INFLUENCE OF FOLIAR FERTILIZATION ON FOLIAR ZINC LEVELS AND NUT PRODUCTION IN BLACK WALNUT

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Abstract.—The impact of foliar zinc fertilizer application on nut-bearing black walnut (*Juglans nigra* L.) trees was studied. Foliar sprays were applied three times per season on two cultivars during four growing seasons by wetting the foliage of the entire crown using a tank mix containing 500 ppm zinc, starting at leaf burst and continuing at 2 week intervals. The fertilizer treatment increased leaf zinc levels but did not impact nut production. Results from this trial indicate that the zinc standard for black walnut foliar nutrient analysis may be similar to the zinc standard of 25 to 100 ppm established for Persian walnut (*J. regia* L.).

INTRODUCTION

The yield of black walnut (*Juglans nigra* L.) cultivars growing under standard levels of management is low compared with other nut crops (Reid et al. 2004). The influence of major nutrients on black walnut seed production has been studied with nitrogen fertilizers providing the largest increase in nut production (Jones et al. 1993, Ponder and Jones 2001, Ponder 2004), however the micronutrient needs of black walnut have not been firmly established. Phares and Finn (1971) proposed tentative critical foliar nutrient levels for hydroponically-grown black walnut seedlings (Table 1) but these recommendations have not been adequately tested under field conditions. A limited number of reports establish observed micronutrient ranges, but do not establish critical sufficiency ranges (McHargue and Roy 1932, Mills and Jones 1996). Micronutrient standards for other commercially important nut crops in the Juglandaceae, Persian walnut (*Juglans regia* L.) and pecan [*Carya illinoinensis* (Wang.) K. Koch], have been established (Smith 2003).

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Table 1.—Standards for leaf tissue nutrients for pecan and Persian walnut as compared to suggested black walnut standards and prestudy observations.

			Black walnut		
Element	Pecan[a]	Persian walnut[a]	Deficient[b]	Hidden hunger[b]	Observed pre-study (2004) range[c]
N (%)	2.3-3.5	2.2-2.6	<2.0	2.0-2.6	2.1-3.1
P (%)	0.12-0.30	0.12-0.20	<0.10	0.10-0.25	0.19-0.33
K (%)	0.75-1.75	1.0-1.75	<0.75	0.75-1.30	1.0-2.2
Ca (%)	0.7-2.5	0.75-2.00	<0.50	0.5-1.1	1.3-2.7
Mg (%)	0.3-0.7	0.20-0.75	<0.15	0.15-0.45	0.26-0.52
Zn (ppm)	60-150	25-100	<15	15-50	25-47

[a] From Smith (2003)
[b] From Phares and Finn (1971)
[c] Range observed from study trees in 2004 before commencement of treatments

The recent experience of a commercial black walnut grower in Iowa suggests that zinc foliar sprays may prove critical for reducing alternate bearing and increasing nut yield (Hansen 2003 personal communication). Zinc foliar sprays have been used effectively to correct zinc deficiency and increase nut yield in pecan (Sparks 1993). Leaf samples collected in July 2004 from black walnut trees growing at the Southwest Research Center study site (before the current study commenced) revealed that the trees accumulated 24.8 to 53.5 ppm Zn in foliage by mid-summer (Table 1). Most trees in our study area would be classified as having "hidden hunger" by Phares and Finn (1971) and would likely respond to zinc fertilization. Normal Zn levels in the foliage of Persian walnut and pecan are ≥ 25 ppm and ≥ 50 ppm, respectively (Table 1). This study was conducted to test the effectiveness of foliar zinc fertilization for increasing zinc levels in the foliage and increasing nut yield of black walnut.

MATERIALS AND METHODS

The trees used in this study are growing at the University of Missouri's Southwest Research Center near Mt. Vernon in southwestern Missouri (lat. 37.0851, long. –93.8695, alt. 337 m), USDA hardiness zone 6. Annual precipitation averages 1,106 mm. The soil is an alluvial Huntington silt loam that is deep, level, well-drained, and rarely flooded. Black walnut seedlings were established at the site in 1993, spaced 12.2 m within and between rows. Blocks of trees four rows wide were grafted to 'Sparrow' and 'Emma K' cultivars between 1996 and 2001 using bark or three-flap methods (Reid 2001).

During this study, the orchard area was fertilized annually in early spring with 84-39-84 kg/ha N-P_2O_5-K_2O, respectively. A grass hay crop consisting of a mixture of orchardgrass (*Dactylis glomerata* L.) and tall fescue (*Festuca arundinacea* Schreb.) was harvested twice annually from alleys between tree rows. Vegetation and weeds near the trees were controlled with glyphosate herbicide applied twice annually. Trees were not irrigated.

Eight trees within each of the two cultivar blocks were selected for the study based on uniform tree size and past nut yield. Two treatments were applied: application of zinc foliar sprays (three per season) versus no foliar zinc applications. Before assigning treatments, trees were ranked according to zinc nutrient status as revealed in leaf analysis conducted in July 2004. Treatments were then assigned at random using a completely randomized experimental design.

Zinc foliar applications started in the spring of 2005 and continued each spring through 2008 (Table 2). The first application of each season was at leaf burst followed by two additional applications at 2 week intervals. The cultivars used in this study often break bud at different times with 'Emma K' initiating new growth earlier than 'Sparrow'. As a result, treatment applications based on physiological stage of growth often resulted in treatments made on different calendar days (Table 2).

Commercially available zinc foliar fertilizer (Texas Pecan Zinc, Traylor Chemical & Supply Co., Inc., 1911 Traylor Blvd., Orlando, FL 32804) containing 10 percent zinc derived from zinc citrate and zinc sulfate was applied with a hand-held, high-pressure spray gun. This product also contains 10 percent nitrogen (urea form), a proven adjuvant for increasing

Table 2.—Dates of zinc foliar applications of 500 ppm zinc to 'Sparrow' and 'Emma K' black walnut trees at the Southwest Research Center in Mt. Vernon, MO.

	Spray dates		
Cultivar and Year	First	Second	Third
'Emma K'			
2005	17-May	31-May	15-Jun
2006	27-Apr	12-May	26-May
2007	10-May	29-May	5-Jun
2008	19-May	2-Jun	17-Jun
'Sparrow'			
2005	17-May	31-May	15-Jun
2006	12-May	26-May	9-Jun
2007	10-May	29-May	5-Jun
2008	2-Jun	17-Jun	2-Jul

zinc absorption from foliar sprays (Smith and Storey 1979). Foliar applications were made by wetting the foliage of the entire tree canopy using a tank mix that contained 500 ppm zinc (1:200 dilutions with water).

The leaf tissue samples were collected in July 2004 prior to the onset of the study, and during July of each year of the study (2005-2008). Post study evaluation of zinc status was determined by collecting leaf samples during July 2009. The leaf samples were taken by removing the mid-leaf pair of leaflets from mid-shoot leaves. Fifty leaflet pairs were collected per tree. Leaf samples were submitted to the Kansas State University soil testing laboratory, Manhattan, KS, for determination of total N, P, K, Ca, Mg, and Zn. Walnut yields were determined by harvesting, hulling, air-drying, and weighing the nuts produced by each tree.

RESULTS AND CONCLUSIONS

Standard protocols for using foliar sprays to increase zinc levels in pecan foliage (Krausz and Lee 2006) can be used to increase zinc levels in black walnut foliage. Foliar sprays are only effective for correcting zinc deficiencies when applied during early spring, during leaf expansion (Sánchez and Righetti 2002). Foliar spray programs to correct zinc deficiency in Persian walnut have been successful (Uriu and Chaney 1970). However, Zhang and Brown (1999) found that only 3.5 percent of foliar applied zinc is absorbed by Persian walnut leaves and becomes biologically active.

Levels of zinc found in black walnut leaves receiving zinc foliar sprays were significantly higher than those that did not receive treatment (Table 3). Zinc levels were increased by foliar fertilization during all 4 years of this study with both cultivars responding similarly. We detected no phytotoxicity related to the application of foliar zinc to black walnut at the concentrations applied in this test. Increases in foliar zinc levels as a result of foliar zinc fertilization did not carry over to the year (2009) following the completion of this trial (Table 3). This observation is consistent with results obtained with tree fruit crops demonstrating that foliar zinc fertilization provides only a single-season fix for zinc deficiency thus requiring annual foliar zinc applications to ensure long term plant health (Swietlik 2002).

Black walnut yield was not consistently influenced by zinc foliar fertilization (Table 4). Yields harvested from 'Emma K' trees were more erratic (year to year) than yields of 'Sparrow' trees. This trend confirms an earlier report by Reid et al. (2004) that 'Emma K' trees are more prone to alternate bearing than 'Sparrow' trees. The yield response from zinc fertilization observed in an Iowa black walnut orchard may have been the result of the destruction of soil organic matter caused by frequent tillage of the orchard floor. Zinc available to tree roots is largely held in the soil within the organic fraction (Stevenson and Ardakani 1972). The destruction of soil organic matter by tillage can lead to zinc deficiency in pecan (Skinner and Demaree 1926) and most likely the black walnut orchard in Iowa.

Table 3.—Concentration of foliar zinc following annual zinc foliar fertilization from 2005 to 2008 of black walnut trees growing at Southwest Research Center, Mt. Vernon, MO. The concentration of foliar zinc in black walnut foliage was also determined in year 2009 after the completion of the trial to test for treatment carry over.

	Foliar Zn Treatment		t test
Cultivar and Year	with (ppm)	without (ppm)	p-value
'Emma K'			
2005	116	54	0.032
2006	83	33	0.032
2007	71	43	0.034
2008	117	45	0.016
2009[a]	43	46	0.84
'Sparrow'			
2005	132	30	0.0003
2006	119	32	0.04
2007	67	44	0.02
2008	181	34	0.003
2009[a]	28	27	0.65

[a] No trees received zinc foliar sprays in 2009

Table 4.—Nut yields with and without annual zinc foliar fertilization did not affect nut yield of black walnut trees growing at Mt. Vernon, MO, 2005-2008.

Cultivar and Year	Foliar Zn Treatment		t test
	with (kg/tree)	without (kg/tree)	p-value
'Emma K'			
2005	21.2	17.5	0.675
2006	20.8	16.2	0.539
2007	0	0	–
2008	13.4	5.6	0.016
'Sparrow'			
2005	21.8	25.4	0.544
2006	13.0	14.6	0.741
2007	12.3	10.6	0.687
2008	9.6	7.5	0.376

Leaf analysis standards for Persian walnut developed in California indicate that healthy tree leaves should contain between 25 and 100 ppm zinc (Smith 2003). Results from our study indicate that zinc standards for black walnut may be more similar to Persian walnut or to those suggested by Mills and Jones (1996) than to the standards suggested by Phares and Finn (1971) from hydroponically growth walnut seedlings. The leaves of nontreated trees averaged between 27 and 50 ppm zinc with no symptoms of deficiency or negative impact on yield.

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