Developing Management Techniques For Black Walnut to Stabilize the Annual Nut Supply

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Abstract

Two studies involving cultural methods to increase nut production of plantation black walnut are presented. In the first study, nut production was measured for 5 years to determine the effect of nitrogen (N) and potassium (K) fertilization separately, in combination, and with and without phosphorus (P) broadcast annually for 4 years at two rates. Fertilization significantly ($P > 0.05$) increased nut production. Treatments containing P with N and/or K were most effective for nut production. Doubling the rate of application did not cause a corresponding increase in nut production. The alternate bearing tendency that was present in year 3 of the study was not apparent in years 4 and 5. In the second study, we measured the effect of three levels of broadcast N fertilization (0 or control, 100 lbs/ac, 150 lbs/ac elemental N) and two levels of foliar applied boron (B) (with and without) on nut production and nutrition of plantation black walnut. Boron (3 lbs Solubor®/100 gals of water/ac) was sprayed on trees in the early catkin stage in a split plot arrangement. Whole plot treatments were the three rates of ammonium nitrate that were broadcast around trees in mid April and again in mid August. Leaf samples were collected in mid June and again in mid August for nutrient analyses. Nut production was higher for treatments with B compared to treatments without B, and leaf B concentration in samples collected in August increased for trees treated with B. There was an increase in leaf N for the highest N treatment, but nut production was not increased for any N rate.

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Introduction

The production of large annual black walnut nut crops is rare and when it does occur, the grower has likely invested in nutrient management. It's no secret, high yields in most crops require substantial nutrient inputs either as inorganic or organic fertilizers. Among nut tree industries, the pecan [*Carya illinoensis* (Wangenh.) C. Kock] and English walnut (*Juglans regia* L.) are probably the most successful in terms of production and consumption. These industries along with state and federal agencies support research programs to ensure their continued growth. Although, the answer to increasing black walnut nut production seems apparent, few studies, trials, or demonstrations have been done or documented to provide growers with the information they need to apply the cultural practices to first, produce a reasonable nut crop annually and secondly, sustain increased production. Because black walnut is valued for its wood, much more research has been done to increase the growth and quality of the tree rather than nut production or nut quality.

Nut harvesting removes a considerable amount of nutrients from the site in the kernels, hulls, and husks of black walnut. Nitrogen estimates alone, based on crude protein content of black walnut kernels, and the percent nitrogen in husks and hulls show that as much as 20 kg (~44 lb) of nitrogen may be removed in 454 kg (~1,000lb) of nuts (Ponder 1997). Therefore, nutrient supplement seems necessary to maintain adequate nutrient levels for tree growth and nut production.

Very little information is available relating black walnut nutrient levels to nut production. It is not known if or how much diameter growth is lost at the expense of nut production.

It was reported earlier that broadcast fertilization with N, P, and K improved diameter growth of planted black walnut trees (Ponder 1998). Unlike N and P, boron (B), which has been shown to be important in the flowering process, is only slightly mobile in plants. Boron deficiency in many crops results in premature flower, and fruit drop, and reduced yield. These are common problems in black walnut, but whose cause has not been established. In the Persian walnut, this problem has been addressed as the loss of nut producing pistillate flowers or PFA (pistillate flower abortion) early in the growing season (Polito et al. 1998). In the present report, results on black walnut nut production in response to (1) fertilizer combinations on five successive nut crops and (2) the first year foliar B application for a stand of planted black walnut are presented.

Methods and Materials

The study site was an 18-year-old upland black walnut planting of the Hammons Products Company of Stockton, Missouri. Soils in the study site are deep, nearly level to moderately sloping, and moderately well-drained. These upland soils are Typic Paleudalfs, fine-loamy, mixed, mesic, and were derived primarily from acid sandstone. Soils in the study area had a mean cation exchange capacity (CEC) of 11.2, 72 mg•ha^{-1} of available phosphorus (P), 200 mg•ha^{-1} of available potassium

(K), and a pH that ranged from 6.1 to 7.2 prior to fertilizer application. These nutrient concentrations are moderately high for this soil.

Seventy-two trees were in the study. All trees were numbered and trunk diameter at breast height was recorded. Trunk diameters at breast height (55 inches [~1.4 m] from the ground) ranged from 20 to 25 inches (~51.3 to 62.5 cm). They were planted in rows at a 39 x 20 ft (~12 x 6 m) spacing. Weeds were controlled with glyphosate [N (phosphonomethyl) glycine] and simazine (6-chloro-N', N'-diethyl-1,3,5-triazine-2,4-diamine) mixture containing 602 and 481g•ha^{-1}, respectively, in 235 L of solution per treated hectare, applied annually in 1.5-m (~5 ft)-wide bands along both sides of the row, using a tractor-drawn sprayer.

To study the effect of fertilizer combinations on annual nut production, a total of 12 treatments including two fertilizer rates, five fertilizer treatments, and an unfertilized control for each rate was used. Each of 12 treatments was applied to one row of six trees annually for 4 years. Treated rows alternated with untreated rows of trees. Fertilizer treatments included N and K separately and in combination, with and without P at two rates. Fertilizers used were NH_4NO_3 (34 percent N), triple superphosphate (46 percent P), and KCl (60 percent K). The amounts of N, P, and K used were based on mass of fertilizer materials and not actual nutrients. Nitrogen and P were applied at rates of 310 and 620 kg•ha^{-1} each, and K was applied at rates of 490 and 980 kg•ha^{-1} annually in the spring. Fertilizers were measured and broadcast by hand around trees over an area that approximated the crown area.

For the boron study, the experimental design was a split-plot with six single-tree replications. Site, soils, tree age, spacing, and weed control were similar to those in the previous study. Treatments were replicated within each of the 6 rows of trees in the study. The 54 trees in the study are nearly 39 ft (~12 m) tall and have a mean diameter of 68 cm (~27 inches). Trees had been thinned and were free to grow on at least three sides. All study trees were numbered and diameter at breast height (dbh) measured before treatments were applied. Treatments were applied (broadcast over area approximating tree canopy) to groups of three trees in two replications. Fertilizer treatments of N were applied at three rates (0 or control, 100, and 150 lbs/ac elemental N from NH_4NO_3 (34 percent N) and one rate of B (disodium octaborate tetrahydrate), Solubor® (20 percent B), (3 lbs/ac). The B was applied as a split plot and N as whole plot treatments. Nitrogen was broadcast by hand around trees in the spring on April 18, 2000 and again on August 24, 2000. Boron was sprayed on trees around bud break (April 26, 2000) by a commercial applicator. The sprayer was able to deliver the desired amount of product 35 ft (~11 m) high into tree crowns. For application, Solubor® was mixed with 50 gals of water (3 lbs Solubor®/ 100 gal of water/ac) containing spreader. Trees were sprayed thoroughly. Trees were sprayed in mid morning on a day with high humidity.

Soil and leaf samples were collected during the second week of June, however, results from soil analyses will not be presented. Leaf samples were collected again during the second week of August. Samples were collected from the same trees and branches each time. Samples were processed according to proper drying and grinding procedures in the laboratory before being shipped to the University

Arkansas Agriculture Diagnostic Laboratory in Fayetteville, Arkansas for analysis of N, P, K, Ca, Mg, sulfur (S), zinc (Zn), B, manganese (Mn), iron (Fe), copper (Cu), aluminum (Al), and sodium (Na). Nuts in both studies were harvested by hand, counted, and bagged according to tree number.

For the first study, treatment effects on nut counts were tested using orthogonal comparisons for planned comparisons. Prior to analysis, nut data were transformed to equalize variance using $\log_{10}$ transformation. Data were analyzed using analysis of variance and comparisons were made using the least significance differences test (SAS Institute 1987). Nut data for the two rates were combined because differences between rates were not significant. For the B study, data for groups of three trees per treatment were averaged for treatment means before being analyzed. Data were analyzed using the GLM program of SAS with mean separation at the 0.05 level according to Duncan's multiple range test.

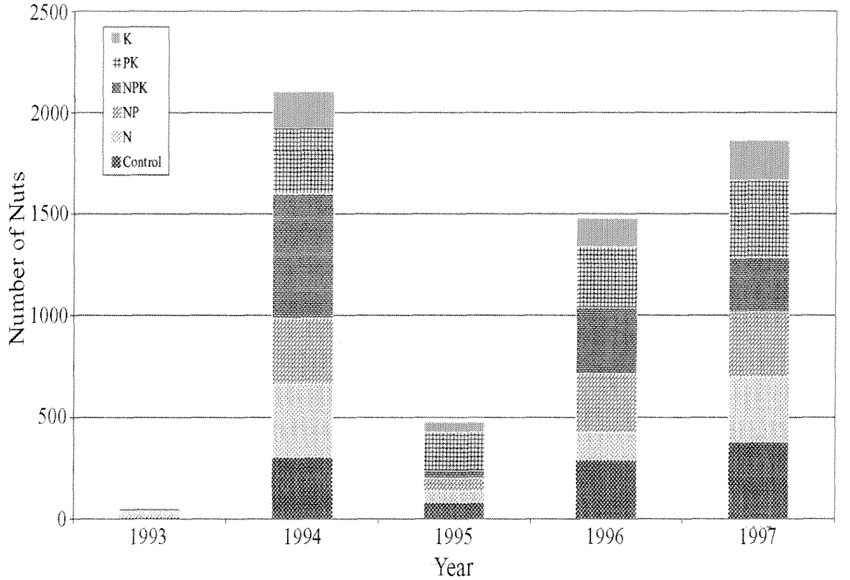

FIGURE 1. Mean annual production of fertilized plantation black walnut by treatment.

Results and Discussion

Nut production for combinations of NPK varied significantly (P > 0.05) with years and treatments over the study period (Figure 1). The largest nut crops were in 1994, the year following the initial treatment application, and in 1997, after four annual treatment applications. The smallest number of nuts was produced in1993, the first year of the study, and 1995, the third year of the study. Nut production increased during the next two years, but production was not as high as for 1994. Also, the number of trees producing nuts increased over the study period from 41 in 1993 to 71 in 1997. Although no trees in 1995 had nut crops in the range of 300 to 500 nuts, and 83 percent of the trees had 100 or less nuts, fertilization increased nut production over the number of nuts produced in 1993. Apparently, the improved tree vigor was not enough in 1994 to support a larger than usual nut crop, and at the same time, increase shoot length sufficiently to support another large nut crop in 1995. On the other hand, tree vigor in 1995 and 1996 was able to support consecutive large nut crops.

The total number of nuts produced over the five year study period according to treatment ranked in the order NPK>PK>control>NP>N>K (Figure 2). Much of the total nut production in the NPK treatment can be attributed to the large number of nuts produced in 1994. However, in 1995, one year later, the NPK treatment had the smallest number of nuts during the study period. Although nut production varied in response to fertilizer combinations from year to year, PK was the most consistent, even in 1995, a low production year (Figure 1).

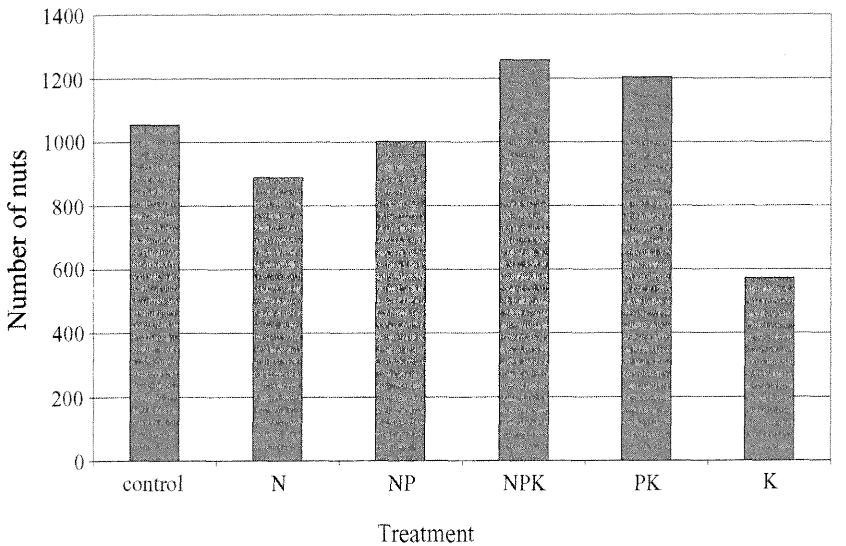

FIGURE 2. Five year cumulative for fertilized plantation black walnut production.

Trees sprayed with B had more nuts than trees not sprayed. Also, trees in the control treatment had significantly more nuts than fertilized trees (Table 1). Trees in the N + B treatments had more nuts than trees fertilized with N without B. Trees treated with B averaged nearly 40 nuts per tree compared to a little over 2 per tree for trees not treated with B. Nitrogen applications did not significantly increase nut production.

It is not surprising that N fertilization did not increase nut production because current female flowers are set in the fall of the previous year. Except for N and B, differences in leaf nutrition associated with treatments were not significant (Tables

TABLE 1. Nut production first year of foliar boron application with and without broadcast nitrogen.

	Number of Nuts	
Nitrogen treatment	With boron	Without boron
Control	94.89a[1]	3.57b
100 lbs./ac.	17.67b	3.00b
150 lbs./ac.	7.33b	0.20b
Mean	39.96	2.26

[1]Means in a row followed by different letters are statistically different at P 0.05.

2 and 3). Foliar N levels for control trees and foliar K for all treatments were below reported levels (Ponder 1998, Mills and Jones 1996, Phares and Finn 1971). Mills and Jones (1996) reported that foliar nutrient values for black walnut ranged from 2.47 to 2.98 percent for N, 0.16 to 0.24 percent for P, 1.32 to 1.47 percent for K, and 1.90 to 2.01 percent for Ca. However, the authors do not inform readers as to what can be expected in terms of nut production. Ponder et al. (1998) reported that nut production was best on trees that had N, P, and K levels that were at least or exceeded 2.71 percent, 0.17 percent, and 1.64 percent, respectively. While it is not known if excess N can diminish black walnut yield, it did reduce pecan yield by 80 percent, doubled the number of nuts with unopened shucks, and reduced nut size (Storey et al. 1986).

Determining foliar nutrient levels in late summer could help predict next year's nut crop. Data recorded in Table 4 shows both leaf N and K are below "adequate levels". This would suggest that the second application of N should be applied earlier in the growing season and that K should be included. Perhaps, seasonal declines or increases (mid August sampling) in tree nutrient concentration over the growing season mean more to assessing the succeeding year's nut crop than do nutrient concentrations earlier in the growing season. Concentrations of the more mobile elements are expected to decline somewhat compared an increase in concentration for less mobile elements. Boron in the leaves of fruit trees is lowest early in the season and increases as leaves become older (Labanauskas et al. 1959; McClung and Lott 1956; Burrell et al. 1956). Boron availability, as most other nutrients, is affected by pH, drought, and leaching. It is most available between pH

TABLE 2. Foliar levels of major nutrients for black walnut trees fertilized with nitrogen and boron.

		%					
N treatment	Boron	N	P	K	Ca	Mg	S
Control	With	2.30	0.16	1.23	2.22	0.40	0.13
	Without	2.42	0.18	1.39	1.97	0.39	0.14
100 lbs./ac	With	2.55	0.17	1.29	2.18	0.42	0.14
	Without	2.57	0.19	1.12	2.03	0.37	0.14
150 lbs./ac	With	2.75	0.16	1.25	1.95	0.39	0.14
	Without	2.58	0.17	1.07	2.45	0.39	0.14
Signifance (p value)		0.05	0.36	0.08	0.06	0.12	0.42

TABLE 3. Foliar levels of minor nutrients for black walnut trees fertilized with nitrogen and boron.

		PPM[1]					
N treatment	Boron	Na	Fe	Mn	Zn	Cu	B
Control	With	36.50	82.83	173.83	17.83	8.05	33.23
	Without	40.67	87.00	119.17	18.62	8.65	24.95
100 lbs./ac	With	31.33	121.83	120.17	19.13	7.47	37.30
	Without	45.83	85.33	107.00	17.95	7.90	24.32
150 lbs./ac	With	38.50	98.33	128.67	15.38	7.25	34.37
	Without	41.00	126.83	127.00	16.75	8.32	22.18
Signifance (p value)		0.09	0.28	0.24	0.40	0.06	0.008

[1]PPM = parts per million (mg/kg)

TABLE 4. Nutrient levels in black walnut leaves for trees fertilized with nitrogen and boron in the year 2000.

	%	
Nutrient	Mid-June	Mid-August
Nitrogen	2.90a[1]	2.17b
Phosphorus	0.17a	0.18a
Potassium	1.36a	1.10b
Calcium	1.82a	2.44b
Magnesium	0.40a	0.40a
Sulfur	0.14a	0.13a
	PPM[2]	
Sodium	44.06a	33.89b
Iron	81.61a	119.11b
Manganese	119.22a	145.39b
Zinc	14.63a	20.59b
Copper	8.91a	7.00b
Boron	16.59a	42.19b

[1]Means in a row followed by different letters are statistically different at P 0.05.
[2]parts per million

of 5.0 to 6.5. Also any factor that causes an increase in plant growth such as warm temperatures, extra light, or extra carbon dioxide will contribute to B deficiency by increasing the plant's need for B.

Information on B demands of black walnut is lacking. There are no reports of specific B needs for black walnut during bud set for reproductive growth or fruit development. Among plant parts, B has been found to be highest in the stigmata followed by the ovaries (Gauch and Dugger 1953). Several investigators reported that when B was absent, there was a very low percentage of germination (O'kelley 1957; Gauch and Dugger 1953;Thompson and Batjer 1950). In addition to B's role in pollen tube germination, it has also been shown to be important in the absorption and translocation of sugars (Vasil 1964).

The overall nut crop for the year 2000 was very poor. The previous year's nut crop had been very good. Undoubtedly, large amounts of nutrients, including B, are removed in large alternate year nut harvest. Perhaps, maintaining "adequate" N, P, and K levels in the foliage is not enough without B fertilization to produce large nut crops. These results on B fertilization are preliminary. Nitrogen fertilization showed an increase in leaf N for the highest dosage without any corresponding increase in nut production for the other rates. These results are encouraging, however, they must be interpreted with caution because they are only for the first year.

Alternate year bearing was not completely eliminated by combinations of NPK fertilizers. Nut production was increased by fertilizer treatments in both studies. However, the study using a combination of NPK showed nut production in the control treatment to be the same or nearly as high as some treatments with fertilizers. This suggest that perhaps some resource such as soil water or some nutrient other than NPK, may be limiting nut production on these sites.

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