences among treatments on April 2012 and May 2012 at α = 0.05 level.

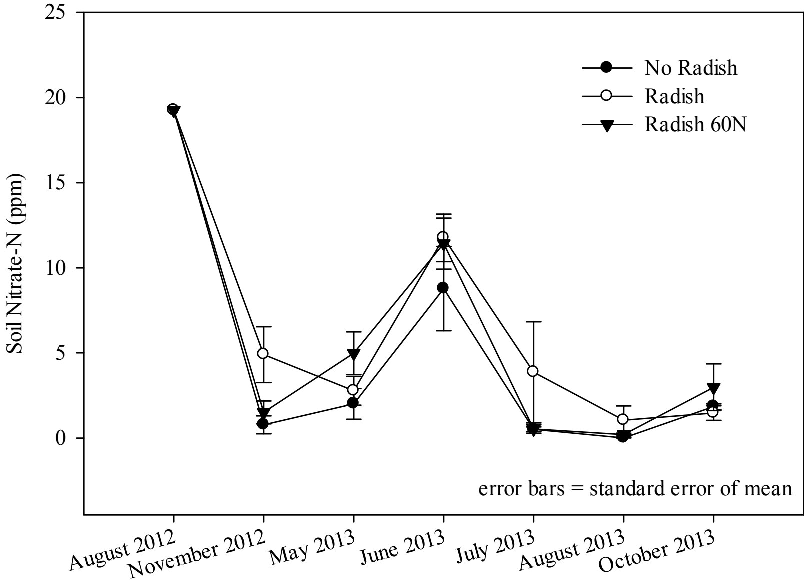

Figure 2. Soil NO_3–N concentrations for 0-1' from 2012 to 2013.

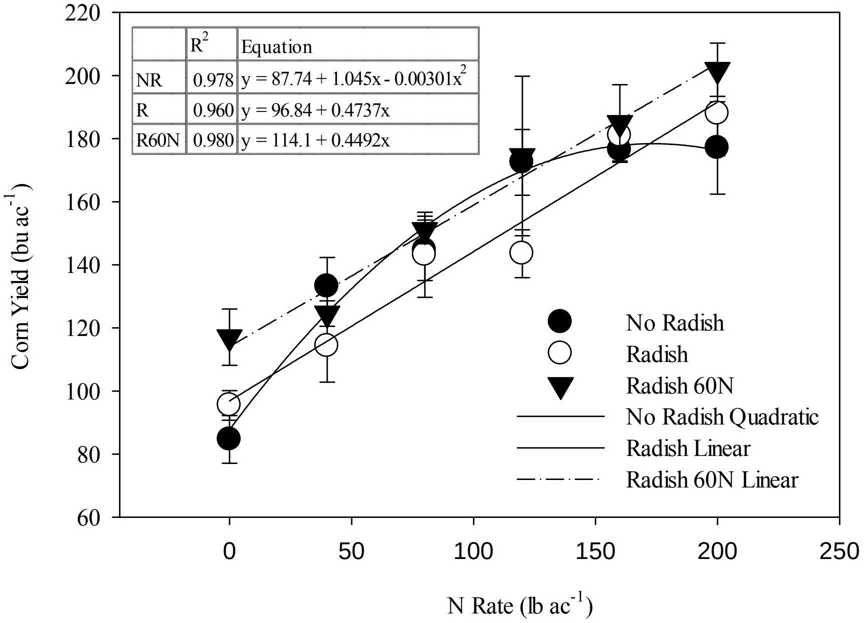

Figure 3. Corn grain yields for 2013.

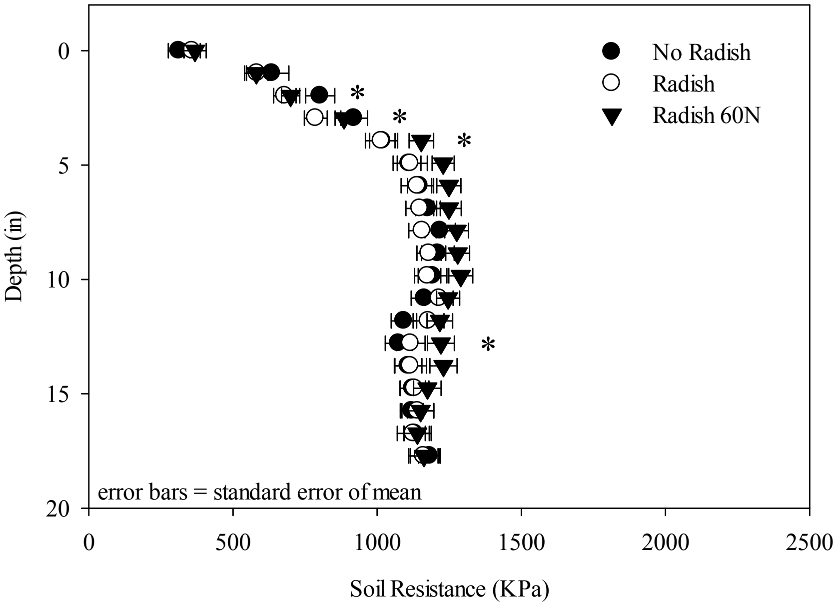

Figure 4. Soil compaction values for June 2013.
*Statistically significant differences among treatments at 1.97 in, 2.95 in, 3.94 in, and 12.8 in at α = 0.10 level.

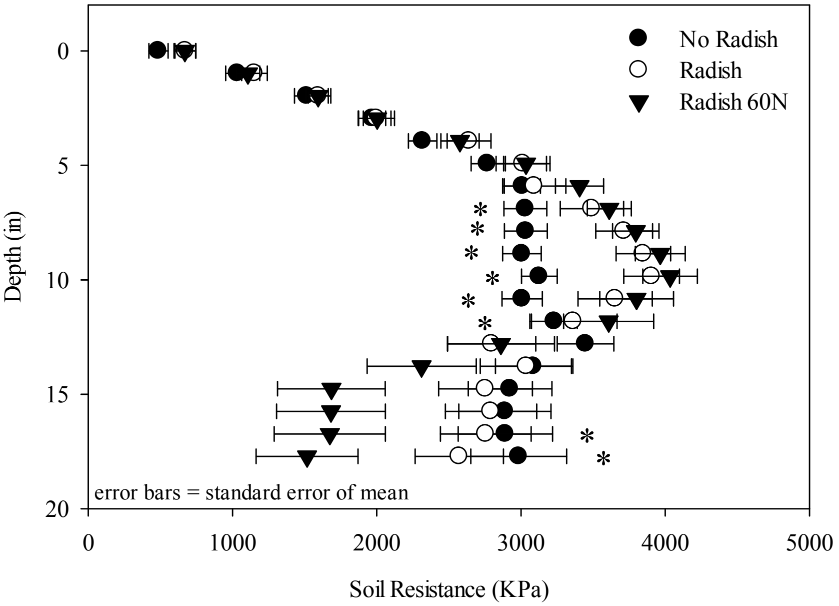

Figure 5. Soil compaction values for August 2013.
*Statistically significant differences among treatments at 6.89 in, 7.87 in, 8.86 in, 9.84 in, 10.83 in, 11.8 in, 16.7 in, and 17.7 in at α = 0.10 level.

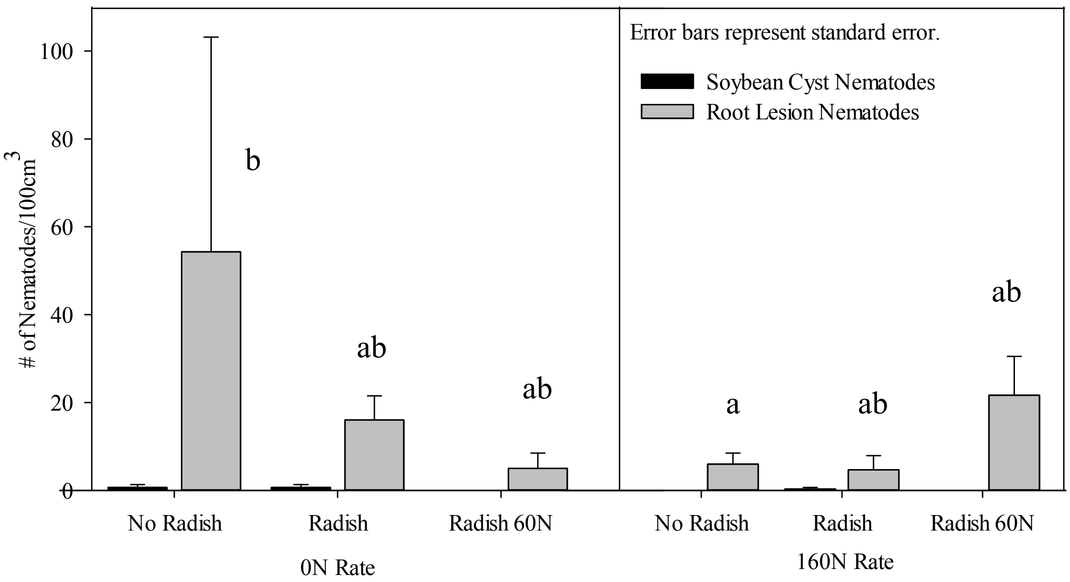

Figure 6. Nematode counts for July 2013.
Different letters indicate statistically significant difference at α = 0.05 level.

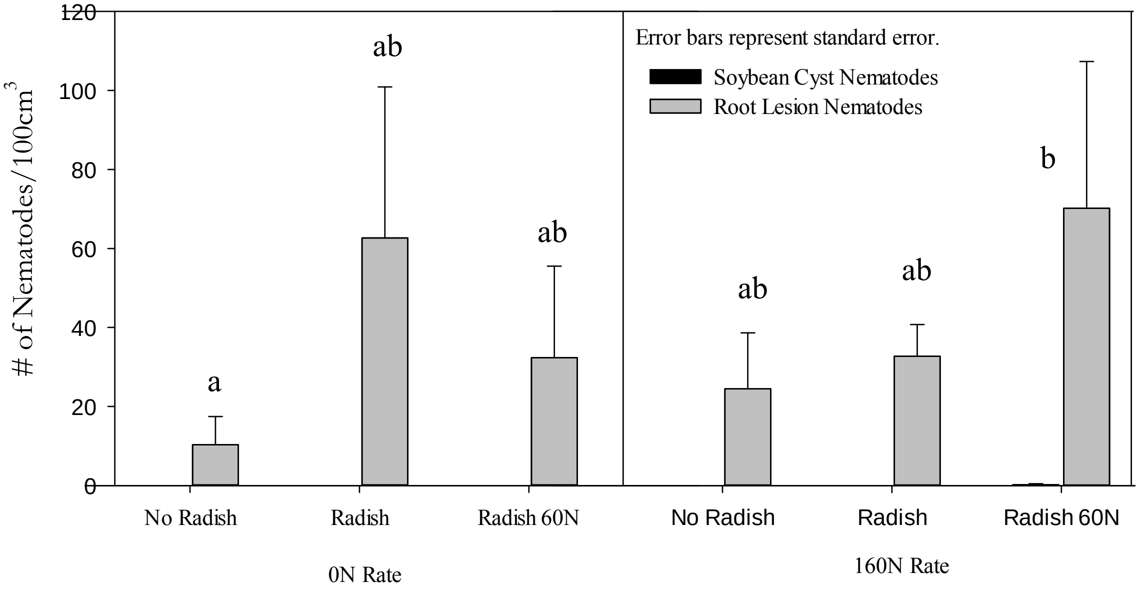

Figure 7. Nematode counts for August 2013.
Different letters indicate statistically significant difference at α = 0.05 level.

PROCEEDINGS OF THE

44th

NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 30

November 19-20, 2014
Holiday Inn Airport
Des Moines, IA

PROGRAM CHAIR:
James L Camberato
Purdue University
915 W State St.
West Lafayette, IN 47907
(765) 496-9338
jcambera@purdue.edu

PUBLISHED BY:
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page**: www.IPNI.net**

ON-LINE PROCEEDINGS:
http://extension.agron.iastate.edu/NCE/