PECAN RESPONSE TO FOLIAR NICKEL APPLICATIONS

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ABSTRACT

New Mexico's pecan industry is one of the state's most important agricultural assets. In 2010, pecan growers in Dona Ana County produced 19,504 kg of pecans, on over 10,000 ha and was worth over $123 million dollars, making Dona Ana county the number one pecan producing county in the nation. Nickel (Ni) is a component of the enzyme urease which is critical for the mobilization of nitrogen within the pecan tree. Deficiency symptoms are often expressed in pecan as a "mouse-ear" deformation of leaflets and have been observed in New Mexico pecan orchards. Trees without adequate Ni have low urease activity in leaves. Foliar application of Ni has been shown to improve tree performance. Other benefits have been postulated including an apparent improvement in lignin biosynthesis and deposition. Two pecan tree varieties were chosen at two geographic locations to evaluate the effects of foliar applied Ni on photosynthesis and leaf N content. Other analyses are underway. Photosynthesis levels appear to be influenced by the application of Ni in combination with N rate at different times of year for immature pecan trees.

OBJECTIVES

The objective of this study was to determine the effects of foliar Ni applications on immature pecan photosynthesis rates and leaf chlorophyll content on trees receiving low and high rates of soil applied nitrogen. The second objective of this study was to determine if Ni application influences lignin content in immature trees.

METHODS

This study was performed during 2012 and 2013 at the NMSU Agricultural Science Center, Artesia, NM (32°45'4.84"N,104°22'57.65"W 3366 ft) and NMSU Research Center Leyendecker, Las Cruces, NM, (32º 11´ 56.66″ N, 106º 44´ 30.50″W 3852 ft) using a total of 60 pecan trees (*Caryaillinoinensis*) distributed at the selected sites. The Artesia location soil type was a Harkey very fine sandy loam (coarse-silty, mixed, superactive, calcareous, thermicTypicTorrifluvents). There were two soil types where the trees were sampled at the Las Cruces location including a Harkey clay loam and Glendale loam (fine–silty, mixed, superactive, calcareous, thermic TypicTorrifluvents).Trees were flood irrigated from a groundwater source. Irrigation, fertilization and pesticide practices were regularly made according to agricultural practices established by the respective farm managers.

Four treatments were defined in the experiment that combined nitrogen (N) and nickel (Ni) at low and high concentrations in a 2x2 factorial structure with four replications. Treatments were combined as followed: (1) High N-High Ni; (2) Low N- Low Ni; (3) High N-Low Ni; (4) Low N- High Ni.

The control treatment (low N-Low Ni) received 26.2g N/tree of soil applied urea and 9.37ml/gal of NIS plus water as a foliar spray. Soils were sampled at both locations to a depth of 20 inches, in two 10 inch increments. Soil samples were analyzed for standard nutrients, pH, salinity, and DTPA extractable Ni (Table 1). Native soil test levels of Ni served as the low Ni treatments for both locations.

Nitrogen was applied as urea at approximately12-24inches away from tree trunk in a trench of approximately 4inches deep and then covered with soil. Nitrogen application was timed to correspond to within 1-3 day of irrigation.Ni was applied to the foliage using an2.1 gallon hand pump sprayer. Ni application was made in the early morning when wind was less than 5mph and temperatures were relatively cool. Pecan foliage was sprayed such that leaves were dripping.
Photosynthesis was measured using the Li-Cor 6400TX machine. The first seasonal photosynthesis measurements were taken approximately 30 to 35 days after the first seasonal Ni application. The second set of measurements were made 20 to 25 days after second seasonal application and the third photosynthesis data was collected 30 days after the second seasonal photosynthesis measurements.

Chlorophyll measurements were taken using the SPAD 502 device (Konica-Minolta), and immediately after photosynthetic measurements were done. The SPAD meter was clamped to the middle section of the leaflet avoiding clamping over the main vein of the leaflet. SPAD readings were averaged over two measurements per tree.

For the analysis of variance, the variables location and cultivar were renamed as a “group” variable to assist with the analysis of variance. Therefore, group one is for Artesia and Pawnee cv. (Art_Paw); group two for Artesia and Western Schley cv. (Art_WS); and group three for Leyendecker and Pawnee cv. (Ley_Paw). A blocking structure was also created for the trees. Each block contained the four treatments.

Measurements of photosynthesis, chlorophyll,leaf N and Ni content, and branch lignin content were taken among other parameters and analyzed one block at a time.A mixed factor analysis was also conducted to evaluate differences among treatments, time, location and cultivar. Analysis on repeated measurements was performed to evaluate photosynthesis; chlorophyll and midday stem water potential between each day of measurement during the year. LS means were created to compare each of the means when an effect was found to be significant and a SAS macro ‘pdmix800’ was performed for further analysis. The macro pdmix800 code for SAS was useful to display this information with letters (such as a, b, c) for an easy assessment of significance among variables. Only photosynthesis and measures of chlorophyll are presented here.

RESULTS AND DISCUSSION

Photosynthesis (Ps) – 2012 Year

There were differences in Ps for the main effect of tree group ($p=0.0028$), and time of sampling main effect ($p=0.0221$). There were several significant interactions as well, including tree group by N ($p=0.0284$), tree group by time ($p<0.0001$), tree group by time by Ni ($p=0.0017$) and time by N by Ni ($p=0.0403$). Because two three-way interactions involving all factors were significant the means for all tree group, time, N and Ni combinations are reported (Table 2).

Within the first sampling date no simple N effects were significant; that is, within time one no comparison of high to low N made for a given combination of tree group and Ni was significant. Simple Ni effects were observed at time one for Art_Paw at the high N level with photosynthesis being 3.00 ± 1.02 units higher for the low Ni application than for the high application(Table 2, Fig. 1). However, for the Art_WSgroup and the low N application a simple Ni effect was significant with photosynthesis estimated to be 2.17 ± 1.02 greater for when Ni was applied over that of no Ni application(Table 2, Fig. 1). At time one Art_WSgroup means were generally greater than the Pawnee cultivar at both Artesia and Leyendecker (Table 2, Fig. 1). There were no simple effects of either N or Ni by the second sampling. The only significant simple effect occurring at the second sampling was between Art_Paw group with a mean of 13.68 and the Art_WSgroupwith mean 19.12 for Ni level one and N level two (Table 2, Fig. 1). However, Art_Pawgroup at time two, N level 2 and Ni level 1 and 2 was less thanArt_WS group at N level 2 and Ni level 1. Additionally, Art_Paw group at time 2 for N level 2 and Ni level 1 was less than theLey_Pawgroup at N and Ni level 2 (Table 2, Fig. 1).

Photosynthesis in Art_Pawgroup responded to N when Ni was not applied and the Art_WSgroup responded to N when Ni was or was not applied (Table 2, Figure 1). These N effects were not consistent as the simple effect of tree group Art_Paw suggested lower photosynthesis at higher N levels (2.38±1.04) but both Art_WS simple effects estimated higher photosynthesis for the higher N level at both Ni levels 1 and 2 (2.16 ± 1.04 and 2.51 ± 1.04, respectively). Overall, tree group effects for tree group Art_WS was greater than tree groupArt_Paw(3.88 ± 1.04) for N level two with no applied Ni. Additionally, photosynthesis was greater (2.72 ± 1.04) for tree group Art_WS compared to group Ley_Paw for Ni level two and N level one (Table 2, Fig. 1).

Additionally, there was a visible difference in some tree groups when they were compared at the same N and Ni level over time. For example, Art_Paw group, at N and Ni level had different Ps values at time one (13.18) and two (15.78) when compare with time three (16.03) (Table 2). Art_Paw group did not exhibit any differences in Ps at the higher N level. There was also no effect on Ps at N level two and Ni level one over time. Ley_Paw group did show a difference in Ps between time one (14.46) and three (16.94) when compare with time two (17.07) at N and Ni level one (Table 1). There was no difference found over time for N or Ni level one for the Art_WS tree group (Table 2, Fig. 1). However, for N level two, no tree group differences were observed over time one, two or three for Ni level one.

For Ni level twotree group Art_Paw had the same Ps pattern for N level one and two through time when Ni was applied (Table 2, Fig. 1). For Art_WS group N level one and Ni level two present differences between time one (19.37) when compared with time two (15.49) and time three (14.18). However, no difference was observed at the higher N level. For Ley_Paw treated with Ni time one remained significantly greater when compared with time two and three for both levels of N (Table 2, Fig. 1).

<u>Leaf Chlorophyll – 2012</u>

Tracking leaf greenness over time for all treatments was primarily done to assess the fertility treatments during the summer months. The influence of N in chlorophyll content has been demonstrated on other trees that belong to the *Junglandaceae* family (Liu et al., 2010), which include pecans.

Acuña-Maldonado et al. (2003) found that pecan leaves contain about 25% of the tree's N in May and about 17% by the time of a killing frost. Acuña-Maldonado et al. (2003) also found that N absorption was greater between budbreak and the end of shoot expansion than at other times of year. For the most part, monitoring leaf chlorophyll status during the summer months can help determine if other nutrients could be limiting chlorophyll content as observed by Covarrubias and Rombolá (2013) for grapes.

Statistical significance was found for tree group ($p=0.0205$), time ($p<0.0001$), group tree X time interaction ($p=0.0061$) and group tree X time X N interaction ($p=0.0176$). Group 1 (Art-Paw) chlorophyll levels in the low-N trees were less than the leaves from trees treated with more N early in the growing season (time 1) (Table 3).This difference for group 1 might be attributed at the physiological stage of pecan trees, since this N application was the first application that the trees had received after the winter season. Leaf chlorophyll levels were greater later in the season which may also be due to application of zinc as a standard management practice and could have improved leaf chlorophyll content.

Group 2 (Art-WS) low N trees had a significant improvement in leaf color (chlorophyll) over time especially toward the end of summer when the last measurement was made (Table 3). The higher N application treatment for Group 2 appeared to keep the N levels similar to each other over the period of measurement. Group 3 (Ley-Paw) chlorophyll levels were not affected by N treatment or time of measurement (mean=43.8).

Nickel applications had no effect on leaf chlorophyll measurements.

Summary

Photosynthesis levels appear to be influenced by the application of Ni in combination with N rates at different times of year for immature pecan trees. Further analysis of leaf stem water potential, and twig lignin content will assist in understanding the role of Ni in immature pecan trees.

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Table 1. Initial soil characteristics for each test location.

	Saturated Paste		Olsen	NH$_4$OAc	DTPA				
	pH	ECe	P	K	Zn	Fe	Cu	Mn	Ni
		dS/m			mg/kg				
Leyendecker	7.6	0.82	6	154	0.3	8.3	0.9	5.7	0.14
Artesia	7.6	1.42	10	256	0.5	3.6	0.7	20.8	0.40

Table 2. LS means for photosynthesis levels of three tree groups over time at low N (N1), High N (N2), Low Ni (Ni1), and High Ni (Ni2) for treatment year 2012.

Time	Ni	Tree Groups					
		1 - Art_Paw		**2 - Art_WS**		**3 - Ley_Paw**	
		N1	**N2**	**N1**	**N2**	**N1**	**N2**
1	**1**	13.18 ef**B**	14.28 de **A**	17.20 bc**A**	18.81 ab **A**	14.46 de**B**	15.75 cd **A**
	2	12.59 ef**B**	11.28 f **B**	19.37 a**A**	18.17 ab **A**	14.01 de **B**	14.77 de **B**
2	**1**	15.78abc**AB**	13.68 c **A**	17.25 abc**A**	19.12 a**A**	17.07 abc**A**	16.71 abc**A**
	2	17.16 abc**A**	15.34 bc**A**	15.49 bc**B**	16.24 abc**A**	17.17 abc**A**	17.99 ab **A**
3	**1**	16.03 abc**A**	13.65 d **A**	15.37 bcd**A**	17.53 a**A**	16.94 ab**AB**	17.17 ab **A**
	2	16.38 abc**A**	15.65 abcd**A**	14.18 cd **B**	16.69 ab**A**	16.90 ab **A**	17.53 ab **A**

*a, b, c, d, e, f Small letters indicate comparison within time for Ni, N and tree group. Means sharing the same letter do not differ significantly at $p \leq 0.05$

*A, B: Comparison for each tree group, and N and Ni combination at time 1, 2 and 3. Means sharing the same letter do not differ significantly at $p \leq 0.05$

Table 3. SPAD LS Means Tree group by time and nitrogen level 2012 Data

Time	**stderror**	**Tree Group**					
		1 Art_Paw		2 Art_Ws		3 Ley_Paw	
		N1	N2	N1	N2	N1	N2
1	1.07	39.5 a	36.1 b	36.6b	38.2 ab	36.9 ab	38.4 ab
2	1.01	43.3abc	42.3bc	43.9abc	41.7 c	45.0 ab	45.6 a
3	1.01	43.9 c	44.7 c	44.5 c	45.0bc	47.7 ab	49.1 a

*a,b,c = e.i. means sharing the same letter do not differ significantly at $p \leq 0.05$

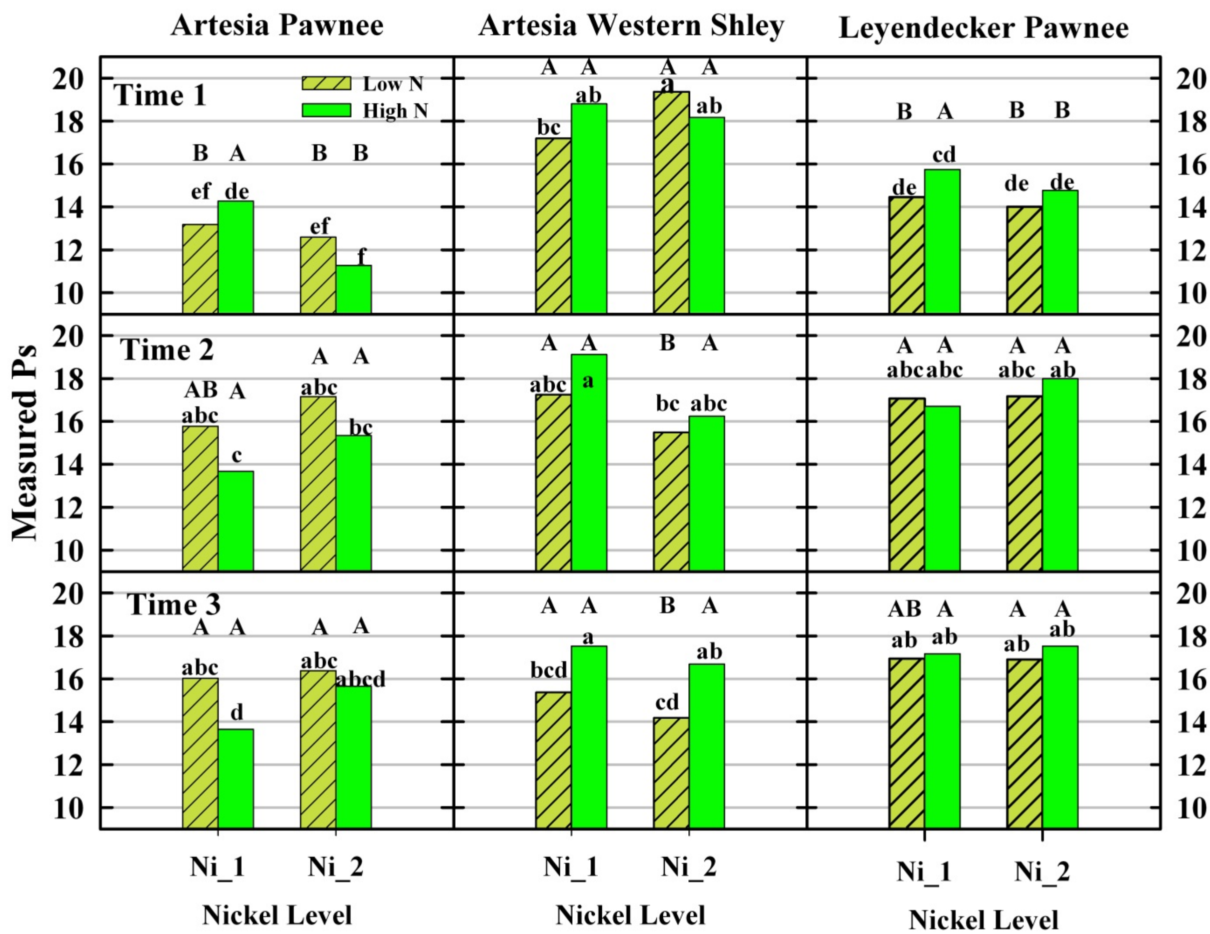

Figure 1.Effect of Ni and N over time for immature pecan trees at two New Mexico locations in 2012.

PROCEEDINGS

OF THE

WESTERN NUTRIENT

MANAGEMENT CONFERENCE

Volume 11

MARCH 5-6, 2015
RENO, NEVADA

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