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FERTILIZATION OF YOUNG 'MINNEOLA' TANGELO TREES WITH BANDED POULTRY LITTER OVERLAID WITH WOOD CHIPS

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Abstract. **Poultry litter can be disked into the soil to conserve nutrients but this incorporation into soil can damage surface roots of citrus trees grown on bedded groves. Young 'Minneola' tangelo trees (*Citrus reticulata* Blanco × *Citrus paradis*i Macf) on Cleopatra mandarin rootstock (*C. reticulata* Blanco) planted on bedded groves, were fertilized for 18 months after planting with surface-banded poultry litter (PL) overlaid with wood chips (WC). PL was applied at 25, 50, and 75 tons per treated acre per year in a 2-foot wide band within the dripline and overlaid with 50, 100, and 150 tons of WC per treated acre per year. Other treatments included poultry litter applied at 20 tons per treated acre per year to a 10-foot wide strip in the middle of the bed twice a year and 1 pound of controlled release fertilizer (10-2.5-3) applied three times per year within the dripline. After 18 months, trunk diameter and plant height of plants receiving all treatments were generally similar except for trees to which poultry was applied in the bed middle, suggesting that the lowest PL/WC rate was adequate for tree growth during this time.**

Approximately 475,000 acres of citrus are grown in Florida on bedded groves on shallow flatwoods soils with high water tables (Florida Agricultural Statistics Service, 2004). Groves in these areas are fertilized with liquid fertilizer through fertigation systems and with granular materials. Organic growers, and others who want to apply animal manures and other organic amendments in bedded groves after planting, usually do not incorporate this material into the soil to avoid damaging shallow citrus root systems. Other options include applying organic amendments like composted municipal solid waste (CMW) into the planting hole followed by later banding 0.5 tons (CMW) per treated acre within the dripline (Widmer et al., 1996) and incorporating from 0.5 to 4.0 lbs of humates into the soil at planting (Webb et al., 1988). Using relatively high applications rates per treated acre, other flatwoods growers have been applying banded poultry litter (PL) within the dripline of newly planted and bearing trees. Shredded urban plant debris composed of woody tissue, leaves, stems, and roots, here referred to as wood chips (WC), have then been applied over the banded poultry litter to possibly reduce nitrogen loss through volatilization and improve soil fertility by adding organic matter as this material decomposes. Working with a consultant and grower who were already using this system, we obtained a Producer Grant from the Southern Sustainable Agriculture Research and Education Program to compare the growth of young citrus trees fertilized with different levels of PL/WC and controlled release fertilizers.

Materials and Methods

Young citrus trees of 'Minneola' tangelo on Cleopatra mandarin rootstock were planted in May 2001 at a 15 × 25 ft. spacing in two rows on raised beds 50 feet wide in a previously planted citrus grove near Vero Beach, Fla. 'Temple' orange trees (*C. temple* Hort. ex Y. Tanaka) on Cleopatra mandarin rootstock were planted every fourth bed at a similar spacing to serve as a pollinator cultivar for the 'Minneola' tangelo. Soil types within the grove included Wabasso fine sand (sandy, siliceous, hyperthermic Alfic Alaquod) and a Pineda fine sand (loamy, siliceous, hyperthermic, Arenic, Glossaqualfs). Only one row of 'Minneola' tangelos per bed or each of five beds was used for the experiment but treatments were applied to both rows per bed.

Composted poultry litter (PL) was applied 2×/year during May and Oct. of 2001 and 2002 within the tree dripline on the upper or bed side of the tree row using a modified, calibrated Millcreek Row Mulcher (MillCreek Manufacturing Co., Bird-in-Hand, Pa.). After the poultry litter was applied within a 2-ft wide windrow 7.5 feet on either side of each tree within the tree row (30 ft^2 per tree), wood chips were applied over the poultry litter using the same equipment. PL and WC application equipment was calibrated before application to deliver the desired application rates.

Poultry litter and wood chips were applied at three different rates, with wood chips applied at twice the rate per treated area of the poultry litter (Table 1). Percent moisture, nitrogen, total lbs nitrogen per ton and the carbon:nitrogen ratios of PL and WC are given in Table 2. The lbs N per ton ranged from 48.1 to 55.0 and from 3.7 to 12.2 for PL and WC, respectively.

Application rates for poultry litter and for animal manures are often specified in tons per gross acre, suggesting that material is spread uniformly over each ft^2 per acre. In bedded citrus groves with two rows per bed, at a 15 × 25 ft spacing or 116 trees per acre, material would be spread only on the 50-ft-wide bed middles (from the midpoint of each drainage ditch of each side of each bed) or in the tree row nearest the bed middle. If 4 tons of PL per acre were applied, 0.1837 lbs of

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Table 1. Fertilizer per year applied to young Minneola tangelo trees in Vero Beach, Florida in 2001-2002.[z]

	Equivalent Inputs/treated acre/year applied in a band 2 ft wide		Equivalent N inputs/treated acre/year applied in a band 2 ft wide × 15 ft long		N inputs/tree/year/30 ft² (2 × 15 ft band)	
	tons		tons		lbs	
Treatments/gross acre/year	PL	WC	PL**	WC***	PL	WC
1) 2 ton PL, 4 tons WC	25	50	0.6	0.4	0.84	0.27
2) 4 tons PL, 8 tons WC	50	100	1.2	0.8	1.68	0.55
3) 6 tons PL, 12 tons WC	75	150	1.8	1.2	3.24	0.83
	Equivalent inputs/treated acre in a band 10 × 15 ft per tree on the bed middle		Equivalent N inputs/treated acre per year in a band 10 × 15 ft per tree on the bed middle		N inputs/tree/10 × 15 ft per tree on bed middle	
4) 4 tons PL broadcast in a 10 ft wide band on the grove middle	20		40.98		3.37	
	Equivalent inputs in an 3.4 ft² area				N inputs per tree per year	
5) 1 lb controlled release fertilizer (10-3-7) 3×/year/116 trees				0.0882 x 43560 = 3,841 lbs N		0.2999
3 lbs of a 10% N applied to a 3.4 ft² area = 0.8824 lbs fertilizer/ft² or 0.0882 lbs N/ft²						

[z]Mean value of PL based on four samples per load for each of four loads: 2.45%N, Mean value of WC based on four samples per load for each of four loads: 0.4% N.
Recommended N rate for young citrus trees at 116 trees per acre in years 1 and 2 is 17-35 and 35-70 lbs N per treated acre per year (Ferguson et al., 1995).

PL would be applied per ft² (8,000 lbs per ton/43,560 ft²). However, if material is applied with a broadcast spreader on the bed middle in a 10 ft wide band, the treated area is 1/5 of the bed middle area of 50 ft, the application rate would be 5× the per gross acre rate (5 × 0.1837 = 0.9185 manure ft²) or 20 tons per treated acre. This calculation provides an equivalency value, a number that suggests that spreading 20 tons of material in a 10-ft band on the bed middle is the equivalent of spreading 4 ton per gross acre because the material has been concentrated within one fifth of the gross acreage.

Applying a 2 ton per gross acre rate per year (4000 lbs/43560 = 0.0918 lbs/ft²) within a 2 ft wide row on the bed middle side of both sides of the tree row would utilize only 4 feet of the 50-ft-wide bed and would concentrate the per gross acre rate 12.5 times (0.0918 lb/ft² × 12.5 = 1.1475 lbs ft² treated area) providing 25 tons per treated acre. Estimated PL and WC application rates are given in Table 1 as per gross acre rates per year, per treated acre rates per year, tons N applied per treated acre per year and lbs N applied per tree per year per 30 ft² (a band 2 ft wide and 7.5 ft long on each side of the tree). These were the applied N rates and not necessarily N rates available to plants soon after application.

Two other treatments were also applied: composted poultry litter broadcast 2×/year during 2001 and 2002 using a calibrated New Holland side delivery manure spreader (New Holland, Pa.) within a 10-ft. band centered on the bed middle of a 50-ft wide bed and controlled release fertilizer (10-2.5-3) applied manually 3×/year within a 1-ft diameter of young citrus trees.

Each treatment was replicated five times with 6 trees per replicate in a completely randomized block design, with one block of treatments on each of five planting beds. Stem diameter and tree height were measured four times in 2001 and 2002 and twice more in 2003, even though the last experimental treatment was applied in October 2002. During 2003 the grower applied poultry litter overlain with wood chips at the 2 ton PL and 4 ton WC rate per year to all trees within the experimental plots. Although not part of the original experiment, growth data from 2003 is also included. Treatment effects on tree growth were compared using a t-test. Significance levels of multiple comparisons were calculated using Tukey's method to ensure that all pair-wise comparisons were carried out at the P = 0.05 level.

Leaf samples for nutrient analysis were taken prior to treatments from the previous growth flush in June and Dec. of 2001 and 2002. Pre-treatment soil samples were taken in May, 2001 with a sampling tube at a 6-inch depth. However, after windrow treatments were applied, obtaining accurate soil samples using a soil sampling tube within the dripline of

Table 2. Analysis of poultry litter and wood chips applied to young Minneola tangelo citrus trees.

	Moisture (%)		N (%)		Totals N/t (lbs)		C:N ratio	
Application date	Poultry litter	Wood chips	Poultry litter	Wood chips	Poultry litter	Wood chips	Poultry litter	Wood chips
May, 2001	23.90	17.6	2.4	0.6	48.1	12.2	11:7.1	65:1
Oct. 2001	29.66	51.8	2.5	0.5	49.3	10.7	11:8.1	39:1
April 2002	35.50	60.5	2.3	0.1	46.8	2.7	9:8.1	145:6
Oct. 2002	25.60	61.7	2.7	0.2	55.0	3.7	11:4.1	91:3

Mean values based on four samples per load.

trees was problematic. Accordingly, the layered poultry litter and urban plant debris was removed, followed by soil sampling at a 6-inch depth within the dripline of trees in December of each year. A composite sample composed of two cores (6-inch depth) was taken from each of three trees per replicate from three of five replicates per treatment. Samples were analyzed by the University of Florida Soil Lab using a double acid (Mehlich I) extractant for P, K, Ca, Mg, Zn, Mn, and Cu. Soil pH, electrical conductivity, NH_4-N, and NO_3-N levels were determined using water extractable ions. Organic matter levels were determined using the Walkley-Black dichromate methodology. Soil tensiometers at a 6 and 12-inch depth for one replicate of each of the five treatments were monitored from June 2001 to Dec. 2002. One ground water monitoring well was also installed in the east and west side of the approximately 10-acre grove to monitor depth to the water table. Rainfall was also measured. Percent moisture, percent N, and C:N ratio of the PL and WC were analyzed by A&L Southern Labs, Inc., Pompano Beach, Fla.

Results/Discussion

Although there were minor differences in growth of trees treated with increasing rates of PL/WC over the 18 month duration of this grant, tree growth did not generally increase as PL/WC application rate increased. In other studies, growth of nursery trees with high initial nutrient levels was not affected by fertilizer N rate during year 1 but was growth was affected by year 2 (Guazzelli et al., 1966; Obreza and Rouse, 1993). However, nine and twelve months (March, 2002 and December, 2002) after planting, trunk diameter but not height of trees receiving the broadcast PL treatment was smaller than that of trees receiving all other treatments. Fertilizer nutrients were placed farther away from the root zone for these PL trees than for trees receiving other treatments, possibly accounting for their decreased growth. Treatment effects on tree growth may have become more pronounced in a longer term experiment.

Nitrogen content of poultry litter ranged from 2.3 to 2.7% whereas that of wood chips was much lower and more variable (0.1-0.6%). The highest carbon:nitrogen ratio of PL was 11:7 but C:N of WC was as high as 145:6 (Table 3) much higher than the suggested 30:1 ratio for efficient composting (Barkdoll et al., 1991). Although the PL and WC layers were not mixed, decomposition of the banded PL/WC material was observed. The combined PL/WC was banded directly against the tree trunk, contrary to recommendations against this practice to limit Phytophthora foot rot, but we did not observe foot rot.

Total costs for purchase, hauling, and applying PL and WC, including capitalization costs for equipment, were $45 and $35 per ton, respectively during 2001-2002 compared with $520 per ton for controlled release fertilizer. Total per tree application costs for treatment 1 (2 tons PL and 4 tons WC) were $1.98; treatment 2 (4 tons PL and 8 tons WC): $3.96; treatment 3 (6 tons PL and 12 tons WC): $5.94; treatment 4 (4 tons PL): $3.09; treatment 5 (3 lbs controlled release fertilizer): $0.99 and $1.29 for years 1 and 2. Total controlled release fertilizer costs for year 1 for the 10-3-7 fertilizer in terms of lbs N applied per tree were $.99 per tree (0.3 lbs N: $0.78 + application cost: $0.21 and for year 2: $1.29 per tree (0.3 lbs N: $0.78 + application costs: $0.51). Considering total application costs per tree, the PL/WC 1, 2, and 3 treatments were 1.7, 3.4, and 5.2 times costs for controlled release fertilizer. However, considering the cost per lb N applied, not necessarily plant available, costs for treatment 1, 2, 3, 4, and 5 were $0.0005, $0.0012, $0.0029, $0.0020, and $0.026, with all PL/WC treatments being cheaper than the controlled release fertilizer treatment in terms of lbs N applied per tree.

Analysis of composite soil samples collected before treatments were applied had a pH range from 5.7 to 7.0; organic matter from 0.3 to 0.8%; and EC values from 0.10 to 0.20 ds/m. In December, 2002, a composite soil sample was taken from one replicate of each treatment in each of two blocks (two soil samples per treatment) and averaged. Each of two values for the same treatment sometimes varied by a factor of 2, indicating the difficulty of obtaining accurate samples. There was no increase in the soil parameters with increasing applications of PL and WC. Soil sampling beneath the banded PL/WC material may have included some PL within the soil sample. Soil sampling within the root zone on the ditch side where PL/WC had not been applied, may have yielded better data for some parameters as could samples from soil leachates.

Compared with pre-treatment pH levels of 5.7-6.9, soil pH in treated areas ranged from 6.1 to 7.1 (treatment 1) and organic matter increased from 0.70 to 1.0% from pre-treatment levels of 0.3 to 0.8%. EC values before treatment ranged from 0.10 to 0.20 ds/m and from 0.18 ds/m for controlled release fertilizer to 0.3 (treatment 3) by December 2002. Pre-treatment values in May, 2001 for NH_4-N and NO_3-N ranged from 2.8 to 4.2 and from 1.9 to 6.5 ppm, but by December 2002, values ranged from 4.1 to 8.1 and 2.1 to 24.4 ppm, respectively. Soil samples from the controlled release fertilizer treatments tended to have the lowest N values with NH_4 and NO_3 levels increasing with treatment level. P levels generally increased with treatment level over time, with excess P levels (176.4 ppm) observed in areas treated with 6 tons PL/12 tons WC by

Table 3. Growth of young Minneola tangelo trees fertilized with poultry litter, wood chips, and controlled release fertilizer.

	Measurement dates											
	6/01	12/01	3/02	12/02	5/03	12/03	6/01	12/01	3/02	12/02	5/03	12/03
Treatments	Diameter (mm)						Height (cm)					
1) 2 t PL, 4 t WC	6.1 a	10.5 ab	15.4 abc	33.3 abc	42.0 ab	58.7 a	68.2 ab	106.3 a	119.0 ab	156.6 a	177.4 ac	215.1 a
2) 4 t PL, 8 t WC	5.9 a	10.7 ab	14.6 ac	30.9 ac	38.7 ab	56.3 a	69.3 ab	102.6 a	114.0 a	148.0 a	171.6 abc	211.5 a
3) 8 t PL, 12 t WC	5.6 a	11.1 b	15.4 ab	33.0 ab	41.9 a	58.6 a	64.9 a	101.4 a	111.2 a	153.3 a	164.2 ac	216.6 a
4) 2 t M broadcast	6.1 a	9.6 ab	12.7 c	27.6 c	35.5 b	52.7 a	69.8 b	99.4 a	113.6 a	147.8 a	158.9 c	195.8 a
5) CR fertilizer	6.2 z	11.5 b	17.2 b	35.5 b	44.1 a	58.9 a	68.6 ab	105.8 a	126.2 b	152.4 a	181.4 b	211.6 a

Means separation within columns by the t-test at $p < 0.05$.

Dec. 2001. Mg and Ca levels also generally increased with treatment level over time in the PL/WC plots but not with other treatments. Fluctuations in water table depth and soil moisture levels generally correlated with rainfall levels but were not affected by treatments.

Leaf analysis. Leaf nitrogen levels were high before treatments were applied in May, 2001 and remained in the optimum to high level through Dec. 2002 (Ferguson et al., 1995), regardless of treatment. P and K levels generally ranged from high pre-treatment levels to high and excessive levels (P = 0.84-1.5%; K = 5.9-8.4%) by Dec. 2002 in all treatments. Mg (2.1-2.5% and Ca 10.5-15.3%) levels were also in the excessive range by the end of the experiment.

After 18 months there were no significant differences in tree diameter and height, among treatments, suggesting that the lowest PC/WC rate (2 tons PL/4 tons WC) and perhaps even lower rates would have be adequate for tree growth. All of the PL/WC and the PL broadcast treatments were more expensive per tree per year in terms of total application costs than the controlled release fertilizer treatment. The PL/WC and the PL broadcast treatments were less expensive than the controlled release fertilizer treatment in terms of the cost per lb N applied, but not necessarily available N per tree. Based on our sampling methods, the PL/WC treatments did not generally increase soil fertility over 18 months. However, applying high rates of organic material should affect soil fertility over longer term experiments. Soil nutrients levels were variable and did not generally increase over time but leaf nutrient levels often reached excessive levels.

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