COMPOST EFFECT ON COTTON GROWTH AND YIELD

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INTRODUCTION

Although there is some use of municipal compost on farms, the utilization of compost is not a standard practice in commercial agriculture. In order for agricultural markets to develop and make compost use a standard practice, the agronomic benefits and safe use of compost application must be demonstrated and a cost benefit analysis developed. Because of the high cost of transportation relative to product value, compost must not only address agronomic concerns, but also be tailored to specific regional factors.

PURPOSE AND GOAL OF THE PROJECT

The goal of this project was to demonstrate the benefits of compost application in commercial agriculture for the purpose of securing markets for municipally derived compost. The project provided comprehensive on-farm demonstrations of the agricultural use of municipal compost on cotton in California. Although the project was conducted in California, the concepts, advantages, and utilization of compost for cotton and other agricultural crops applies nation-wide.

This paper presents the first year's results of the three-year project which started in 1994.

DEMONSTRATION SITE

The first year of the demonstration took place on Torigiani Farm, a large cotton crop farm in the Lost Hills Valley. The demonstration site was 72 acres in size. The size was designed for a side-by-side comparison of compost application to current agronomic practices.

The demonstration highlighted growth, yield, and water conservation. The project utilized yard waste/biosolids compost produced by San Joaquin Composting, Inc. (SJC) of Lost Hills, California. SJC has been operating a large-scale yard waste/biosolids composting operation receiving feedstocks from the cities of Los Angeles and Fresno, California. Torigiani Farm continued to conduct its regular farming practices in the compost-amended plots.

The primary concern of the project team was to ensure a quality product that is stable and mature and that meets the needs of the demonstration and commercial users. SJC has produced the compost for this demonstration, transported it to the site, and worked closely with the project team to insure product quality and acceptability to the agricultural users. Torigiani Farms provide the demonstration site, carried out all necessary land preparation, planted the cotton, irrigated the land, maintained the crops, and harvested the crops. Land preparation, planting practices, and maintenance of the compost-amended portion of the site were conducted exactly the same as for the rest of the farm, with the exception of the application of co-composted yard waste and biosolids prior to planting. The project team designed the plots, supervised the entire process, and collected both soil moisture and plant growth data.

TABLE 1
San Joaquin Compost Analysis

Constituents Tested	As Received (%)	Dry Weight (%)
Total Nitrogen (TN)	1.4	2.1
Organic Nitrogen [TN-(NH_3N + NO_3N)]	1.4	2.1
Ammonia (NH_3N)	0.060	0.089
Nitrate (NO_3N)	0.004	0.006
Phosphorous (P_2O_5)	2.2	3.3
Potassium (K_2O)	1.4	2.1
Calcium (Ca)	2.9	4.3
Magnesium (Mg)	1.0	1.5
Sulfate (SO_4S)	0.15	0.23
Chloride (Cl)	0.13	0.20
Sodium (Na)	0.15	0.22
Moisture	32.7	0.0
Organic Matter	15.3	33.8
Ash	52.0	66.2
Bulk Density (lbs/ft^3)	50.0	34.0
pH Value	7.5	X
Electrical Conductivity (EC 1:5 w/w) (mmhos/cm)	4.5	6.7
Total Dissolved Salts (TDS)	1.6	2.3
Carbon to Nitrogen Ratio [(OM/2)/N]	5	X
Ag Index (<2 = poor; >10 = excellent)	18	X

METHODOLOGY

Compost Type and Method of Preparation

The co-composted yard waste and biosolids was prepared from source-separated yard waste collected from households in the City of Los Angeles and from the Hyperion Treatment Plant. This material was blended and composted using a mechanically turned windrow system by SJC. The compost produced at SJC was used at the Torigiani Farms demonstration site, which is located approximately 12 miles from the SJC facility. The compost product used in this demonstration project complied with United States Environmental Protection Agency regulations to protect public health, safety, and the environment, as stated in 40CFR503. The analytical report of the compost by the Soil Control Laboratory, a certified laboratory, is given in Table 1.

Compost quality was high and typical of biosolids compost. Total nitrogen, mostly as organic nitrogen, was 1.4 percent and would be released slowly over the growing period, supplementing any inorganic nitrogen applied as fertilizer. Phosphorus and potassium levels were higher than many biosolids composts. The agricultural index of 18 was excellent.

Compost Rate and Method of Application

In December 1994, the compost was applied using a hydraulically driven, spinner-type, truck-mounted manure spreader. After application, the compost was disked into the top six inches of soil. The compost was applied at rates of 0, 3, and 6 dry tons per acre (dt/a).

Design of the Demonstration Site

The 72-acre demonstration site was divided into nine equal eight-acre plots. Three plots were randomly chosen for each rate of compost application (see Figure 1). Soil type, in general, was loam. Before compost application, soil samples from all plots were collected and sent to a certified laboratory for analysis.

FIGURE 1
Design of Demonstration Site

Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9
72 Rows	72 Rows	72 Rows	72 Rows	72 Rows	72 Rows	72 Rows	72 Rows	72 Rows
228 Feet	228 Feet	228 Feet	228 Feet	228 Feet	228 Feet	228 Feet	228 Feet	228 Feet
Rate 3 dt/a	Rate 0 dt/a	Rate 6 dt/a	Rate 6 dt/a	Rate 3 dt/a	Rate 0 dt/a	Rate 3 dt/a	Rate 0 dt/a	Rate 6 dt/a
Replicate 1			Replicate 2			Replicate 3		

Planting and Growth Measurements

Cotton seeds were planted on April 24 and 25, 1995, using commercial farming equipment at a rate of 16.5 pounds per acre. Growth measurements included height of plants, number of leaves, number of branches, length of branches, number of buds, number of bolls, and yield of crops.

Water Retention Tests

After the heavy rains of January 1995, soil samples from all nine plots were taken for measurements of soil water content at field capacity, as well as daily measurements of water content for determination of water retention.

One hundred grams from each sample were oven-dried at 103°C for 24 hours. Water was then added to these soils to bring them to field capacity level; 23 grams of water were required to bring the dried soil from each plot to field capacity. Two hundred grams of wet soil from each plot's sample were transferred to a plastic container weighing 8.7 grams. Daily water loss was measured for two weeks.

RESULTS

Since cotton is not a high-cash crop, the rates of compost application chosen for this project (3 and 6 dt/a) were low. Although the rates of compost application were low, incorporation of 3 and 6 dt/a improved the crop growth, cotton yield, and water retention.

In general, the increases in growth, yield, and water retention were greater in the east ends of the plots in comparison to the west ends of the plots. This could be due to the higher salt concentrations in the soil in the west ends. When compost was added, the percentage of increase in growth, yield, and water retention was greater in the west ends than in the east ends when compared to the same ends of the control plots. Apparently, compost application was very effective in improving the physical and chemical properties of the west ends, resulting in great improvements as compared to non-amended plots.

In addition to improvement of soil's physical and chemical properties, incorporation of compost into the soil added a considerable amount of available nitrogen. The available nitrogen from the soil, and then from the compost after application, was 51 pounds per acre, 121 pounds per acre, and 164 pounds per acre for 0 (plots 2, 6, and 8), 3 (plots 1, 5, and 7), and 6 dt/a (plots 3, 4, and 9), respectively. These figures were calculated using the data provided by the Soil Control Laboratory and from Table 1. Nitrogen added by compost was calculated from Table 1, assuming the rate of mineralization was 15 percent during the first year. Nitrogen from the soil was calculated using the soil analysis provided by the Soil Control Laboratory (laboratory results not shown). These figures do not include the fertilizer added by the growers.

Effect of Compost on the Vegetative Parts of Compost

Cotton Height

The height of the plants increased with compost application during the measuring period (see Figure 2). The percentage of increase in height ranged from 4.6 to 12.5 percent for the compost application of 3 dt/a and from 9.7 to 13.9 percent for the compost application of 6 dt/a.

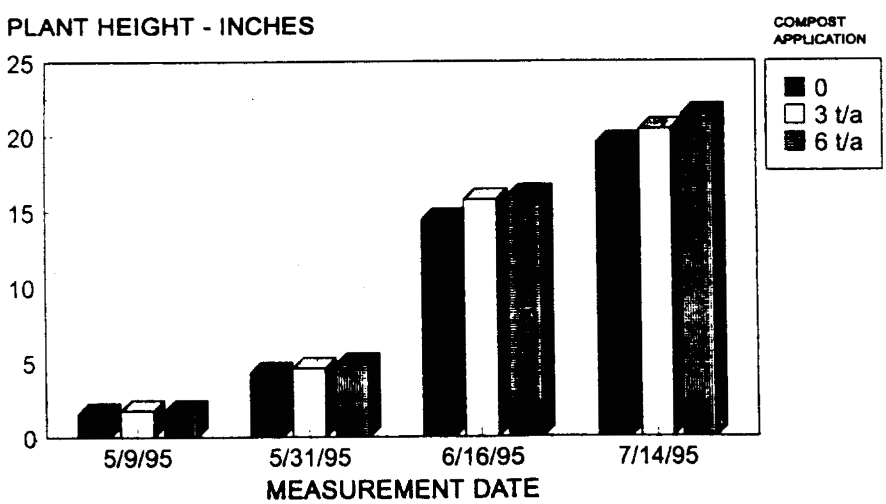


Figure 2. Effect of compost application on cotton plant height.

Plant heights in the east ends of the plots were greater than in the west ends. However, the percentage of increase due to compost application was greater in the west ends of the plots. The percentage of height increase in the east ends ranged from 3.6 to 6.6 percent for the compost application of 3 dt/a and 4.5 to 8.2 percent for the compost application of 6 dt/a, while the percentage of increase in the west ends ranged from 5.4 to 14.3 percent for the compost application of 3 dt/a and 14.6 to 21.6 percent for the compost application of 6 dt/a.

Number of Leaves

The number of leaves also increased with compost application (see Figure 3). The percentage of increase in the number of leaves ranged from 6.7 to 10.1 percent for the compost application of 3 dt/a and 8.9 to 23.7 for the compost application of 6 dt/a. The patterns of increase in the east and west ends of the plots were similar to those of the height increase. Since the increase in the number of leaves did not reduce the size of the leaves (visual observation), the area of photosynthesis increased. This was one of the main factors in growth improvement.

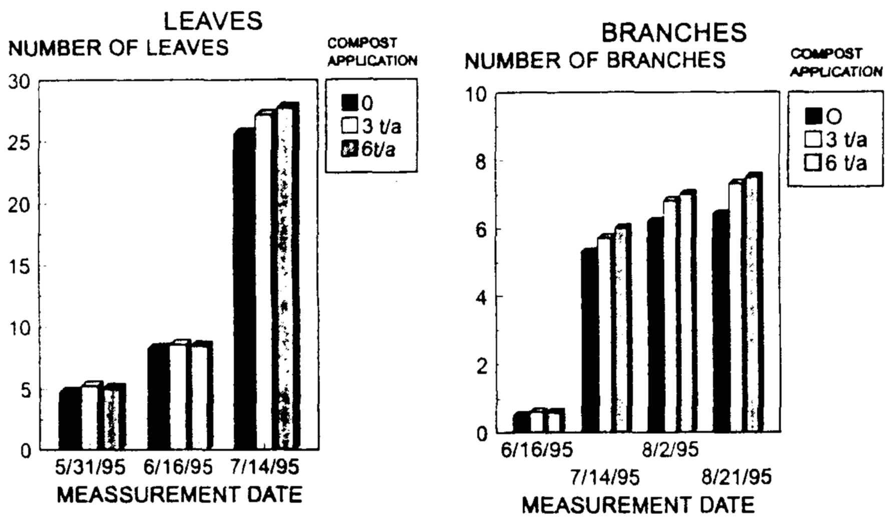


Figure 3. Effect of compost application on the number of leaves and branches on cotton.

Number and Length of Branches

Since the number and length of the branches might influence the number of flowers and the yield of crops, their measurements were included in this study. Both the number and length of the branches were increased by compost application. Figure 3 shows the increase in number of branches as a result of compost application. The percentage of increase in the number of branches for the compost application of 3 dt/a ranged from 7.5 to 20.0 percent, while the percentage of increase for the compost application of 6 dt/a ranged from 12.9 to 20.0 percent. The percentage of increase in the length of branches for the compost application of 3 dt/a ranged from 10.9 to 16.7 percent, while the percentage of increase for the compost application of 6 dt/a ranged from 11.9 to 17.6 percent. Again, the patterns of increase in the east and west ends of the plots were similar to those for number and height of leaves.

TABLE 2
Effect of Compost on Number of Buds*

Compost Rate (dt/a)	Collection Site	Number of Buds**	Percent Increase
0	east ends of plots	6.50	—
	west ends of plots	5.10	—
	entire plots	5.80	—
3	east ends of plots	7.40	13.8
	west ends of plots	5.30	3.9
	entire plots	6.35	9.5
6	east ends of plots	7.40	13.8
	west ends of plots	6.30	23.5
	entire plots	6.85	18.1

*Measurement date was 7/14/95.
**Each number is the average number of buds of 30 plants from each end and 60 plants from entire plots.

Effect of Compost on the Reproductive Parts of Cotton

Bud, Flower, and Boll Formation

Compost application enhanced the production of bud, flower, and boll formation. The percentage of increase in bud production was 9.5 percent for the compost application of 3 dt/a and 18.1 percent for the compost application of 6 dt/a (see Table 2).

Appearance of the flowers was also enhanced by compost application. The number of flowers increased by increasing the rate of compost application. Twice the number of flowers were found on the 3 dt/a plots as compared to the control, and three times as many flowers were found on the 6 dt/a compost plots as compared to the control. The percentage of increase in boll numbers ranged from 14.9 to 27.3 percent for the compost application rate of 3 dt/a and 17.0 to 45.4 percent for the compost application rate of 6 dt/a (see Table 3). Figure 4 shows the increase in the number of bolls as a result of compost application. The percentage of increase in early measurement dates is much larger than later dates, which indicates earlier boll production in compost-amended plots. Increase in boll formation due to compost application was greater in the west ends than the east ends of the plots.

Crop Yield

Compost increased the cotton yield significantly (see Table 4). The increase is probably the result of soil improvement and the nitrogen addition to the soil. The percentage of increase for the compost application of 3 dt/a was 24.4 percent, and the percentage of increase was 37.2 percent for the compost application rate of 6 dt/a. Again, the percentage of increase was greater in the west ends of the plots, while the total yield was higher in the east ends.

TABLE 3
Effect of Compost on Number of Bolls

Compost Rate (dt/a)	Measurement Date	Number of Bolls*	Percent Increase
0	7/14/95	1.1	—
	8/2/95	2.4	—
	8/21/95	4.7	—
3	7/14/95	1.4	27.3
	8/2/95	3.0	25.0
	8/21/95	5.4	14.9
6	7/14/95	1.6	45.4
	8/2/95	3.4	41.7
	8/21/95	5.5	17.0

*Each number is the average number of bolls of 60 plants from three plots (20 plants from each plot, 10 plants from the east ends and 10 plants from the west ends).

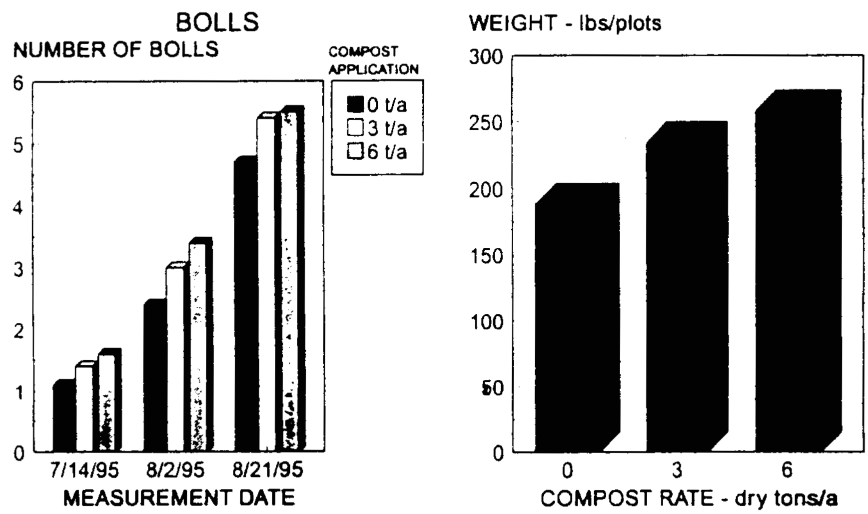


Figure 4. Number of cotton bolls and yield from 30 plots.

Effect of Compost on Water Retention of the Soil

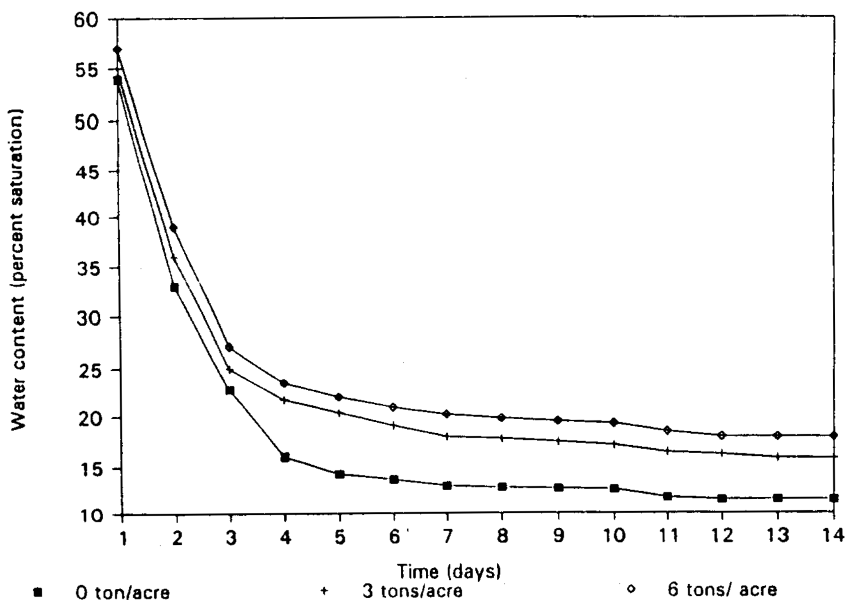
Most of the water loss from the soil took place a few days after saturation. For example, over 46 percent of the soil water was evaporated from the non-amended soil after 24 hours. This loss for soils amended with 3 dt/a and 6 dt/a of compost was 45 percent and 43.5 percent, respectively. The water savings in this case was 1.1 percent and 2.6 percent for the compost application rates of 3 dt/a and 6 dt/a, respectively. Fourteen days later, the savings were greater: 4.4 percent for the compost application rate of 3 dt/a and 6.8 percent for the compost application rate of 6 dt/a (see Figure 5). During periods of water stress, the increase in water content could significantly affect cotton yield.

TABLE 4
Effect of Compost on Cotton Yield*

Compost Rate (dt/a)	East Ends		West Ends		Entire Plots	
	Weight** (g)	% Increase	Weight** (g)	% Increase	Weight** (g)	% Increase
0	207		169		188	
3	246	18.8	223	31.9	234	24.4
6	258	24.6	258	52.6	258	37.2

*Measurement date was 11/30/95.
**Each number is the average weight of 15 plants from each end and 30 plants from entire plots.

FIG. 5: Compost effect on soil water content



SUMMARY

Compost application to cotton fields, even during the first year, showed an increase in plant growth and yield. This could be the result of both chemical and physical properties. The nitrogen, which was in an organic form, was released slowly over the growing season. This nitrogen supplemented the usual nitrogen provided through fertilization. Phosphorus and potassium were also increased. Compost contains micronutrients which could also have affected plant growth.

Normally, the beneficial effects of the organic matter from compost is not seen for two or more years. However, there was an increase in water content for both the 3 and 6 dt/a application rates. Compost improves soil's water retention and other physical properties, enhancing root proliferation and development. The manifestations of compost on the soil's chemical and physical properties undoubtedly enhanced cotton plant growth and yield.