Organic Lemon Production

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Abstract

This experiment was initiated in March 2000 to study the feasibility of growing organic lemon in the desert southwest of Arizona. A ten-acre field planted to lemons in 1998 was selected on Superstition sand at the Yuma Mesa Agricultural Research Center. The initial soil test in top 6 inches was 5 parts per million (ppm) NO_3^- *and 4.9-PPM* $NaHCO_3^-$*-extractable P. Soil pH was 8.7 in the top 6 inches. Seven treatments were applied in randomized complete block design repeated three times. The treatments were control, compost and clover, compost and perfecta, compost and steam, manure and clover, manure and perfecta and manure and steam Leaf tissue analysis indicated that nitrate level was significantly influenced by treatment. Organic insect control treatments for citrus thrips were as equally effective as the non-organic commercial standards.*

Introduction

Lemons are the most commonly produced citrus grown in Arizona. There are about 13,000 acres of lemons in the state, down about 2,000 acres from 1993 (Arizona Agricultural Statistics 2000). Among the 13,000 acres, about 12,000 acres of lemons are grown in Yuma County. Yield across the state fluctuates from year to year with average yield of 550 cartons per acre. To date, virtually all of the lemons produced in Arizona are grown using conventional fertilizers and pesticides.

There is an increasing demand for organically grown citrus among consumers, but this interest has not led to a large increase in organically produced fruit. Only a small portion of the total fresh fruit acreage in the US is grown organically, however, 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

> *"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."* (Natural Resources Defense Council, 1999).

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

Because of the inability to use conventional pesticides, organic citrus producers encounter several challenges that inorganic producers never face. The first is weed control. A Texas grower with several years of growing organic grapefruit grows cover crops. McCloskey and Wright have been investigating cover crops at the Citrus Agriculture Center in Waddell for several years (McCloskey *et al.*, 1997). We found that in Central Arizona, strawberry clover

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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 provide a source of available organic nutrients and organic matter to the trees once the cover crop biomass is incorporated into the soil.

The prime disadvantage of the cover crops is the potential loss of yield, probably due to competition for water. The Texas grapefruit grower mentioned above experiences a yield loss of 10 to 15% compared to conventional farming. This is similar to the yield loss for oranges grown at the Citrus Agriculture Center under a clover cover crop. Another challenge is the difficulty in establishing a cover crop in sandy Yuma citrus soils. We have tried to establish a cover crop in a citrus grove on the Yuma Mesa, however the lack of constant moisture in the sandy upper layer of the soil negatively affected seed germination.

An alternative to the use of cover crops is the “Perfecta” field cultivator or the Steam Unit. This cultivator comes equipped with three rows of staggered goosefoot shovels that will till the soil to a maximum depth of just six inches. Efficient use of the Perfecta cultivator requires more passes through the orchard, since weeds must be small to be efficiently removed. The steam unit is an experimental weed control machine that uses steam to kill weeds. Dr. McCloskey believes that he can import one of these machines from their New Zealand manufacturers.

Another challenge to the organic grower is the citrus thrips. 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 new insecticide technology became available for use in citrus, Surround WP. Surround is a highly refined kaolin mineral that produces a white coating on the tree. This coating acts as a repellent, and clings to thrips that come into contact with it resulting in mortality. Surround WP has consistently been shown to control citrus thrips as well as the commonly used commercial pesticides commonly used today. Additionally, in a 1997 study, use of this compound produced the highest quality of fruit (Kerns and Tellez, 1998). Further research with this compound in 1999 shows there were significant yield increases using Surround, compared with the control, yet high variability between the treatment units precluded significant differences. In 2000, Surround was approved by OMRI as an organic pesticide.

Another challenge is soil fertility and maintaining sufficient leaf N for fruit production. We propose to use commercially available organic fertilizer and locally available manure as N sources and as means to improve soil structure and fertility.

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.

Materials and Methods

A 10-acre experimental site was selected on March 13, 2000 on Superstition sand soil at Yuma Mesa Agriculture Center, University of Arizona to evaluate organic lemon production. Two-year-old ‘Limoneira 8A Lisbon’ lemons on *Citrus volkameriana* rootstock were used with twelve trees per row in east to west orientation at 25 x 25 feet spacing. Soil samples were taken at the outset of the experiment for analysis. Selected soil chemical properties shown in the Table 1 indicate high pH at 8.7, low nitrate nitrogen level of 2.9 ppm and low potassium level at 59 ppm in top 6-inches of soil depth.

All plots were flood irrigated every seven to twenty one days depending on the season. Seven treatments including a control, compost and clover, compost and perfecta, compost and steam, manure and clover, manure and perfecta and manure and steam were initially planned in completely randomized block design replicated three times. Each experimental unit is made of two rows of twelve trees with one-twelve tree row used as a guard row. The compost was made of non-decomposed yard waste material and manure was from beef cattle feedlot. Feedlot manure and composted yard waste were applied on March 17, 2000 at 10 and 15 tons per acre respectively, to provide nutrients needed for lemon growth. Strawberry clover (*Trifolium fragiferum*) was applied on March 24, 2000 at a rate of 20 lbs. per acre. Nitrogen was applied to the entire plot at a rate of 0.2 lbs. N per tree as urea ammonium nitrate 32-0-0 during February and March 2000, prior to the start of the experiment.

Tree trunk diameter data was collected at the prior to the start of the experiment. Leaf samples were collected on 8-15-00 and analyzed for Nitrate nitrogen. Fifty leaves were randomly collected in zip lock bags, brought laboratory. Leaves were washing with distilled water, and ground with a small food processor. Nitrate determination was made immediately using portable nitrate electrode (Cardy meter). Three electrodes were used for each treatment to evaluate nitrate variability between electrodes.

Insect control treatments were divided into two regimes, organic and a commercial standard. All organic treatments were composed of only OMRI approved materials and subject to change depending on the pest encountered. However, in 2000 citrus thrips, *Scirtothrips citri* was the only pest encountered 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 or Carzol (formetamate HCl) at 1 lb/ac. Treatments were applied on 19 April, 12 May, 21 June, and 01 August using a handgun sprayer calibrated to deliver 250 gal/ac.

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

Results

Lemon trees have not started to produce fruit therefore, the evaluation of treatments is based on tissue sampling and soil samples. The initial soil samples indicated that both nitrate and phosphorus level were low, 2.9 ppm N and 4.9 ppm P in top 6-inch soil. Status of soil and nutrients are shown in Table 1. Nutrients content of yard compost was very low and little effect on soil and leaf tissue.

Pretreatment trunk diameters ranged from 25 to 32 mm.

Leaf analysis: During the first year where we had used seven treatments, leaf sample analysis was limited to nitrate determination. The effect of treatments on leaf nitrate level is shown in Figure 1 and Table 2. Results indicate that leaf nitrate varied significantly due to treatments. Plots that did not receive any fertilizer application had the lowest leaf nitrate treatment. Manure had tendency to affect more leaf nitrate. Sub-sampling and electrode had no effect on leaf nitrate.

Soil samples collected from 0-6 inches and 6-12 inches are shown in Table 3. Significant difference was observed among treatments. Organic matter and phosphorus were the elements the most influenced by treatments. The depth of sampling has also a great effect on nutrient status in he soil. Figure 3, 4, 5 show the effect of soil sampling depth as affected by treatment. Mobile nutrient such as 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.

Both the commercial standard and the organic treatment regimes were equally effective in controlling citrus thrips on these young trees. Although statistical differences were detected between treatments on several occasions (adults on 14 June and 12 July, and nymphs on 1 and 28 June), these differences were minor and do not indicate relevant differences in product performance. Both treatment regimes required multiple applications to maintain control due to the continual production of fresh unprotected flush.

By August 2000, it was clear that several difficulties had emerged. The yard compost was found to be so low in nitrogen and other nutrients that we were concerned that it would not provide enough nitrogen for adequate lemon tree growth. We then decided to replace yard compost with commercially available seabird guano (12-12-2.5-6Ca-1.5S) as a source of N P K. Also, after consulting with the manufacturers of the steam unit, we determined that the use of the unit would be cost prohibitive, because of the cost of the unit as well as the cost of the fuel needed to heat the water needed to produce the steam. Also, the manufacturers were unwilling to sell the steam units, but rather would only lease the equipment. Finally, we were unable to achieve a good stand of clover because we seeded the clover too late.

Therefore, we decided to completely renew the experimental design for 2001. The new experimental design will include the following treatments applied in completely randomized block design replicated four times: control, clover, guano with the use of the perfecta for weed control and manure with the use of the perfecta for weed control. Also, all the trees in the three organic treatments will be treated with Surround. Thrips control in the control trees will be via commercial standard insecticides.

Conclusions

This experiment is a work in progress. While our original decision to use locally available manure appears to be a good one, our choice of yard compost was not. We expect that the seabird guano will be an acceptable alternative. While our inability to test the steam unit is disappointing, its elimination has allowed us to simplify the experiment, and focus our attention on combinations of treatments that are more likely to be adopted by lemon producers. We still are having difficulty establishing the clover crop, however will continue to investigate methods that we can use to ensure a good stand.

Literature Cited

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Table 1. The initial soil characterization taken at different depth increments.

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	2.0	3.2	62	5600
36-48	8.7	0.5	56	1.6	2.3	56	5800

Table 2. Analysis of variance of leaf nitrate content as affected by treatments, sampling and Cardy meter (nitrate electrodes)

Source of variation	Degrees of Freedom	P>F[z]
Rep	2	<.0001
Treatments	6	<.0001
Samples	1	NS
Cardy	1	NS
R^2 [y]		0.775
CV(100)[x]		12.5%

[z] Values less than 0.05 indicate significance. NS = Non significant

[y] Indicates that 77.5% of total variation in leaf nitrate content that can be accounted for by a linear function involving the four sources of variation.

[x] The coefficient of variation is an expression of the experimental error as a percentage of the mean. On a scale of 1 to 100, lower values indicate the precision of the experiment.

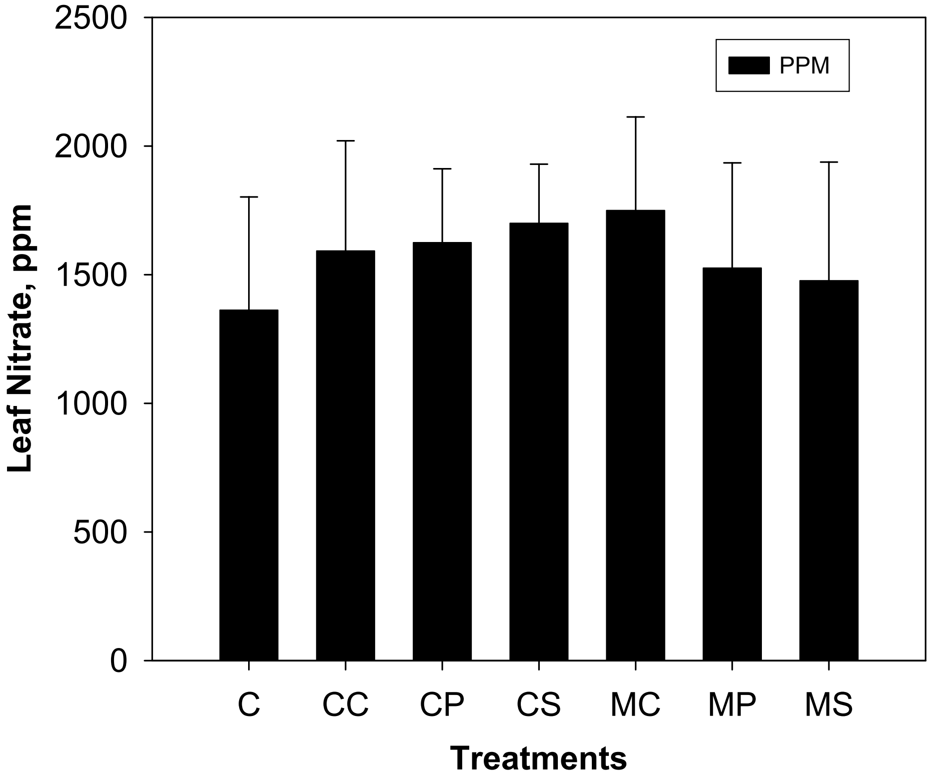

Figure 1. Leaf nitrate concentration, ppm and associated standard deviation evaluated by Cardy meter as affected by soil amendments

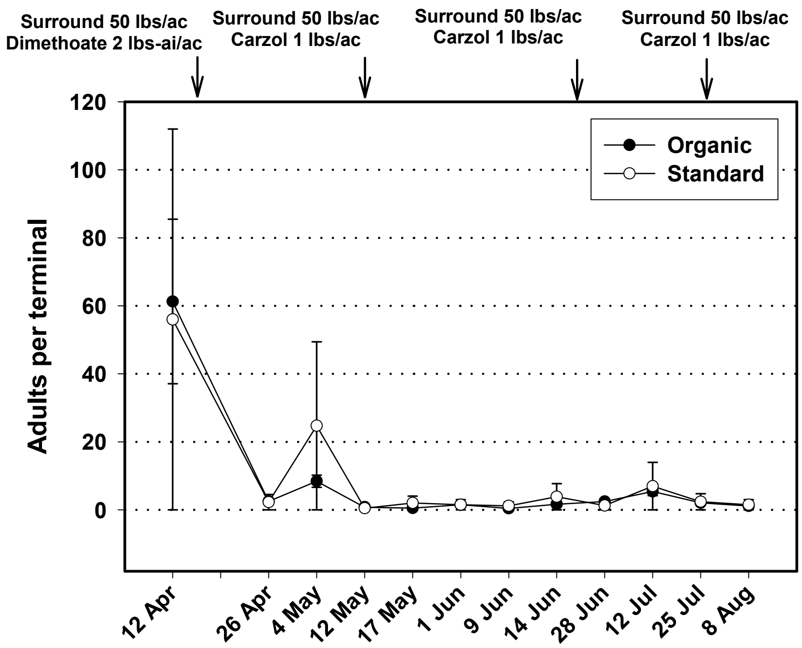

Figure 2 Mean number ± SEM (Standard error of the Mean) of adult citrus thrips per terminal flush on lemons treated organically or with commercially standard insecticides.

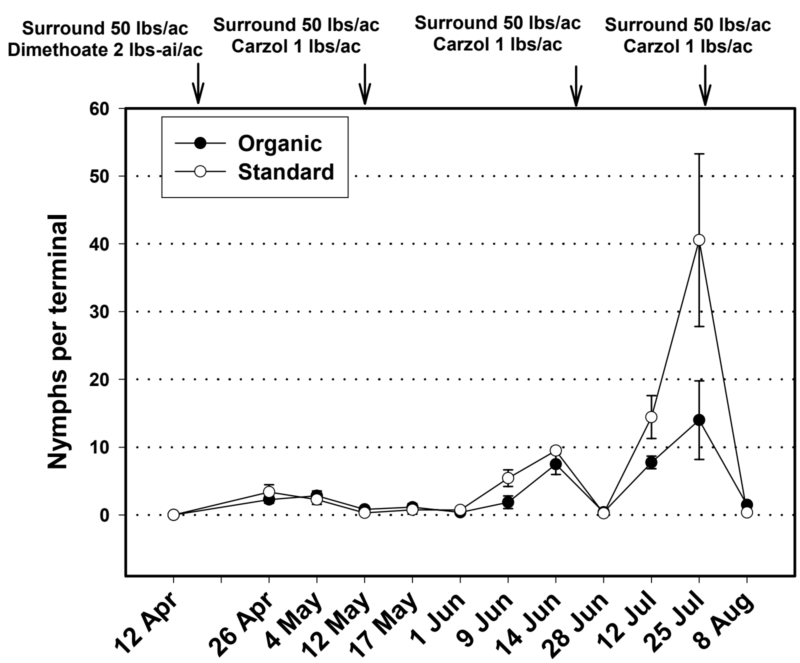

Figure 3 Mean number ± SEM of immature citrus thrips per terminal flush on lemons treated organically or with commercially standard insecticides.

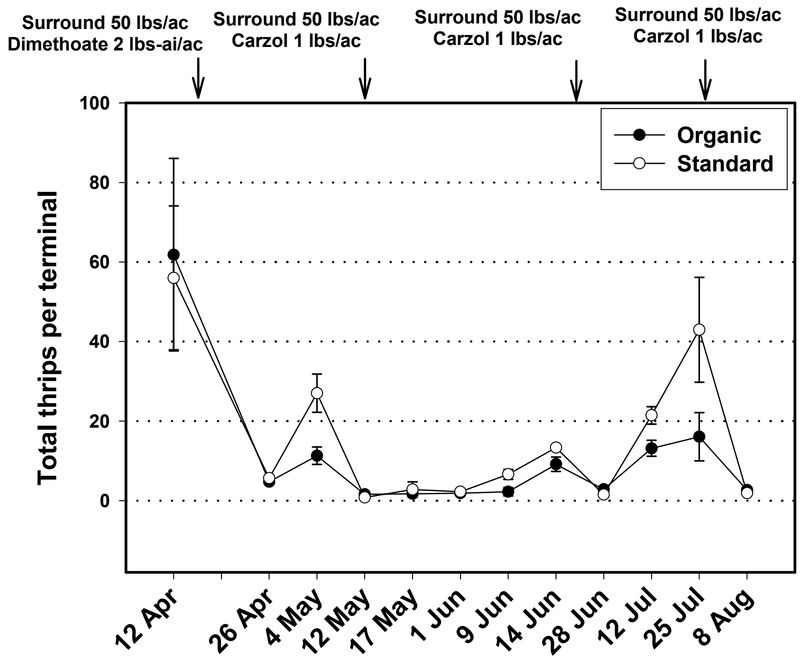

Figure 4 Mean number ± SEM of total citrus thrips per terminal flush on lemons treated organically or with commercially standard insecticides.