Effects of Organic Apple Production Systems on Foliar Macronutrient Concentrations

Choi, H.S.[1] & Rom, C.[2] & Lee, Y.[1]

Key words: ground cover management system, nutrient, organic apple

Abstract

An organic apple (Malus × domestica Borkh.) orchard was established to study the interaction effects of ground cover management systems (GMS) and nutrient sources (NS) on soil and tree nutrient status and tree growth. Trees received one of four GMS: 1) green compost (GC), 2) wood chips (WC), 3) shredded paper (SP), and 4) mow-and-blow (MB). Across all GMS, one of three NS was applied: A) a commercial organic fertilizer (CF), B) poultry litter (PL), and C) control (NF). Overall, GMS had greater effects on the variables than did NS. GC mulch supplied greater nutrients, followed by WC, SP, and MB mulches. SP trees had lower foliar [N] in the first two years than the GC and WC trees. GC- and WC-treated trees had larger trunk cross sectional area than the SP and MB trees.

Introduction

For maintaining the optimum nutrition for fruit trees, organic managers must be aware not only of the level of nutrients sufficient to prevent abnormal tree growth and leaf symptoms but also of those necessary to avoid reduced fruit quality and pest incidences with GMS (Shear, Faust, 1980). Few studies of organic orchard nutrition have generally been conducted in the arid Pacific Northwest, the West, or the colder Northeast region with little or no research in the warm and humid Southern region in the U.S. This study was established to evaluate soil and foliar nutrient concentrations, and tree growth when grown under four GMS with three NS in the Southern U.S.

Materials and methods

GMS mulches with NS annually applied to 'Enterprise' apple trees on M.26 rootstocks at the University of Arkansas, Main Agricultural Experiment and Extension Center, Fayetteville (36°N, 94°W), AR, USA in April from 2006 (year 1) to 2008 (year 3). GMS were as follows: 1) urban green compost from leaves, grass, and small brush (GC), 2) raw wood chips (WC), 3) shredded paper mulch (SP), and 4) mow-and-blow green mulch (MB). GMS were split-plot for NS treatments applied. The NS treatments were: A) formulated, certified organic pelletized fertilizers (10N-2P-8K, Nature Safe®) (CF), B) composted poultry litter (PL), and C) control (NF) where nutrition would be derived from the GMS. On the GC, WC, SP mulches, an approximately 10-cm thick layer of mulch was initially applied in April of year 1 and annually reapplied for maintaining the mulch depth by adding the GMS in years 2 and 3. Annual nutrient applications (PL,

[1] Research Division of Organic Agriculture NAAS, Suwon, 441-707, Republic of Korea, E-mail dhkdwk7524@daum.net, Internet www.rda.go.kr

[2] Department of Horticulture, University of Arkansas, Fayetteville, AR 72701, U.S.A., E-mail crom@uark.edu, Internet www.hort.uark.edu

CF) were made at rates equivalent to approximately 50 g actual N per tree per year in April.

The experimental design was a randomized complete block with six replications of each treatment. The data analysis was performed using the PROC GLM procedure of SAS statistical analysis software (SAS version 8.2, Cary, NC, USA), and mean comparison was calculated by least significant difference (LSD, $\alpha = 0.05$).

Results and Discussion

GMS and NS provided a wide range of nutrient contents and C:N ratios to the systems (Table 1), and mostly, GC and WC mulches supplied greater nutrient contents per tree of each year. GC mulch supplied two times greater N (998 g) than the WC mulch (429 g). SP and MB mulches supplied less than 50 g N per year recommended for young apple tree growth.

Tab. 1: Estimated amount of macronutrients applied of ground cover management system (GMS) and nutrient source (NS) in average of 3 years in an organic apple orchard, Fayetteville, AR.

GMS+NS	Supplied nutrient content (g/tree/year)				C:N ratio
	C	N	P	K	
Green compost+Commercial	15,240	1,018	166	468	15
Green compost+Poultry litter	16,121	1,015	205	492	16
Green compost+No fertilizer	14,861	961	149	438	15
Wood chips+Commercial fertilizer	18,382	449	50	182	41
Wood chips+Poultry litter	19,262	446	89	206	43
Wood chips+No fertilizer	18,003	392	33	152	46
Shredded paper+Commercial	8,051	96	18	37	84
Shredded paper+Poultry litter	8,932	93	57	61	96
Shredded paper+No fertilizer	7,672	39	1	7	197
Mow-and-blow+Commercial	808	80	20	42	10
Mow-and-blow+Poultry litter	1,689	78	59	66	22
Mow-and-blow+No fertilizer	429	23	3	12	19

All GMS-treated foliar [N] was in a low range of 1.7 to 2.2% in August of years 1 and 2 (Table 2) based on the recommendation (2.4 to 2.6% of N for young non bearing apple trees) of a conventional apple orchard (Stiles, Reid, 1991) and below the ideal nutrient range obtained by a conventional apple orchard in Arkansas (Naraguma, 1994). Lower foliar [N] was found in the SP-treated trees in years 1 and 2. GC trees that usually maintained high foliar [N] showed less [P] among the GMS in years 2 and 3, while SP trees with low foliar [N] in years 2 and 3 had high foliar [P]. This was similar to the previous result that trees with low foliar [N] were usually more foliar [P] (Faust, 1989). However, an adequate level of foliar [P] (0.11 to 0.33%) (Stiles, Reid, 1991) was observed for GC trees during the years. WC, SP, and MB-treated trees had more than adequate [P] level in years 2 and 3. Foliar [K] was not consistently affected

by the treatments in August of each year and ranged optimum levels of 1.3 to 2.1% for tree growth (Stiles, Reid, 1991) (Table 2). In April of year 2, the freezing damaging was observed for all the trees, and the symptoms seemed to be more severe in the SP-treated trees. This would have caused the SP trees to grow or regrow late in a season, which could have increased the [K] in the August of year 2. Treatment effect, however, was diminished for foliar [K] in year 3, probably due to the larger tree size as years advanced.

Tab. 2: Foliar [N], [P], and [K] of 'Enterprise'/M.26 apple trees in an organic orchard as affected by ground cover management system (GMS) and nutrient source (NS) from years 1 (2006) to 3 (2008)

GMS+ NS	[N] (%)			[P] (%)			[K] (%)		
	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3
GCCF	2.1	2.0	2.2	0.16f	0.21	0.14	1.8ab	1.7cd	1.4
GCPL	2.0	2.1	2.3	0.24cde	0.19	0.14	1.9a	1.7d	1.3
GCNF	2.0	2.1	2.2	0.37ab	0.39	0.16	1.9a	1.7cd	1.4
WCCF	2.2	2.0	2.2	0.20ef	0.33	0.31	1.8ab	1.7d	1.7
WCPL	2.1	2.0	2.2	0.32bc	0.35	0.27	1.8ab	1.7d	1.6
WCNF	2.1	2.1	2.0	0.42a	0.53	0.42	1.9ab	1.9bc	1.6
SPCF	2.0	1.7	2.0	0.29bcd	0.42	0.50	1.7bcd	1.8cd	1.7
SPPL	1.9	1.7	1.9	0.33ab	0.53	0.50	1.7abc	2.0ab	1.7
SPNF	1.8	1.7	2.2	0.31bc	0.65	0.44	1.5e	2.1a	1.6
MBCF	1.9	2.0	2.2	0.21def	0.42	0.38	1.6de	1.6d	1.4
MBPL	2.0	2.0	2.1	0.29bcde	0.47	0.32	1.8ab	1.7d	1.4
MBNF	1.7	2.0	2.2	0.33ab	0.43	0.39	1.6cde	1.7d	1.5
P value	ns	ns	ns	<0.05	ns	ns	<0.001	<0.05	ns

Different letters above bars indicate significant difference as determined by LSD, 5% level. GCCF = Green compost + Commercial fertilizer; GCPL = Green compost + Poultry litter; GCNF = Green compost + No fertilizer. WCCF = Wood chips + Commercial fertilizer; WCPL = Wood chips + Poultry litter; WCNF = Wood chips + No fertilizer. SPCF = Shredded paper + Commercial fertilizer; SPPL = Shredded paper + Poultry litter; SPNF = Shredded paper + No fertilizer. MBCF = Mow-and-blow + Commercial fertilizer; MBPL = Mow-and-blow + Poultry litter; MBNF = Mow-and-blow + No fertilizer

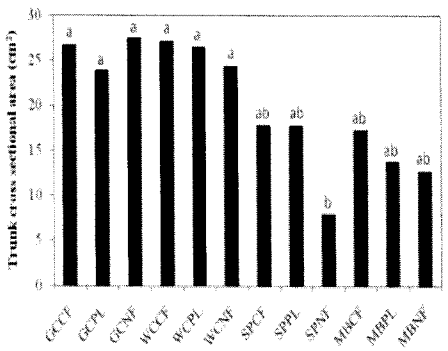

Fig. 1. Trunk cross sectional area of 'Enterprise'/M.26 apple trees in an organic orchard as affected by ground cover managemtn systems and nutrient source in year 3 (2008)

Different letters above bars indicate significant difference as determined by LSD, 5% level. GCCF = Green compost + Commercial fertilizer; GCPL = Green compost + Poultry litter; GCNF = Green compost + No fertilizer. WCCF = Wood chips + Commercial fertilizer; WCPL = Wood chips + Poultry litter; WCNF = Wood chips + No fertilizer. SPCF = Shredded paper + Commercial fertilizer; SPPL = Shredded paper + Poultry litter; SPNF = Shredded paper + No fertilizer. MBCF = Mow-and-blow + Commercial fertilizer; MBPL = Mow-and-blow + Poultry litter; MBNF = Mow-and-blow + No fertilizer.

GC- and WC-treated trees, receiving greater nutrients than those of SP and MB trees (Table 1), increased trunk cross sectional area (Fig. 1). SP+NF treatment plots had the highest ratio of C:N, lower foliar [N] in years 1 and 2, and had the smallest trunk cross sectional area.

Conclusions

WC treatment would be the best GMS from the aspect of N use and tree growth. Data developed in this study could be used to develop standards and recommendations for organic orchard nutrition. The project also provided a demonstration for growers as the growth effects of GMS during all three years of an organic orchard were visually profound.

References

Faust M. (1989): Nutrition of fruit trees. In: Physiology of Temperate Zone Fruit Trees: John Wiley & Sons, Beltsville, U.S.A., p. 53-132.

Naraguma J. (1994): Seasonal foliar nutrient content changes as related to productivity of coffee (*Coffee arabica*) in Burundi and Apple (*Malus domestica*) in Arkansas. MS. Thesis, University of Arkansas, U.S.A.

Shear C.B., Faust M. (1980): Nutritional ranges in deciduous tree fruits and nuts. Hort. Rev. 2:142-163.

Stiles W.C., Reid W.S. (1991): Orchard Nutrition Management. Cornell Cooperative Extension Ithaca, U.S.A.