Effect of Organic Amendments on Lemon Leaf Tissue, Soil Analysis and Yield[1]

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Abstract

An experiment was initiated in 2000 to study the feasibility of growing organic lemon in the southwest desert of Arizona. An eight-acre field was selected on Superstition sandy soil at the Mesa Agricultural Research Center to conduct this investigation. Lemon trees were planted at 25 feet spacing in 1998. The initial soil test in top 6 inches was 5 ppm nitrate-nitrogen and 4.9 ppm NaHCO3-P. Soil pH was 8.7 in the top 6 inches. Four treatments were applied in randomized complete block design repeated four times. The treatments were beef cattle feedlot manure and perfecta, clover and guano, guano and perfecta, and standard practice treatment. Soil samples were collected from 0-6 and 6-12 inches the first week of March 2001 and analyzed for NO_3*-N* NH_4*-N, total nitrogen, organic matter and available P. Preliminary results showed no difference in* NO_3*-N,* NH_4*-N in 0 to 6 and 6 to 12 inches between treatments. Total nitrogen increased significantly from 0.0262% in standard treatment to 0.0375% in the manure treatment. Similarly, soil organic matter increased from 0.297% in standard treatment to 0.4337% in the manure perfecta treatment. Phosphorus level increased significantly from 6.962 ppm in guano perfecta to 11.187 PPM in manure perfecta treatment. Leaf tissue analysis indicated that nitrate level was influenced by treatment. Yields of Guano treatments were significantly greater than yields of the other treatments. Both commercial standard and organic treatments were equally effective in controlling citrus thrips, but repeated applications were required. Mite population has been detected at low level with no significant differences observed among treatments.*

Introduction

Organic fruit production has recently gained the attention of the conventional citrus farmer. One of the main reasons for this interest has been the passage and implementation of the Food Quality and Protection Act (FQPA). With this bill's passage, the EPA has aggressively moved to limit usage of several pesticides that are widely used in Arizona Citriculture. Environmental groups have complained that the EPA is moving too slow, and are clamoring for faster implementation. These groups ultimate goal might be summarized by the following quote from the Natural Resources Defense Council

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"In the long run, both farmers and the public will be best protected by a fundamental restructuring of pesticide policies and agricultural research and education programs to minimize pesticide use and rely instead on non-chemical, biologically based methods that prevent pest problems."[2]

In December 2000, the USDA released the final rule for the National Organic Program. This action has increased interest in organic farming.

At the same time, there is an increasing demand for organically grown citrus among consumers. Some California growers have already responding to consumer's demand by growing lemons and oranges organically. However, there is also a need to evaluate the possibility of growing citrus organically in Arizona, especially for lemons.

Lemons are the most important and profitable citrus species grown in Arizona. Total lemon acreage in Arizona is about 13,000 acres, about 40% of the states' total citrus acreage (Arizona Agricultural Statistics 2000). Of the 13,000 acres in the state about 12,000 acres of lemon are grown in Yuma County. Yield fluctuates from year to year with average yield of 550 cartons per acre.

Organic citrus producers encounter several challenges that inorganic producers may not ever face. Researchers at the University of Arizona have worked on several cultural management techniques that may help growers meet the challenges of organic lemon production. One of these challenges is weed control. A Texas grower with several years experience growing organic grapefruit controls weeds using cover crops. Drs. McCloskey and Wright have been investigating cover crops in citrus at the Citrus Agriculture Center in Waddell for several years[3]. They found that strawberry clover and white Dutch clover were suitable as cover crops, as those varieties are able to withstand the Arizona summer heat. Advantages of these cover crops include an ability to suppress weed growth, and to maintain citrus leaf nutrient concentration at a level similar to that of trees growing under clean culture.

Disadvantages of the cover crops include loss of yield, probably due to competition for water. The Texas grower mentioned above experiences a yield loss of 10 to 15% compared to conventional farming. Thus, an alternative to cover crops is mechanical weed control.

Disking is the traditional method of controlling weeds. Recently, some Arizona citrus growers who control their weeds mechanically have begun to use the Perfecta field cultivator in place of the disk. The Perfecta is a tractor-pulled implement that comprises three rows of offset triangular shoes that travel through the soil just below the surface. The Perfecta is particularly effective for smaller weeds and does not appear to damage tree roots as does the disk. For this reason the Perfecta is a good choice for organic lemon production.

Another challenge for the organic grower is soil fertility and maintaining sufficient leaf N for fruit production. Manure as a source of organic nutrients is readily available from a feedlot and two dairy farms in Yuma County. We propose to use this locally available manure, commercially available organic fertilizer and clover cover crops as N sources and as means to improve soil structure and fertility.

A third challenge for the organic grower is insect control. In Arizona, citrus thrips, (*Scirtothrips citri*) is the primary insect pest that acts as a hindrance to organic citrus production. Traditionally, non-organic broad-spectrum insecticides have been used to control citrus thrips. In 1999 a particle film became available, Surround WP, that was shown to have activity towards citrus thrips. Surround is a highly refined kaolin mineral that produces a white coating on the tree, but does not interfere with photosynthesis or stomatal conductance. Dr. David Kerns' work has shown that this coating acts as a repellent, and clings to thrips that come into contact with it, resulting in some mortality. In addition to thrips control and sunburn protection, Surround has been shown to increase fruit earliness and may increase yield in mature citrus. In 2000, Surround was approved by OMRI as an organic pesticide.

Therefore, with this information in mind, we proposed to establish organic treatments designed to eliminate the need for conventional fertilizers, insecticides and herbicides while maintaining lemon fruit yield and fruit size.

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[2] Natural Resources Defense Council Fact Sheet. "Fields of Change - A New Crop of American Farmers Finds Alternatives to Pesticides.

[3] McCloskey, W.B., G.C. Wright, and K.C. Taylor. 1997. Managing Vegetation on the Orchard Floor in Flood Irrigated Arizona Citrus Groves. In: Wright, G.C. (ed.). 1997 Citrus Research Report. College of Agriculture Series P-109. pp. 91-103.

Materials and Methods

An experimental site was selected on Superstition sandy soil at the Yuma Mesa Agricultural Research Center, University of Arizona to evaluate the effect of organic amendments, weed and insect control on lemon growth and yield. Selected soil chemical properties (Table 1) indicated high pH at 8.7, low nitrate nitrogen level of 2.9 ppm and low potassium level at 59 ppm in the top 6-inches of soil. Lemon trees were planted in 1998, twelve trees per row in east west orientation at 25 by 25 feet spacing. Each experimental unit consisted of two-twelve tree rows from which yield data will be taken and with one-twelve tree row used as a guard row. All plots were flood irrigated every 7 to 21 days depending on the season. Since 2000, the experimental layout has had four treatments including: standard practices (non-organic), manure perfecta, clover and guano perfecta, applied in completely randomized block design replicated four times.

Standard practices treatments was made of applying nitrogen as ammonium sulfate (21-0-0) and, phosphorus as 11-52-0 (N-P-K). Weeds in the standard treatment were controlled by a repeated discing and roundup application. For the manure perfecta treatment, manure was applied at 10 tons per acre with a manure spreader in March 2001. Weeds were controlled using the perfecta. For the guano perfecta treatment, guano was applied as guano 7-7-7 N-P-K with irrigation water to provide 40 lb-N, 40 lb-P and 40 lb-K per acre. Again, weeds were controlled in this treatment using the perfecta.

For the guano clover treatments, guano was applied as guano 7-7-7 N-P-K with irrigation water to provide 40 lb-N, 40 lb-P and 40 lb-K per acre. Clover was planted in the fall of 2001. Clover germinated well and developed a good stand until spring. Clover was then stressed by the elevated summer temperatures. It was anticipated that the clover would out compete and control weeds in the clover treatment, however that has not proven to be the case.

Following manure, guano and fertilizer applications in the standard treatments, soil samples were taken from 0-6 and 6-12 inch deep on April 12, 2001 and analyzed in a commercial laboratory. Also, thirty to 50 leaves were randomly collected in zip lock bags and brought to the laboratory. Leaves were washed with distilled water, divided in two groups. The first sample group was ground with a small food processor. Nitrate-nitrogen determination was made immediately using portable electrode, Cardy meter. . Second group samples were washed with distilled water, dried at 65C and ground to pass 1 mm sieve before they were sent to a commercial laboratory for chemical determination.

Insect control treatments were divided into two regimes, organic and a commercial standard. The organic regime was subdivided into three treatments based on fertilizer, ground cover, and weed management. All organic treatments were composed of only OMRI approved materials and subject to change depending on the pest encountered. In 2001, citrus thrips, *Scirtothrips citri* and Yuma Spider Mites were encountered, but citrus thrips was the only pest at economically damaging levels. Thus, the organic treatment consisted only of applications of Surround WP (kaolin) applied at 50 lbs/ac. The commercial standard consisted of applications of either Dimethoate at 2 lbs-ai/ac, Success (spinosad) at 4 oz/ac, or Carzol (formetamate HCl) at 1 lb/ac. Treatments were applied on 10 and 25 April, 21 May, 8 June, 11 July, and 15 August using a hand-gun sprayer calibrated to deliver 250 gal/ac.

Citrus thrips and mite populations were sampled using an 8 x 12 in. black baking pan covered by 0.25 in. hardware cloth. Yellow 3 x 5 in. sticky cards were placed in the bottom of the pans to capture the pests. Samples were taken from flush growth by tapping the growth onto the hardware cloth for 5 sec. Forty pieces of flush were sampled per treatment replicate. Four pieces of flush were sampled per sticky card. The sticky cards were transported to the laboratory where adult and immature thrips and mites were counted under a dissecting scope. Treatment differences were discerned using ANOVA and an F protected LSD ($P < 0.05$).

Damage ratings, using a 1 to 5 scale, were taken on 16 October by visually rating damage to the foliage that was produce between April and October. The rating scale used was 1 = no damage, 2 = few crinkled leaves present, 3 = many crinkled leaves present, 4 = many crinkled leaves and some defoliation present, and 5 = substantial defoliation present (buggy whipping). Treatment differences were discerned using ANOVA and an F protected LSD ($P < 0.05$).

Yield data was collected on 2/7/02. Trees were strip-picked. The entire harvest from each tree was weighed.

Results and Discussion

Manure. Very often, the rate of manure application is determined based on its nitrate content. This form of nitrogen is readily available to plants but it is also subject to rapid leaching following irrigation, particularly in sandy soil. Figure 1 shows the transformation of nitrate and ammonia in manure pile stored in open air for one year, prior to application to the field. Fresh manure had initially a high ammonia concentration that decreased rapidly from 7431 ppm in the first month to less than 100 ppm after one year. Inversely, nitrate-nitrogen concentration increased from 13.5 to 67.5 ppm during the same period of time. Therefore, the rate of manure application should be determined based on manure analysis performed at the time manure is applied. The other manure characteristics are reported in Tables 1a and 1b. The changes in chemical properties are due to the increase in dry matter content and water loss over time as the moisture decreased from 25 to 11%.

Soil Chemical properties. Initial selected soil properties are reported in Table 2. Soil organic matter and nitrogen were low, and pH was high. The application of various amendments significantly influenced the total nitrogen, Organic Matter (OM) and phosphorus content. When soil was sampled from 0-6 and 6-12 inch deep only OM and phosphorus were affected (Table 3).

Figures 2, 3 and 4 show the effect of treatments on soil depths, 0-6 and 6-12 inches. Nitrate did not appear to be affected by sampling depth. Mobile nutrients move rapidly out of root systems with irrigation water. Phosphorus that has low mobility tends to accumulate near the soil surface.

Leaf samples. Figure 5 shows the effect of amendment application on leaf sap nitrate-nitrogen as determined by Cardy meter at two sampling periods, April and July, 2001. Although the results present some variability, manure appears to have greater effect on sap nitrate during the July's sampling. The analysis of variance is not shown in this report. However, results indicated that treatments had a similar effect on total nitrogen (TN), total P, S, K, Ca, Zn Mg, Mn and Cu (Table 4). These results indicated that manure and guano were both as effective as a standard treatment. The time of sampling appeared to affect nutrient content in the lemon leaves.

Yield. First yield data collected in 2001 is reported in Figure 6. Yield is relatively low for the first harvest. However data show that the guano treatments had significantly greater yields than did the manure and standard control treatments.

Insect Control. Both the commercial standard and the organic treatment regimes were equally effective in controlling citrus thrips (Figure 7). All of the treatment regimes required multiple applications to maintain control due to the continual production of fresh unprotected flush. Mite populations, although detectable, were not high and we could not detect any differences among the treatments for mite control (Figure 8). The fact that the mite populations did not develop to economically threatening level in any of the treatments indicates that these treatments may have some mite activity. However, since our experimental design did not utilize an untreated control, this possibility cannot be verified without further investigation.

Based on damage ratings, the organic regimes and the commercial standard were equally effective in preventing substantial damage (Figure 9). A mean damage rating above 3 would indicate a failure to effectively prevent significant damage.

Table 1a. Changes in chemical properties of manure applied to lemon over one year period.

Month	Organic Nitrogen	Total Kjeldahl Nitrogen	P	K	S	Ca	Mg	Na	Zn	Fe	Mn	Cu
	%								ppm			
1	4.1	4.8	5.0	2.9	0.6	10.1	0.6	0.4	189.5	2009.8	199.5	107.0
6	2.1	2.2	1.3	3.3	1.5	2.4	0.9	1.8	464.5	5163.3	218.3	46.5
12	2.0	2.0	1.3	5.6	1.3	2.7	0.9	1.7	440.3	5049.8	214.5	54.3

Table 1b. Additional changes in chemical properties of manure applied to lemon over one year period.

Month	Salts	Ph	Moist	DM
	Mmho/cm	Unit	----- % ----	
1	51.5	6.9	25.7	74.3
6	67.1	7.6	19.9	80.1
12	81.6	8.2	11.3	88.7

Table 2. The initial soil characterization taken at different depths.

Soil depth, in.	PH	Salinity dS/M	Sodium ppm	Nitrate Ppm	Phosphorus ppm	Potassium Ppm	Calcium ppm
0-6	8.7	0.5	50	2.9	4.9	59	4800
6-12	8.9	0.5	86	4.2	6.1	64	4700
12-24	8.6	0.5	57	4.3	4.5	60	4200
24-36	8.5	0.5	58	2	3.2	62	5600
36-48	8.7	0.5	56	1.6	2.3	56	5800

Table 3. The Analysis of variance on soil nitrate, ammonia, total nitrogen, organic matter and $NaHCO_3$ –P as affected by soil amendments applied to the superstition soil at Mesa Valley Research Center in 2000.

Source of Variation	DF	NO_3	NH_4	Total N %	OM %	PO_4
		P>F				
Trt.	3	0.1736	0.5454	0.0758	0.0019	0.0481
Depth	1	0.9750	0.1653	0.5198	< 0.0001	0.008
R square		0.5254	0.3461	0.3552	0.7348	0.537
CV (%)		67.222	44.767	36.00	20.04	37.53

Table 4. Means of selected nutrient concentration in leaf tissue as affected by amendment application, 2001.

Source of variation	NO_3	N	P	K	S	Ca	Yield
	---------------------- % -------------------------						Lb/tree
Manure	12.5a*	1.87 a	0.16 a	1.38 b	0.23 b	2.64 a	
Standard	10.5 bc	1.84 b	0.17 a	1.67 a	0.30 a	2.67 a	
Guano	11.5 ab	1.63 d	0.14 b	1.48 ab	0.33 a	2.85 a	
Clover	10.0 c	1.81 c	0.16 a	1.29 b	0.29 ab	2.70 a	

* Treatment means with the same letter are not significantly different at 5% alpha level.

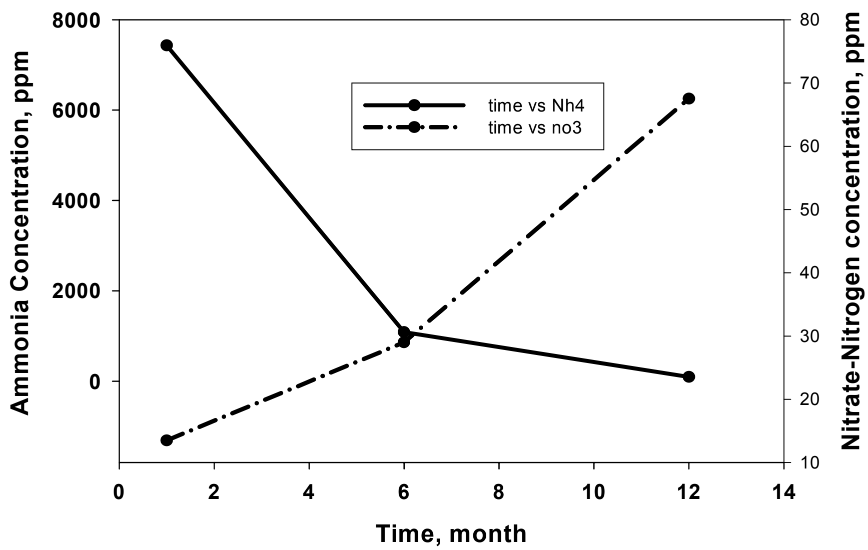

Figure 1. Ammonia loss and nitrate nitrogen formation from manure disposed on the airfield in one year at Yuma Mesa Agricultural Research Station, 2001.

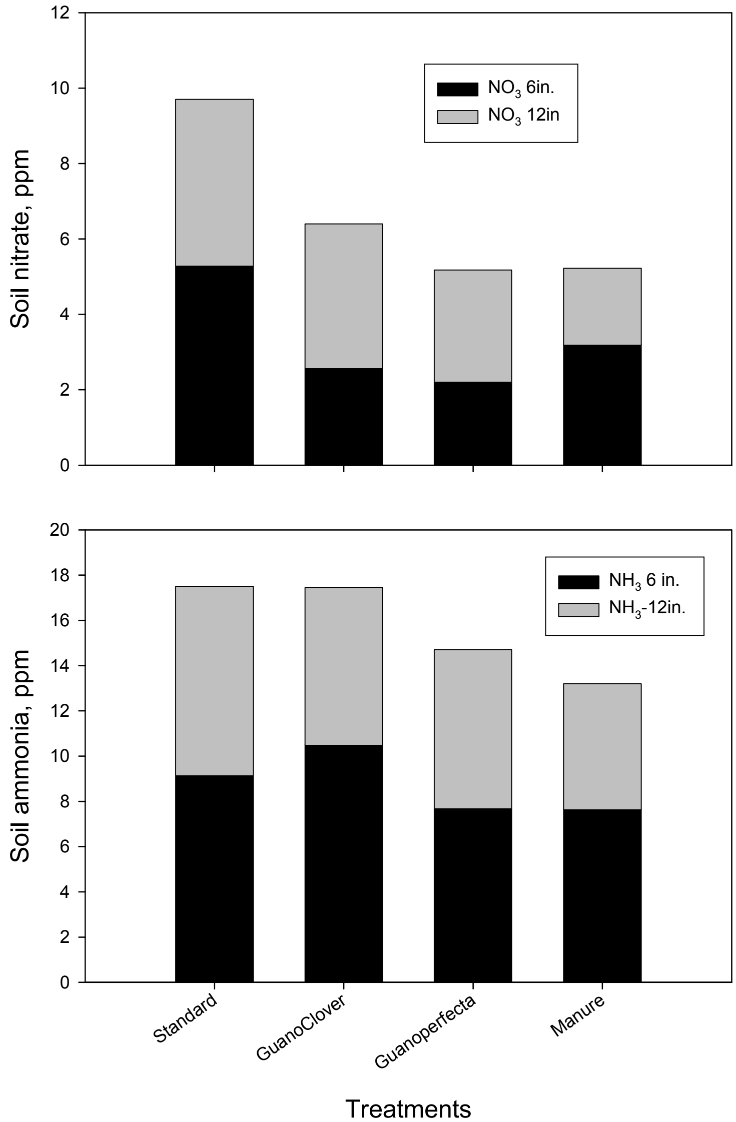

Figure 2. The effect of nutrient sources on soil available nitrate nitrogen (NO_3-N and ammonium nitrogen (NH_4-N) from 0-6 and 6-12 inches.

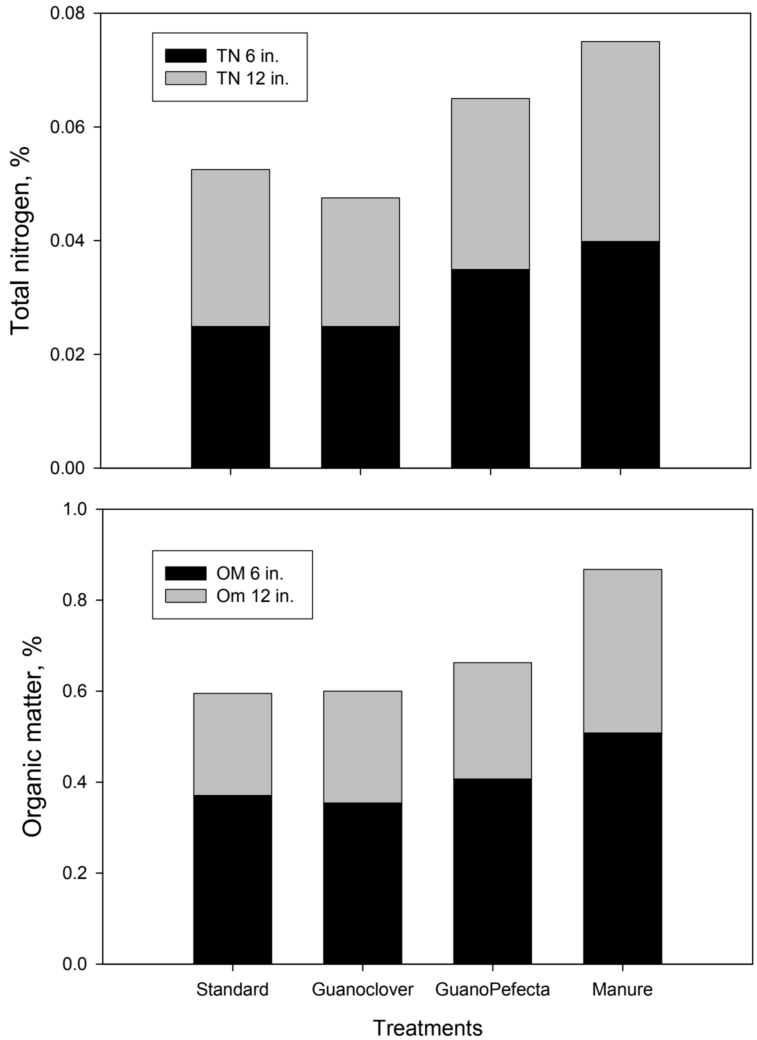

Figure 3. The effect of soil nutrient sources on soil total nitrogen and organic matter content from 0-6 and 6-12 6 and 12 inches.

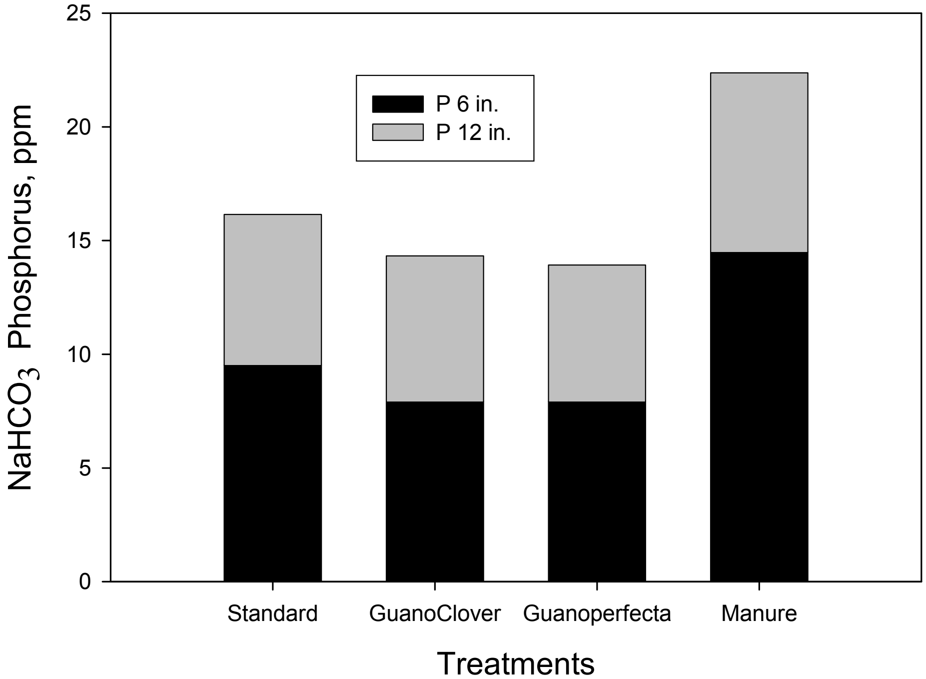

Figure 4. The effect of soil amendment application on soil $NaHCO_3$ P from 0-6 and 6-12 inches

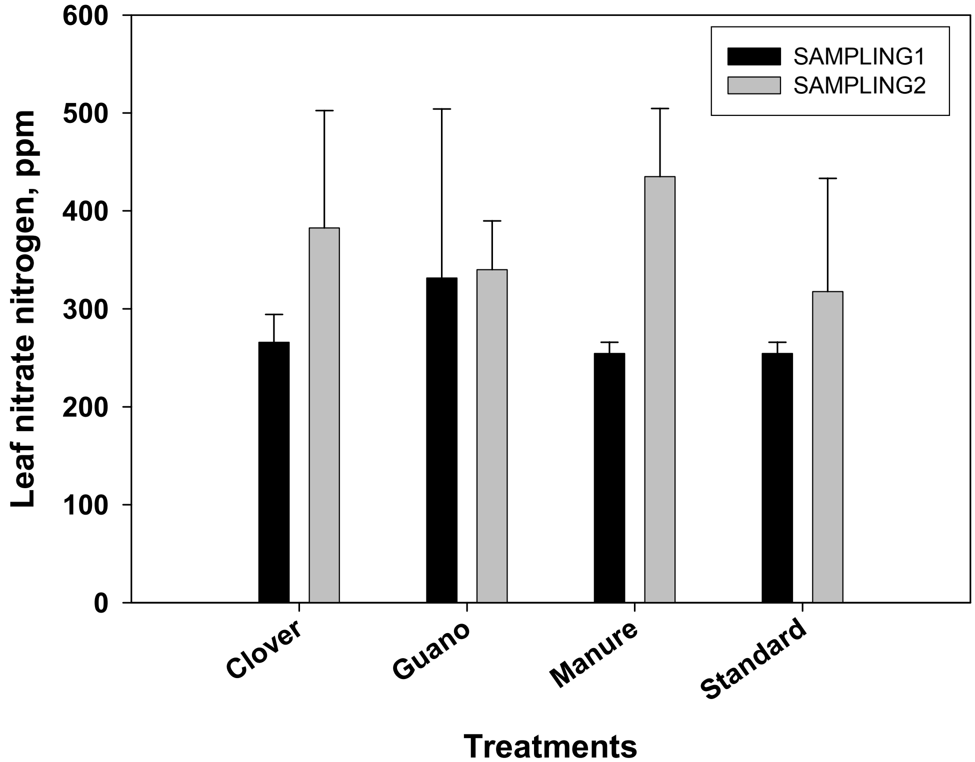

Figure 5. Lemon leaf nitrate-nitrogen concentration, ppm and associated standard deviation evaluated by Cardy meter as affected by soil amendments and sampling time

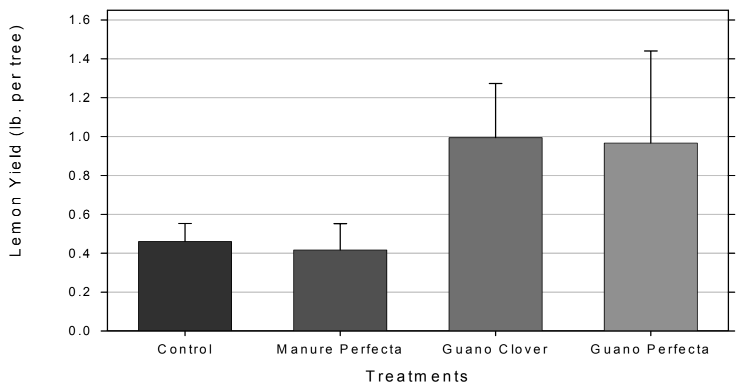

Figure 6. The effect of amendment application on lemon yield grown in Yuma Mesa Agricultural Research Station in 2001

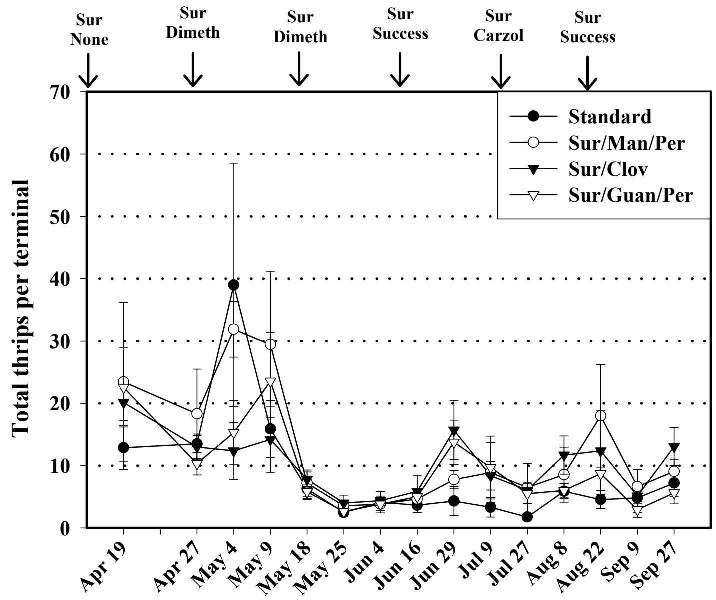

Figure 7. Mean number ± SEM of citrus thrips per terminal flush on lemons treated organically or with commercial standard insecticides. The organic treatments were all treated with Surround but consisted of different fertilizer, ground cover, and weed management programs.

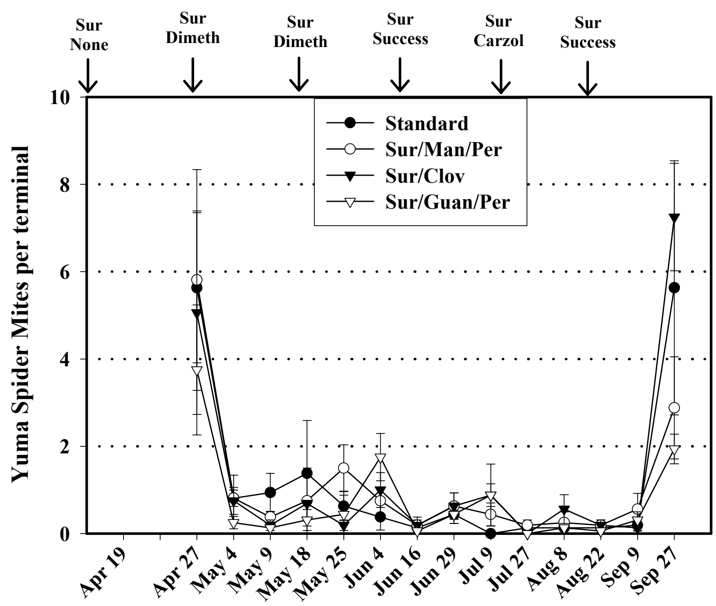

Figure 8. Mean number ± SEM of Yuma spider mites per terminal flush on lemons treated organically or with commercial standard insecticides. The organic treatments were all treated with Surround but consisted of different fertilizer, ground cover, and weed management programs.

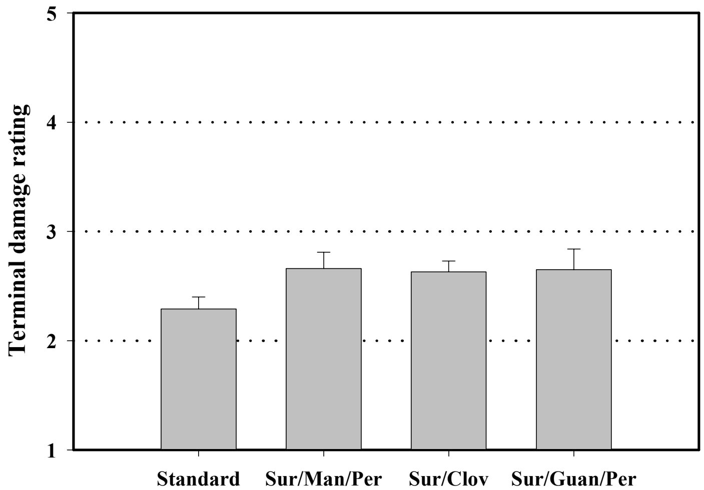

Figure 9. Mean number ± SEM damage rating of lemon terminal growth treated organically or with commercially standard insecticides. The rating scale was 1 = no damage, 2 = few crinkled leaves present, 3 = many crinkled leaves present, 4 = many crinkled leaves and some defoliation present, and 5 = substantial defoliation present (buggy whipping).