Utilizing Compost as an Alternative Method to Standard Seedings: Final Report

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16. Abstract:
The research underlying this report consisted of an investigation designed to determine if the establishment of vegetation on Highway ROW could be improved by the application of compost as mulch compared to various traditional methods of protection. Conclusions drawn from examination of the evidence indicate that a layer of compost mulch greater than 2 inches adversely affected emergence and establishment of desired vegetation, whereas soil moisture retention was comparable on sub-plots treated with by straw mulch held in place by jute netting. Compost manufactured topsoil, or a 4-inch layer of compost mulch.

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UTILIZING COMPOST AS AN ALTERNATIVE METHOD TO STANDARD SEEDINGS: FINAL REPORT

by

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Research Report Number 0-4571

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IMPLEMENTATION STATEMENT

The investigation undertaken during TxDOT Project 0-4571 resulted in an accumulation of useful information. The potential for positive, usable future benefits from this project is high.

An implementation project could build on the foundation laid during TxDOT Project 0-4571, and should result in the development of cost-effective best management practices (BMP). The general approach could be similar to the approach used in reclamation of land disturbed by strip-mining, and can include compost treatments, topsoil replacement, site stabilization, seedbed preparation, plant selection, erosion mitigation practices, development and implementation of a suitable irrigation system, and refinement of best management practices.

The project should lead to the conclusion that one of the suggested compost treatments possesses the attributes needed to qualify it as a TxDOT recommended general-use treatment. Erosion mitigation and vegetation management BMP can be developed or modified to take advantage of the stability created by the selected treatment.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

Author's Disclaimer

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view of policies of the Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Patent Disclaimer

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new useful improvement thereof, or any variety of plant which is or may be patentable under the patent laws of the United States of America or any foreign country.

Engineering Disclaimer

Not intended for construction, bidding, or permit purposes.

Trade Names and Manufacturer's Names

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate

(Revised September 1993)

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CHAPTER I

INTRODUCTION

1.1 Texas Highway System

The state of Texas occupies about seven percent (267, 277 square miles) of the total water and land area of the United States. Texas is second in land area to Alaska, but is greater in combined land area than the ten states of Connecticut, Maine, Massachusetts, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, and Vermont combined (Figure 1.1). The greatest north-south distance (801 miles) is from the northwest corner of the Panhandle to the extreme southern tip of Texas near Brownsville, on the Rio Grande. The greatest east-west distance (773 miles) is from the extreme eastward bend of the Sabine River in Newton County to the extreme western bulge of the Rio Grande just above El Paso. The lowest points in Texas are at sea level, while the highest point in Texas is Guadalupe Peak (8749 feet) in Culberson County. The normal average annual precipitation in Texas ranges from 8.8 inches at El Paso to 58.3 inches at Orange (Texas Almanac, 2003).

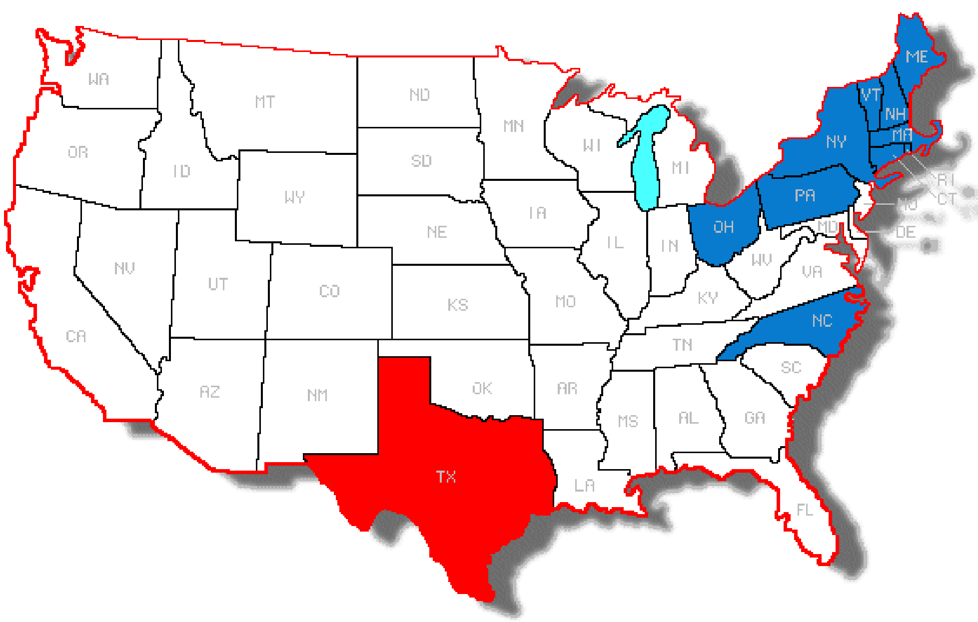


Figure 1.1 Map of the Contiguous Forty-Eight States Showing the Comparative Size of the State of Texas to Ten Other States

According to the Federal Highway Administration (FHWA), the state of Texas has 79,260 miles of agency owned public roads (FWHA, 2001). North Carolina, with 78,266 miles of roads and highways, is the only other state that maintains a comparable public highway network. In fact, the Texas highway system contains more miles of public roads than the combined total of agency owned roads in the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, and Vermont (FWHA, 2001). Table 1.1 presents a comparison and contrast of the number of miles of agency owned public roads between Texas and the ten states listed above.

Table 1.1 Comparison and Contrast of the Number of Miles of Roadway in the Texas Highway System With Ten Selected States

State	Total Rural Highway Miles	Total Urban Highway Miles	Total Agency Owned Public Roads
Texas	68,587	10,673	79,260
Connecticut	1,901	1,816	3,717
Maine	7,632	774	8,406
Massachusetts	1,209	1,641	2,850
New Hampshire	3,575	410	3,985
New York	11,009	4,017	15,026
North Carolina	69,069	9,197	78,266
Ohio	15,269	4,020	19,289
Pennsylvania	32,207	7,843	40,050
Rhode Island	267	902	1,169
Vermont	2,454	177	2,631
Total	213,179	41,470	254,649

1.2 Compost Use By State Departments of Transportation

The roadway, bridges, culverts, and related physical structures represent a huge capital outlay, and must be protected from damage resulting from wind and water erosion. In many instances, an unpaved buffer or right-of-way (ROW) ditch is included in the highway design.

Maintenance and upkeep of the unpaved buffer or ROW ditch is a key element in an overall strategy designed to protect the integrity of the roadway and related structures (Booze-Daniels et al. 2000). The unpaved ROW buffer allows storm water to infiltrate into the soil and serves as an open drainage channel for storm water runoff. Cross-section slope must not allow overland flow to erode the face of the ditch, longitudinal slopes must prevent open channel flow from exceeding the permissible velocity of the channel, and the vegetation selected must provide protection for the channel while allowing storm water flow to pass with a minimum of interference (Chow, 1959).

Empirical evidence collected by state departments of transportation (DOT) in Connecticut, Florida, Idaho, New Hampshire, Oregon, Texas, Virginia, and Washington indicates that compost is effective in erosion mitigation and vegetation establishment on highway ROW. The states of Oregon and Washington applied compost as a surface mulch; Connecticut, Florida, Idaho, New Hampshire, and Virginia used incorporation; Texas was used both incorporation and surface application (CCREF, 2002). Table 1.2 presents a summary of the projects, compost types, and application methods used by the selected state DOT.

Table 1.2 Compost Use By Selected State Departments of Transportation (Adapted from CCREF, 2002)

State	Type of Project	Type of Compost	Application Method
Connecticut	Landscape Plantings	Mushroom Substrate	Incorporation
	Wetlands Creation	Yard Trimmings	Incorporation
Florida	Turf Establishment	Biosolids & Yard Trimmings	Incorporation
		Biosolids & MSW	Incorporation
		Yard Trimmings (only)	Incorporation
Idaho	Vegetation Establishment	Dairy Manure	Incorporation
New Hampshire	Wildflower & Roadside Plantings	Recycled Organic Materials	Incorporation
Oregon	Erosion Control	Yard Trimmings	Surface
Texas	On Site Topsoil Mfg	Manure Compost	Incorporation
	Revegetating Difficult Slopes	Feedlot Manure/Cotton Burr/Wood Chips	Surface
Virginia	Wildflower Plantings	Yard Trimmings	Incorporation
Washington	Soil Bioengineering	Class A Biosolids	Surface

1.3 Overview of Experiment

The study compared and contrasted the effects of five different depths of compost mulch with five seeding methods specified by the Texas Department of Transportation (TxDOT). Soil temperature, soil moisture, and soil fertility parameters were examined during the study. The primary objective was to determine if broadcast seeding covered by compost mulch provided more benefits than TxDOT standard seeding methods with respect to the establishment of plants from a specified seed mix.

A review of scientific literature and field trials in three diverse geographical regions of the state of Texas defined the research component of this experiment. Physical evidence, visual observations, and laboratory analysis were combined with descriptive and inferential statistical methods to form the investigative component.

The investigative component of the study was defined by a randomized block split-plot experimental design. Ten treatments (replicated three times) were randomly assigned to either an irrigated or a non-irrigated main plot in each of three blocks. Field sites were located in Lubbock, Karnes, and Falls counties of Texas (Figure 1.2), representing the Southern High Plains, Blackland Prairies, and Northern Rio Grande Plain regions of the state (ESSC, 2003).

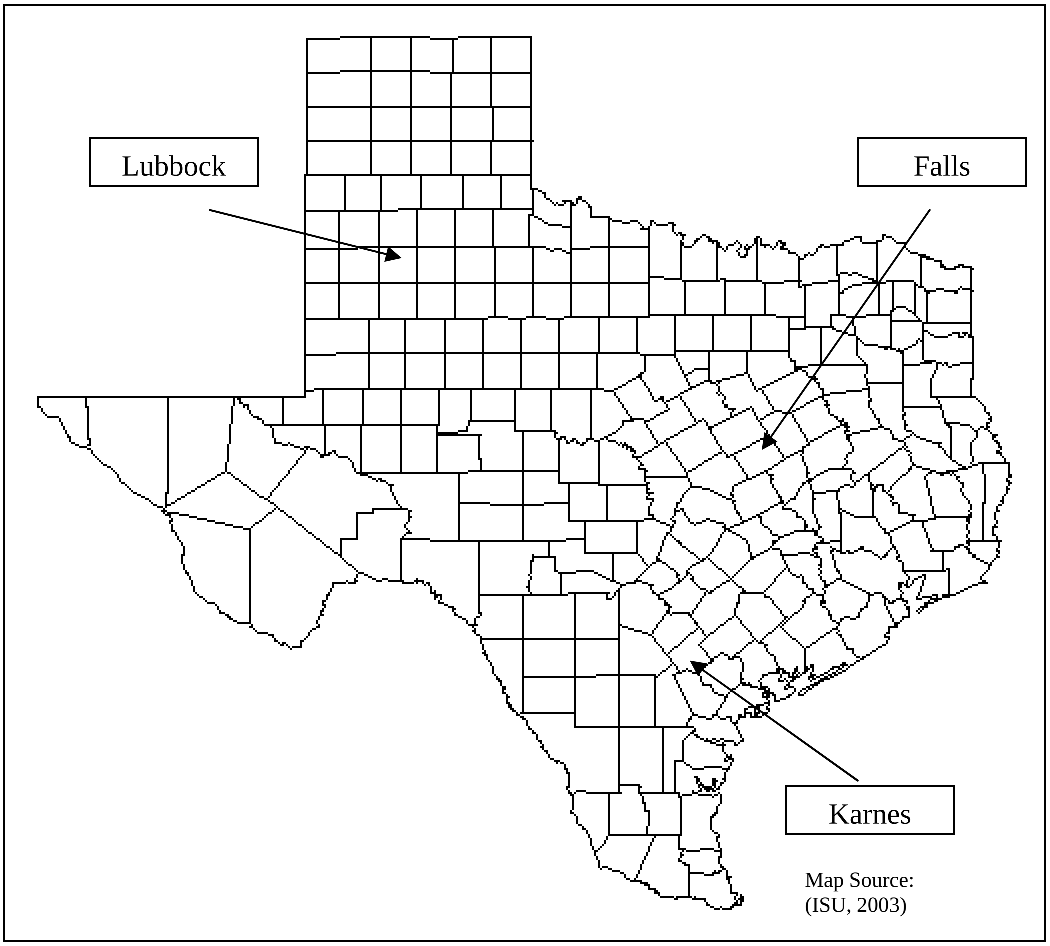


Figure 1.2 Counties in Which the Three Field Sites Were Located

CHAPTER II

LITERATURE REVIEW

2.1 Selected Sources of Organic Waste in the United States

The United States Environmental Protection Agency (EPA) estimated that 232 million tons (US) of municipal solid waste (MSW) was generated in the United States during the year 2000 (EPA, 2002). The organic fraction of the MSW stream consisted of approximately 87 million tons of paper and paperboard, 28 million tons of yard trimmings, 26 million tons of food waste, and 13 million tons of wood (EPA, 2002). Approximately 40 million tons of paper and paperboard and 0.5 million tons of wood were recovered and recycled, and 16 million tons of yard clippings and 0.7 million tons of food waste were recovered for composting (EPA, 2002).

The EPA (1999) estimated that 7 million tons of biosolids would result from treatment of drinking water and municipal wastewater in the year 2000. The amount of sludge or biosolids produced by a publicly owned treatment works (POTW) is dictated by the quality of an incoming drinking water source or the level of treatment required for a wastewater stream. The EPA classifies final disposition of biosolids as either disposal or beneficial use. Disposal of biosolids is accomplished by placement in a landfill, surface application to a specified land area, or incineration; beneficial use includes land application or advanced treatment (EPA, 1999).

According to the National Agricultural Statistics Service (NASS), approximately 17 million bales of cotton were produced in each of the crop years 1999 through 2002 (NASS, 2003). Depending on the harvesting and ginning equipment available, from 0.20 to 0.35 ton of residue (gin trash) results from processing one bale of cotton (Hilbers, 2003). If a typical cotton crop produces 17 million bales, then from 3.4 to 5.9 million tons of gin trash results.

The 1994 animal population summary (NRCS, 1995) showed that there were 89.6 million beef cattle, 13.7 million dairy cattle, 60 million swine, and 290.8 million laying chickens, 7,017.5 million broilers, and 289 million turkeys in the United States. The manure produced by such huge numbers of animals can cause environmental and ecological contamination if improperly managed (NRCS, 1995). Confined animal feeding operations (CAFO) such as beef feedlots, dairies, and swine and poultry feeding operations can be sources of groundwater, surface water, and air pollution (NRCS, 1995).

In a CAFO, inefficient consumers (Hayden, 2003) are provided with ample amounts of feed, which results in production of large quantities of manure. The NRCS (1995) estimates that on an as-excreted basis, one animal unit (AU) of beef, dairy, swine, layers, broilers, and turkeys produces 59.1, 80.0, 63.1, 60.5, 80.0, and 43.6 pounds of manure each day, respectively. An animal unit (AU) is a standard of comparison based on 1,000 pounds of livestock live weight (NEH, 1992) and is used for statistical reporting purposes in the United States. A 1,400-pound dairy cow, for example, equals 1.4 AU, but a 200-pound hog only equals 0.2 AU (NRCS, 1995). Table 2.1 presents an estimate of annual manure production for selected agricultural animals in the United States.

The total amount of manure produced and the recoverable quantity vary with the location of the facility, the area of confinement, and the methods used to collect the manure (NRCS, 1995). Table 2.2 presents an estimated mean manure recovery for animal manure in the United States. The recovery percentage used for each animal type shown in Table 2.2 is the mean of the recovery percents listed in *Animal Manure Management* (NRCS, 1995) for the West, South Central, South, East, Midwest, and Northern Plains regions of the United States.

Table 2.1 Estimated Manure Production for Selected Agricultural Animals[a]

Animal	Estimated Animal Weight (pounds)	Animals In One AU[b]	Population (millions)	Total AU (millions)	Manure Production (lb/AU/day)	Total Manure Production (million tons/year)
Beef	1,000	1	89.6	89.6	59	966
Dairy	1,400	1.4	13.7	19.2	80	280
Swine	200	5	60.0	12.0	63	138
Turkeys	15	67	289.0	4.3	44	34
Layers	5	200	290.8	1.4	60	16
Broilers	5	200	7,017.5	35.1	80	512
Total	n/a	n/a	n/a	n/a	n/a	1,946

[a] on an as excreted basis

[b] A standard of comparison based on 1,000 pounds of livestock live weight (NEH, 1992). A 1,400-pound dairy cow, for example, equals 1.4 AU, but a 200- pound hog only equals 0.2 AU (NRCS, 1995).

Table 2.2 Estimated Mean Manure Recovery for Selected Agricultural Animals[a]

Animal	Total Manure Production (million tons/year)	Mean Recovery Percent	Total Recoverable Manure (million tons/year)
Beef	966	80	773
Dairy	280	75	210
Swine	138	76	105
Turkeys	34	78	27
Layers	16	93	14
Broilers	512	93	513
Total	1,946	n/a	1,642

[a] on an as excreted basis

2.2 Selected Organic Waste in Texas

Approximately 0.45 million tons of biosolids was produced in the state of Texas in the year 1999. Disposal methods include land application (50%), landfilling (35%), surface disposal (3%), composting (9%), and other (3%) (Goldstein and Block, 1999). Texas cotton production for the crop years 1999 through 2002 averaged approximately 4.5 million bales per year (NASS, 2003), which generated approximately 1.1 million tons of organic waste products during each of the crop years.

Confined animal feeding operations in Texas house approximately 2.6 million head of beef (NASS, 2003a), 0.3 million dairy cows (NASS, 2003a), 0.9 million swine (NASS, 2003b), and 113.2 million chickens (NASS, 2003c). Annualized manure production from animals at CAFO in Texas is approximately 44.1 million tons. Table 2.3 presents a breakdown of manure production by animal type, and is based on NASS statistics for February, 2003.

Table 2.3. Estimated Manure Production for Selected Agricultural Animals in Texas[a]

Animal	Estimated Animal Weight (pounds)	Animals In One AU[b]	Population (millions)	Total AU (millions)	Manure Production (lb/AU/day)[c]	Total Manure Production (million tons/year)
Beef	1000	1	2.6	2.6	59.1	28.1
Dairy	1400	1.4	0.3	0.4	80.0	6.1
Swine	200	5	0.9	0.2	63.1	2.1
Layers	5	200	19.0	0.1	60.5	1.0
Broilers	5	200	94.2	0.5	80.0	6.9
Total	n/a	n/a	n/a	n/a	n/a	44.1

[a] on an as excreted basis

[b] A standard of comparison based on 1,000 pounds of livestock live weight (NEH, 1992). A 1,400-pound dairy cow, for example, equals 1.4 AU, but a 200-pound hog only equals 0.2 AU (NRCS, 1995).

[c] Animal Manure Management, *NRCS/RCA Issue Brief 7.* (NRCS, 1995)

2.3 Management of Organic Waste

The vast amount of organic waste generated in the State of Texas precludes landfilling or land application as viable waste management alternatives. Heavy metals and pathogens are of primary concern when dealing with biosolids (EPA, 1999). Air, soil, groundwater, and surface water contamination from high nitrogen and phosphorous concentrations are environmental hazards associated with operation of CAFO (Consumers Union, 2000; Muchovej and Rechcigl, 1995; NRCS, 1995; Withers and Sharpley, 1995).

The Texas Commission on Environmental Quality (TCEQ) and the Texas State Soil and Water Conservation Board (TSSWCB) recognized this fact, and initiated the Composted Manure Incentive Project in September 2000 (TCEQ, 2000). TCEQ entered into joint ventures with the Texas Department of Transportation (TxDOT) to use compost on landscaping and revegetation projects on Texas highway rights of way (TCEQ, 2000; McCoy and Cogburn, 2001). The Composted Manure Incentive Project includes provisions addressing the export of manure from the point of generation to other regions of Texas, development of guidelines designed to insure that compost is properly produced, issuance of permits for compost facilities, assistance in establishment of markets and their support, and identification of State projects on which compost can be effectively utilized (TCEQ, 2000).

2.4 Compost Use

Incorporation into the root zone, inclusion as a growing medium component, or application as mulch are the three ways compost is typically used (USCC, 1996), with the method of application varying with the requirements and stated objectives of each project. For example, the Connecticut DOT employed each of the three application methods in test projects designed to reduce erosion (incorporation), as a component in a soil mix for trees and shrubs (soil/compost mixture), and to improve turf establishment (incorporation and surface dressing) (ConnDEP, 2001). Persyn et al. (2002) concluded that application of compost blankets to selected Iowa highway embankments was effective in reducing runoff rates and interrill erosion rates. The results of a Federal Highway Administration (FWHA) study comparing the effectiveness of compost mulch to hydro mulch at a newly constructed intersection in suburban Washington DC (EPA, 1997), showed that areas treated with compost (only) outperformed areas treated with hydro mulch and areas treated with compost and fertilizer after six months. The Texas DOT has successfully utilized both incorporation and surface application of compost to establish vegetation and control erosion on highway ROW (McCoy and Cogburn, 2001).

Addition of organic matter, such as compost, to the soil improves the physical condition of the soil in relation to plant growth (Norland, 2002). Aggregates form more readily and are more stable, the bulk density of the soil is decreased, moisture holding capacity is increased, aeration is improved, water infiltrates at higher rates, the soil drains more rapidly, and cation exchange capacity is increased (Brady and Weil, 2002; EPA, 1997; Hill and James, 1995; Boyle et al., 1989).

Compost applied as mulch can increase nutrient concentrations and the organic matter content of a given soil. In a three-year study, soil under plots treated with a 4.0-inch layer of compost consisting of horse manure, bedding material, and sawdust had higher concentrations of selected nutrients and higher organic matter content than did plots treated with fabric, or no mulch (Feldman et al., 2000). Mean pH increased from 6.3 (before application of treatments) to 6.6 at the end of the study, and the average organic matter content increased from 3.3 lb/acre to 7.6 lb/acre.

Composts that have not been completely processed or matured may contain chemicals that are harmful or fatal to plants (Zucconi et al., 1981). A greenhouse study (Ozores-Hampton et al., 2002) found that both germination and the mean number of days to emergence of three weed species was either prevented or retarded when seeds were covered with mulch consisting of immature municipal solid waste-biosolids compost. In a study performed for the Iowa DOT, Richard et al., (2002) attributed reduced crop emergence in biosolids compost to persistence of phytotoxic compounds in the media. Phytotoxicity is typically associated with composts having high carbon/nitrogen ratios, with toxic concentrations of organic acids providing the principal toxic effect (Ozores-Hampton et al., 2002; Stratton et al., 1995).

Studies indicate that the thickness of a mulch layer can prevent emergence of various plant species. Feldman et al. (2000) stated that one of the benefits of compost mulch is its role as a weed suppressant. A 1.5-inch layer of biosolids-woodchip compost mulch laid over the soil surface suppressed weeds in a study conducted by Barker and O'Brien (1995), while Ozores-Hampton et al. (2002) found that common purslane (*Portulaca oleracea)*, large crabgrass (*Digitaria sanguinalis)*, pigweed *(Amaranthus retroflexus L.)*, Florida beggarweed (*Desmodium tortuosum)*, and dichondra (*Dichondra repens)* failed to germinate under a 4-inch layer of mature compost. Pearson (2002) found that a 1-inch layer of mature beef feedlot compost effectively suppressed Green Sprangletop (*Leptochloa dubia)* in a greenhouse study.

CHAPTER III

EXPERIMENTAL DESIGN

3.1 Field Sites

Personnel from the Texas Department of Transportation (TxDOT) and Texas Tech University (TTU) cooperated in the selection of field test sites in Lubbock, Falls, and Karnes Counties. The field sites were approximately 700 feet in length and were located on rural farm road ROW, between the clear zone adjacent to the roadway and the ROW fence or boundary. One rectangular test site consisting of three blocks was located within each of the field sites (Figure 3.1). Each block was 10 feet wide and 200 feet long. A buffer strip separated each block and each main plot.

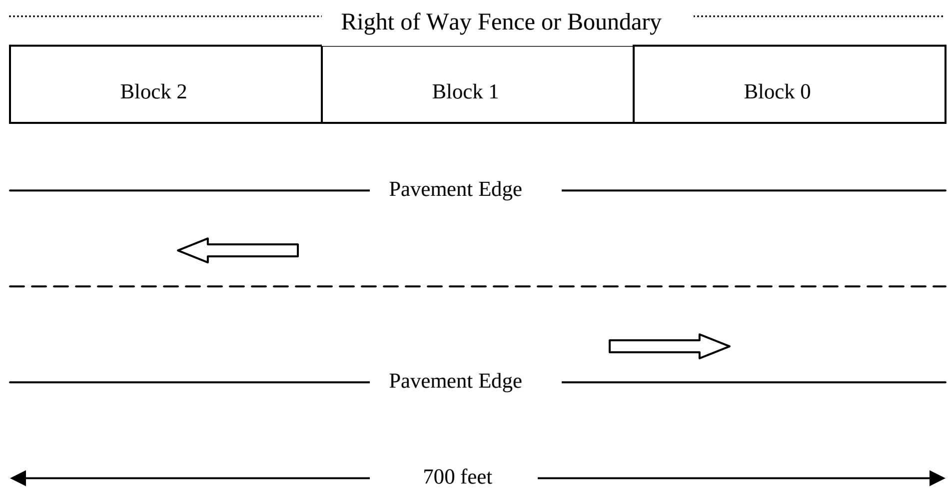
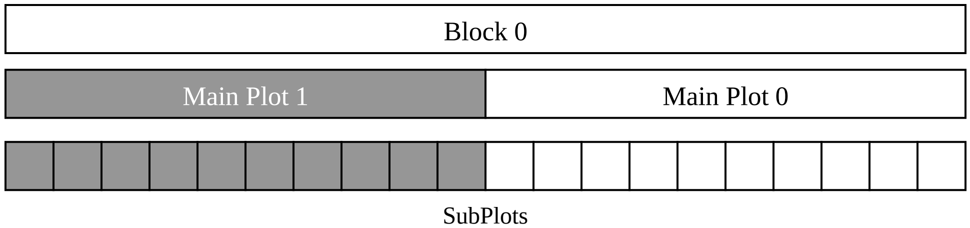


Figure 3.1 Illustration of Blocks Within a Field Test Site
(Drawing is not to scale)

The field sites provide information concerning the effects of supplemental irrigation versus no irrigation on ten different treatments, with each treatment being replicated three times. Five of the treatments represented standard seeding methods practiced by TxDOT and five treatments contained various compost seeding methods. Due to the number of factor combinations requiring evaluation, the Split-Plot Design (Little and Hills, 1972) was selected. Figure 3.2 illustrates the subdivisions for a selected block at a field site.



Note: Shaded main plots and sub-plots received supplemental irrigation.
Unshaded main plots and sub-plots did not receive supplemental irrigation.

Figure 3.2 Illustration of Subdivisions for One Block Within a Field Site

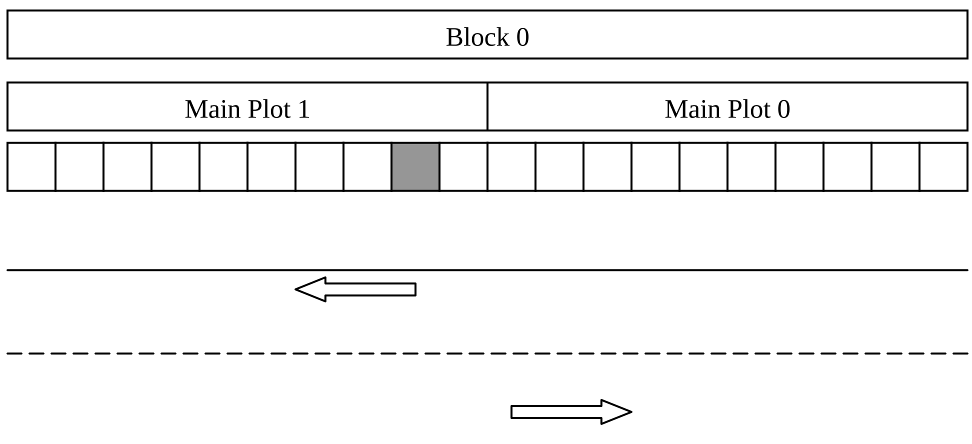
3.2 Experimental Design

The governing criterion for the experimental design was irrigation versus no irrigation. Sub-plots in one main plot of each block received supplemental irrigation in the amount of 0.5-inch per month, while the sub-plots in the other main plot of the same block did not. After the irrigation status of the two main plots within each block was determined, each of the ten treatments (Table 3.1) was randomly assigned to sub-plots within a main plot. Irrigation treatments and sub-plot treatments were assigned without regard for the field site at which the treatment would be applied. The final step in the assignment process was the random assignment of blocks to each of the three field sites. A random number table (Little and Hills, 1972) was used for all assignments.

Table 3.1 Sub-Plot Treatments

Treatment Identifier	Seeding Method	Sub-Plot Treatment Description
T0	Broadcast	No Surface Protection
T1	Broadcast	Soil Retention Blanket
T2	Broadcast	Straw Mulch-Soil Retention Blanket
T3	Broadcast	Cellulose Fiber Mulch
T4	Broadcast	Compost Manufactured Topsoil
T5	Broadcast	General Use Compost (0.25-inch layer)
T6	Broadcast	General Use Compost (0.50-inch layer)
T7	Broadcast	General Use Compost (1.00-inch layer)
T8	Broadcast	General Use Compost (2.00-inch layer)
T9	Broadcast	General Use Compost (4.00-inch layer)

A unique sub-plot reference number indicated the field site, block, main plot, irrigation treatment, sub-plot sequence number, and sub-plot treatment for each treatment plot. Figure 3.3 illustrates the coding for sub-plot 101017. Details of the experimental design and the sub-plot reference numbers for each field site are listed in Tables 3.2, 3.3, and 3.4.



1 = field site	FM 81, Karnes County, Texas
0 = block	Figure 3.1
1 = main plot	Figure 3.2
0 = irrigation status	0 = irrigated; 1 = not irrigated
1 = sub-plot sequence number	numbering is 0 through 9, from right to left
7 = sub-plot treatment	Table 3.1

Figure 3.3 Illustration of a Sub-Plot Reference Number

Table 3.2 Detailed Experimental Design for the Karnes County Field Site

Sub-Plot Reference Number	Field Test Site	Block	Main Plot	Irrigation 0 = Yes 1 = No	Sub-Plot	Sub-Plot Treatment	Sub-Plot Treatment Description
100107	1	0	0	1	0	7	General Use Compost (1.00-inch layer)
100118	1	0	0	1	1	8	General Use Compost (2.00-inch layer)
100122	1	0	0	1	2	2	Straw Mulch
100131	1	0	0	1	3	1	Soil Retention Blanket
100140	1	0	0	1	4	0	No Surface Protection
100153	1	0	0	1	5	3	Cellulose Fiber Mulch
100164	1	0	0	1	6	4	Compost Manufactured Topsoil
100175	1	0	0	1	7	5	General Use Compost (0.25-inch layer)
100189	1	0	0	1	8	9	General Use Compost (4.00-inch layer)
100196	1	0	0	1	9	6	General Use Compost (0.50-inch layer)
101001	1	0	1	0	0	1	Soil Retention Blanket
101017	1	0	1	0	1	7	General Use Compost (1.00-inch layer)
101024	1	0	1	0	2	4	Compost Manufactured Topsoil
101036	1	0	1	0	3	6	General Use Compost (0.50-inch layer)
101045	1	0	1	0	4	5	General Use Compost (0.25-inch layer)
101059	1	0	1	0	5	9	General Use Compost (4.00-inch layer)
101063	1	0	1	0	6	3	Cellulose Fiber Mulch
101078	1	0	1	0	7	8	General Use Compost (2.00-inch layer)
101082	1	0	1	0	8	2	Straw Mulch
101090	1	0	1	0	9	0	No Surface Protection
110109	1	1	0	1	0	9	General Use Compost (4.00-inch layer)
110114	1	1	0	1	1	4	Compost Manufactured Topsoil
110121	1	1	0	1	2	1	Soil Retention Blanket
110132	1	1	0	1	3	2	Straw Mulch
110140	1	1	0	1	4	0	No Surface Protection
110153	1	1	0	1	5	3	Cellulose Fiber Mulch
110166	1	1	0	1	6	6	General Use Compost (0.50-inch layer)
110177	1	1	0	1	7	7	General Use Compost (1.00-inch layer)
110188	1	1	0	1	8	8	General Use Compost (2.00-inch layer)
110195	1	1	0	1	9	5	General Use Compost (0.25-inch layer)
111003	1	1	1	0	0	3	Cellulose Fiber Mulch
111010	1	1	1	0	1	0	No Surface Protection
111025	1	1	1	0	2	5	General Use Compost (0.25-inch layer)
111036	1	1	1	0	3	6	General Use Compost (0.50-inch layer)
111042	1	1	1	0	4	2	Straw Mulch
111059	1	1	1	0	5	9	General Use Compost (4.00-inch layer)
111064	1	1	1	0	6	4	Compost Manufactured Topsoil
111077	1	1	1	0	7	7	General Use Compost (1.00-inch layer)
111081	1	1	1	0	8	1	Soil Retention Blanket
111098	1	1	1	0	9	8	General Use Compost (2.00-inch layer)
120107	1	2	0	1	0	7	General Use Compost (1.00-inch layer)
120116	1	2	0	1	1	6	General Use Compost (0.50-inch layer)
120128	1	2	0	1	2	8	General Use Compost (2.00-inch layer)
120135	1	2	0	1	3	5	General Use Compost (0.25-inch layer)
120149	1	2	0	1	4	9	General Use Compost (4.00-inch layer)
120151	1	2	0	1	5	1	Soil Retention Blanket
120163	1	2	0	1	6	3	Cellulose Fiber Mulch
120172	1	2	0	1	7	2	Straw Mulch
120184	1	2	0	1	8	4	Compost Manufactured Topsoil
120190	1	2	0	1	9	0	No Surface Protection
121002	1	2	1	0	0	2	Straw Mulch
121019	1	2	1	0	1	9	General Use Compost (4.00-inch layer)
121026	1	2	1	0	2	6	General Use Compost (0.50-inch layer)
121034	1	2	1	0	3	4	Compost Manufactured Topsoil
121040	1	2	1	0	4	0	No Surface Protection
121055	1	2	1	0	5	5	General Use Compost (0.25-inch layer)
121067	1	2	1	0	6	7	General Use Compost (1.00-inch layer)
121071	1	2	1	0	7	1	Soil Retention Blanket
121083	1	2	1	0	8	3	Cellulose Fiber Mulch
121098	1	2	1	0	9	8	General Use Compost (2.00-inch layer)

Table 3.3 Detailed Experimental Design for the Lubbock County Field Site

Sub-Plot Reference Number	Field Test Site	Block	Main Plot	Irrigation 0 = Yes 1 = No	Sub-Plot	Sub-Plot Treatment	Sub-Plot Treatment Description
200100	2	0	0	1	0	0	No Surface Protection
200112	2	0	0	1	1	2	Straw Mulch
200125	2	0	0	1	2	5	General Use Compost (0.25-inch layer)
200136	2	0	0	1	3	6	General Use Compost (0.50-inch layer)
200148	2	0	0	1	4	8	General Use Compost (2.00-inch layer)
200151	2	0	0	1	5	1	Soil Retention Blanket
200169	2	0	0	1	6	9	General Use Compost (4.00-inch layer)
200173	2	0	0	1	7	3	Cellulose Fiber Mulch
200187	2	0	0	1	8	7	General Use Compost (1.00-inch layer)
200194	2	0	0	1	9	4	Compost Manufactured Topsoil
201001	2	0	1	0	0	1	Soil Retention Blanket
201012	2	0	1	0	1	2	Straw Mulch
201023	2	0	1	0	2	3	Cellulose Fiber Mulch
201039	2	0	1	0	3	9	General Use Compost (4.00-inch layer)
201040	2	0	1	0	4	0	No Surface Protection
201055	2	0	1	0	5	5	General Use Compost (0.25-inch layer)
201066	2	0	1	0	6	6	General Use Compost (0.50-inch layer)
201077	2	0	1	0	7	7	General Use Compost (1.00-inch layer)
201088	2	0	1	0	8	8	General Use Compost (2.00-inch layer)
201094	2	0	1	0	9	4	Compost Manufactured Topsoil
210103	2	1	0	1	0	3	Cellulose Fiber Mulch
210119	2	1	0	1	1	9	General Use Compost (4.00-inch layer)
210126	2	1	0	1	2	6	General Use Compost (0.50-inch layer)
210134	2	1	0	1	3	4	Compost Manufactured Topsoil
210147	2	1	0	1	4	7	General Use Compost (1.00-inch layer)
210155	2	1	0	1	5	5	General Use Compost (0.25-inch layer)
210160	2	1	0	1	6	0	No Surface Protection
210171	2	1	0	1	7	1	Soil Retention Blanket
210188	2	1	0	1	8	8	General Use Compost (2.00-inch layer)
210192	2	1	0	1	9	2	Straw Mulch
211009	2	1	1	0	0	9	General Use Compost (4.00-inch layer)
211012	2	1	1	0	1	2	Straw Mulch
211020	2	1	1	0	2	0	No Surface Protection
211036	2	1	1	0	3	6	General Use Compost (0.50-inch layer)
211041	2	1	1	0	4	1	Soil Retention Blanket
211055	2	1	1	0	5	5	General Use Compost (0.25-inch layer)
211068	2	1	1	0	6	8	General Use Compost (2.00-inch layer)
211074	2	1	1	0	7	4	Compost Manufactured Topsoil
211083	2	1	1	0	8	3	Cellulose Fiber Mulch
211097	2	1	1	0	9	7	General Use Compost (1.00-inch layer)
220001	2	2	0	0	0	1	Soil Retention Blanket
220012	2	2	0	0	1	2	Straw Mulch
220026	2	2	0	0	2	6	General Use Compost (0.50-inch layer)
220035	2	2	0	0	3	5	General Use Compost (0.25-inch layer)
220047	2	2	0	0	4	7	General Use Compost (1.00-inch layer)
220054	2	2	0	0	5	4	Compost Manufactured Topsoil
220068	2	2	0	0	6	8	General Use Compost (2.00-inch layer)
220073	2	2	0	0	7	3	Cellulose Fiber Mulch
220080	2	2	0	0	8	0	No Surface Protection
220099	2	2	0	0	9	9	General Use Compost (4.00-inch layer)
221105	2	2	1	1	0	5	General Use Compost (0.25-inch layer)
221110	2	2	1	1	1	0	No Surface Protection
221121	2	2	1	1	2	1	Soil Retention Blanket
221132	2	2	1	1	3	2	Straw Mulch
221144	2	2	1	1	4	4	Compost Manufactured Topsoil
221157	2	2	1	1	5	7	General Use Compost (1.00-inch layer)
221166	2	2	1	1	6	6	General Use Compost (0.50-inch layer)
221178	2	2	1	1	7	8	General Use Compost (2.00-inch layer)
221183	2	2	1	1	8	3	Cellulose Fiber Mulch
221199	2	2	1	1	9	9	General Use Compost (4.00-inch layer)

Table 3.4 Detailed Experimental Design for the Falls County Field Site

Sub-Plot Reference Number	Field Test Site	Block	Main Plot	Irrigation 0 = Yes 1 = No	Sub-Plot	Sub-Plot Treatment	Sub-Plot Treatment Description
300005	3	0	0	0	0	5	General Use Compost (0.25-inch layer)
300018	3	0	0	0	1	8	General Use Compost (2.00-inch layer)
300026	3	0	0	0	2	6	General Use Compost (0.50-inch layer)
300030	3	0	0	0	3	0	No Surface Protection
300044	3	0	0	0	4	4	Compost Manufactured Topsoil
300051	3	0	0	0	5	1	Soil Retention Blanket
300069	3	0	0	0	6	9	General Use Compost (4.00-inch layer)
300073	3	0	0	0	7	3	Cellulose Fiber Mulch
300082	3	0	0	0	8	2	Straw Mulch
300097	3	0	0	0	9	7	General Use Compost (1.00-inch layer)
301100	3	0	1	1	0	0	No Surface Protection
301118	3	0	1	1	1	8	General Use Compost (2.00-inch layer)
301122	3	0	1	1	2	2	Straw Mulch
301136	3	0	1	1	3	6	General Use Compost (0.50-inch layer)
301149	3	0	1	1	4	9	General Use Compost (4.00-inch layer)
301153	3	0	1	1	5	3	Cellulose Fiber Mulch
301165	3	0	1	1	6	5	General Use Compost (0.25-inch layer)
301177	3	0	1	1	7	7	General Use Compost (1.00-inch layer)
301184	3	0	1	1	8	4	Compost Manufactured Topsoil
301191	3	0	1	1	9	1	Soil Retention Blanket
310003	3	1	0	0	0	3	Cellulose Fiber Mulch
310011	3	1	0	0	1	1	Soil Retention Blanket
310022	3	1	0	0	2	2	Straw Mulch
310030	3	1	0	0	3	0	No Surface Protection
310049	3	1	0	0	4	9	General Use Compost (4.00-inch layer)
310057	3	1	0	0	5	7	General Use Compost (1.00-inch layer)
310065	3	1	0	0	6	5	General Use Compost (0.25-inch layer)
310076	3	1	0	0	7	6	General Use Compost (0.50-inch layer)
310084	3	1	0	0	8	4	Compost Manufactured Topsoil
310098	3	1	0	0	9	8	General Use Compost (2.00-inch layer)
311105	3	1	1	1	0	5	General Use Compost (0.25-inch layer)
311112	3	1	1	1	1	2	Straw Mulch
311124	3	1	1	1	2	4	Compost Manufactured Topsoil
311130	3	1	1	1	3	0	No Surface Protection
311148	3	1	1	1	4	8	General Use Compost (2.00-inch layer)
311157	3	1	1	1	5	7	General Use Compost (1.00-inch layer)
311161	3	1	1	1	6	1	Soil Retention Blanket
311179	3	1	1	1	7	9	General Use Compost (4.00-inch layer)
311186	3	1	1	1	8	6	General Use Compost (0.50-inch layer)
311193	3	1	1	1	9	3	Cellulose Fiber Mulch
320109	3	2	0	1	0	9	General Use Compost (4.00-inch layer)
320118	3	2	0	1	1	8	General Use Compost (2.00-inch layer)
320123	3	2	0	1	2	3	Cellulose Fiber Mulch
320130	3	2	0	1	3	0	No Surface Protection
320142	3	2	0	1	4	2	Straw Mulch
320151	3	2	0	1	5	1	Soil Retention Blanket
320164	3	2	0	1	6	4	Compost Manufactured Topsoil
320176	3	2	0	1	7	6	General Use Compost (0.50-inch layer)
320187	3	2	0	1	8	7	General Use Compost (1.00-inch layer)
320195	3	2	0	1	9	5	General Use Compost (0.25-inch layer)
321008	3	2	1	0	0	8	General Use Compost (2.00-inch layer)
321017	3	2	1	0	1	7	General Use Compost (1.00-inch layer)
321026	3	2	1	0	2	6	General Use Compost (0.50-inch layer)
321034	3	2	1	0	3	4	Compost Manufactured Topsoil
321042	3	2	1	0	4	2	Straw Mulch
321050	3	2	1	0	5	0	No Surface Protection
321069	3	2	1	0	6	9	General Use Compost (4.00-inch layer)
321075	3	2	1	0	7	5	General Use Compost (0.25-inch layer)
321083	3	2	1	0	8	3	Cellulose Fiber Mulch
321091	3	2	1	0	9	1	Soil Retention Blanket

CHAPTER IV

MATERIALS AND METHODS

4.1 Field Site Preparation

Field test site preparation occurred during the period March 15 through March 19, 2003. The Lubbock County field site was prepared on March 15, the Karnes County field site on March 17, and the Falls County field site on March 18 and 19. Preparation of the Falls County field site was delayed due to a rainfall event. Approximately two weeks before site preparation, Roundup-Pro™ herbicide was applied to each field test site at a rate of 1 quart/acre in an attempt to kill existing vegetation.

Soil within each field test site was cultivated to a depth of 4 to 6 inches by a tractor-towed disk. The Lubbock County site was prepared with a tractor furnished by the Texas Tech University Civil Engineering Department, and a disk furnished by Western Implements, Lubbock, Texas. The South Texas Implement Company in Kenedy, Texas provided a John Deere tractor with a disk, front-end loader, and an equipment operator for preparation of the Karnes County site. The Texas Department of Criminal Justice, William P. Hobby Unit, provided a tractor with a disk, a tractor with a front-end loader, an operator for each piece of equipment, and a 10-person crew to assist with site preparation at the Falls County site.

When seedbed preparation was complete, a string line was stretched along the boundary of the field test site nearest to the right of way boundary. The three blocks, main plots, and buffer strips were laid out along the line and marked with color-coded survey stakes. A red stake indicated the beginning of a block, while a yellow stake indicated the beginning of a main plot. A 10-foot square PVC pipe template was used to mark each sub-plot. Survey stakes were driven in the ground at each corner to mark the boundary of each individual sub-plot. A unique six-digit number (Figure 3.3) and color-coding on the survey stake at the upper left corner identified each sub-plot. Blue-topped survey stakes indicated that the sub-plot was located in an irrigated main plot. White-topped survey stakes indicated sub-plots in a main plot that received no supplemental irrigation. Figure 4.1 presents an example of sub-plot boundary markers. Figure 4.2 shows a view of the Karnes County field site immediately following application of treatments on March 17, 2003.

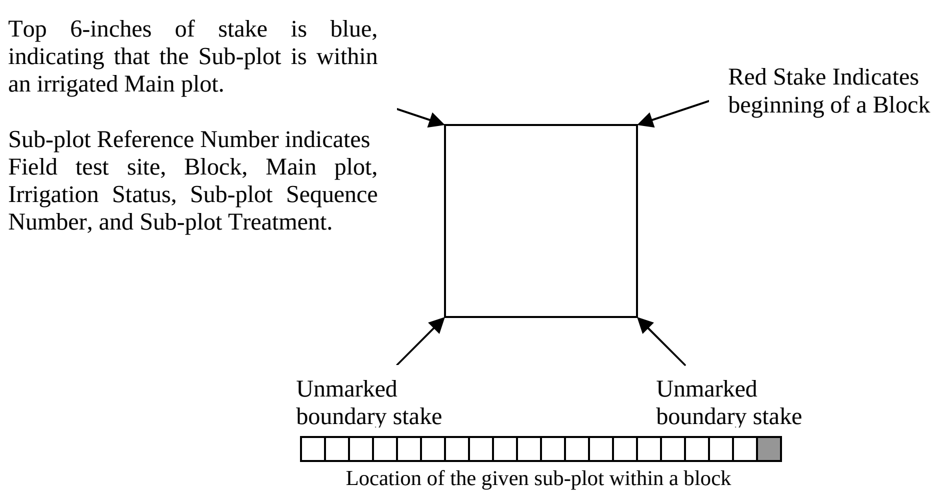


Figure 4.1 Illustration of Sub-Plot Boundary Markers.

Figure 4.2 The Karnes County Field Site Immediately Following Application of Treatments on March 17, 2003

Tractor-drawn mechanical planting devices are typically employed when seeding operations are performed on highway ROW, but the 100 ft^2 surface area of each sub-plot and the small quantity of seed required made mechanical seeding devices impractical for this project. Therefore, broadcast hand-seeding was selected as the most appropriate planting method.

Seed for each sub-plot was massed and placed in a numbered plastic bag at TTU. During site preparation, each sub-plot was individually hand-seeded, and then raked to insure seed-to-soil contact. A randomly selected treatment (Table 3.1) was applied to each sub-plot after broadcast seeding. Fertilizer (100 lb N /acre) was applied after the soil retention blanket, straw mulch, or cellulose fiber mulch had been placed. One-half inch of water was applied to randomly selected main plots after site preparation was complete.

Each treatment (Table 3.1) was applied to each of six randomly selected sub-plots at each field site. One replicate was located in the irrigated main plot and one in the non-irrigated main plot (Figure 3.2) of each of the three blocks (Figure 3.1). Seed were broadcast on all sub-plots, and each sub-plot was raked to assure seed-to-soil contact. Control sub-plots (T0) received no protective cover. Terrajute soil retention blanket (T1) was installed immediately after broadcast seeding, and was secured with 6-inch metal staples. The straw mulch-soil retention blanket treatment (T2) consisted of a layer of straw (2.5 tons/acre, TxDOT, 1993) held in place by a sheet of Terrajute soil retention blanket. American Fiber Mulch (recycled paper) (T3) was applied with a Model 300 Bowie Industries Hydromulcher provided by Bowie Industries, Inc., Bowie, TX (Figure 4.3). The hydromulch consisted of 4,000 gallons of water, 2,000 pounds of American Fiber Mulch (TxDOT, 1993), and 50 pounds of Hydro-Stik® tackifier. Compost manufactured topsoil (T4) was blended on site (TxDOT, 1993). After the site was disked to a depth of approximately four inches, a one-inch layer of compost (0.31 cubic yards) (USCC, 1996) was placed on the surface of selected sub-plots. The compost was tilled into the soil with a Honda rotary tiller. Compost was applied over the broadcast seed on sub-plots selected for treatment with either a 0.25-inch (T5), 50-inch (T6) 1.00-inch (T7), 2.00-inch (T8), or 4.00-inch (T9) layer of compost mulch.

Figure 4.3 Application of Cellulose Fiber Mulch at the Falls County Field Site

4.2 Seed Requirements

The Texas DOT requires a specific seed mix, seed quality, and seeding rate for clay soils or sandy soils in each TxDOT district (TxDOT, 1993). The permanent rural seed mix for sandy soils was used at the Lubbock County site, whereas the permanent rural seed mix for clay soils was used at the Karnes and Falls County sites. The three required seed mixes used in the field trial were purchased from Frontier Hybrids, Inc. in Abernathy, Texas, and conformed to requirements set by the Texas Seed Law (Frontier, 2003; TDA, 2000). Equation 4.1 was used to determine the quantity of bulk seed needed to achieve a specific pure live seeding rate. Tables 4.1, 4.2, and 4.3 present the species, the seeding rate, and the bulk seed needed to plant one acre. Table 4.4 shows the amount of bulk seed required for one sub-plot at each field site.

$$B = R / P \tag{4.1}$$

where,

B = Bulk seed in pounds/acre
R = Seeding rate (Pure Live Seed (PLS)/ acre)
P = Purity of the bulk seed (percent)

Table 4.1 Permanent Rural Seed Mix for Sandy Soils (Lubbock County, Texas)

Species	Seeding Rate (PLS/acre)	Pure Live Seed (Percent of Bulk Seed)	Bulk Seed Required (lb/acre)
Green Sprangletop	0.3	88.97	0.34
Weeping Lovegrass (Ermelo)	0.8	87.87	0.91
Blue Grama (Hachita)	1.0	71.39	1.40
Sand Dropseed	0.3	84.25	0.36
Sand Bluestem	1.8	80.37	2.24
Purple Prairieclover	0.5	82.14	0.61
Total	4.7	n/a	5.86

Table 4.2 Permanent Rural Seed Mix for Clay Soils (Karnes County, Texas).

Species	Seeding Rate (PLS/acre)	Pure Live Seed (Percent of Bulk Seed)	Bulk Seed Required (lb/acre)
Green Sprangletop	0.3	88.97	0.34
Sideoats Grama (Haskell)	2.7	75.89	3.56
Bermudagrass	1.8	83.30	2.16
Buffalograss (Texoka)	1.6	89.92	1.78
Plains Bristlegrass	1.2	80.86	1.48
Illinois Bundleflower	1.0	94.97	1.05
Total	8.6	n/a	10.37

Table 4.3 Permanent Rural Seed Mix for Clay Soils (Falls County, Texas)

Species	Seeding Rate (PLS/acre)	Pure Live Seed (Percent of Bulk Seed)	Bulk Seed Required (lb/acre)
Green Sprangletop	0.3	88.97	0.34
Bermudagrass	1.2	83.30	1.44
Sideoats Grama (Haskell)	3.6	75.89	4.74
Little Bluestem (Native)	2.0	69.98	2.86
Illinois Bundleflower	1.0	94.97	1.05
Total	8.1	n/a	10.43

Table 4.4 Bulk Seed Required for Each Sub-Plot

Field Site Location	Bulk Seed Required (lb/sub-plot)
Lubbock County	0.0135
Karnes County	0.0238
Falls County	0.0239

4.3 Compost

Cotton burr compost was applied at the Lubbock County site, biosolids compost was applied at the Karnes County site, and dairy cattle compost was applied at the Falls County site. The cotton burr compost was produced in Lubbock County, the biosolid compost (from San Antonio Municipal Wastewater Treatment Plant sludge) was produced in Bexar County, and the dairy manure compost was produced in Erath County. Table 4.5 presents selected constituents for the composts used in the study.

Table 4.5 Selected Constituents of Compost Applied at Field Test Sites

Field Test Site (County)	N Dry Basis (%)	P Dry Basis (%)	K Dry Basis (%)	Ca Dry Basis (%)	Mg Dry Basis (%)	Na (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	H_2O (%)
Lubbock	1.64	0.28	3.17	2.29	0.52	1927	46	267	9	120	19.4
Karnes	1.07	1.42	0.44	3.68	0.18	1741	444	692	223	148	56.2
Falls	0.46	0.33	1.33	3.27	0.26	2342	88	309	29	155	23.8

Equation 4.2 (USCC, 1996) was used to determine the volume of compost needed to cover a 100 square foot area to a specified depth. Table 4.6 shows the volume of compost required for each application depth. A plastic pail having capacity of approximately 0.03 yd^3 was determined to be the most suitable container for measuring compost in the field. Table 4.7 shows the number of pails of compost required for each application depth. Figure 4.4 shows the application of compost at the Falls County field site.

$$V = 0.0031DA \tag{4.2}$$

where,

V = Volume of compost in cubic yards
D = Depth of compost layer in inches
A = Area of one Sub-plot (100 square feet)

Table 4.6 Compost Requirement in Cubic Yards for Each Application Depth

Surface Area of One Sub-plot (Square Feet)	Application Depth (Inches)	Compost Requirement (Cubic Yards)
100	0.25	0.08
100	0.50	0.16
100	1.00	0.31
100	2.00	0.62
100	4.00	1.24

Table 4.7 Five-Gallon Pails of Compost Required for Each Application Depth

Surface Area of One Sub-plot (Square Feet)	Application Depth (Inches)	Compost Requirement (5-gallon pails)
100	0.25	3
100	0.50	6
100	1.00	11
100	2.00	22
100	4.00	45

Figure 4.4 Compost Application at the Falls County Field Site

4.4 Supplemental Fertilizer

Scott's *Turfbuilder®* lawn fertilizer having a guaranteed analysis of 27% total nitrogen (TN), 3% available phosphate (P_2O_5), 4% soluble potash (K_2O), 8% sulfur (S), 2% iron (Fe), and 1% manganese (Mn) was applied to sub-plots treated with the soil retention blanket (T1), straw mulch (T2), and cellulose fiber mulch (T3). Fertilizer was applied at a rate of 100 pounds of nitrogen per acre after the soil retention blanket, straw mulch, or cellulose fiber mulch had been placed. Phosphorus, potassium, iron, and manganese were applied at rates of 11.1 lb/acre, 14.8 lb/acre, 7.4 lb/acre, and 3.7 lb/acre, respectively. Equation 4.3 was used to determine the amount of bulk fertilizer (0.85 pounds) required to achieve the100 lb N/acre application rate. Equation 4.3 was rearranged (Equation 4.4) to find the application rate for phosphorus, potassium, and iron.

$$F = AR/43560N \quad (4.3)$$

where,

F = bulk fertilizer (pounds) required for one sub-plot
A = area of one Sub-plot (100 square feet)
N = nitrogen concentration (27%) in the bulk fertilizer
R = nitrogen application rate (100 lb/acre)
43560 = square feet in one acre

$$R = 43560XF/A \quad (4.4)$$

where,

F = bulk fertilizer (0.85 pound) required for one sub-plot
A = area of one Sub-plot (100 square feet)
X = constituent concentration (%) in the bulk fertilizer
R = constituent application rate (lb/acre)
43560 = square feet in one acre

4.5 Supplemental Irrigation

Three randomly selected main plots at each field site received supplemental irrigation, whereas the other three main plots at each field site did not. One-half inch of supplemental water was applied to the selected main plots at three specified times during the experiment. Table 4.8 shows the irrigation schedule for each of the field test sites. Irrigation was applied using a portable system consisting of a trailer-mounted 1,025-gallon water supply tank, flexible suction and discharge hoses, flow meter, pressure gage, Honda P205 pump, schedule 40 PVC pipe and fittings, and Hunter A10 adjustable sprinkler heads. The system was designed to apply approximately 15 gallons per minute at 30 psi to a 10 foot x 100 foot rectangle. An irrigation depth of 0.5-inch for one irrigated main plot required 313 gallons. Figure 4.5 presents a diagram of the components of the portable irrigation system, Figure 4.6 presents a diagram of the sprinkler layout, and Figure 4.7 shows the portable irrigation system and an irrigation event at the Karnes County field site.

Table 4.8. Supplemental Irrigation Schedule for the Field Sites

Date	Experiment Day	Field Site	County
03/15/2003	00	FM 3020	Lubbock
03/17/2003	02	FM 81	Karnes
03/19/2003	04	FM 712	Falls
04/17/2003	33	FM 3020	Lubbock
04/18/2003	34	FM 81	Karnes
04/19/2003	35	FM 712	Falls
05/19/2003	65	FM 3020	Lubbock
05/20/2003	66	FM 81	Karnes
05/21/2003	67	FM 712	Falls

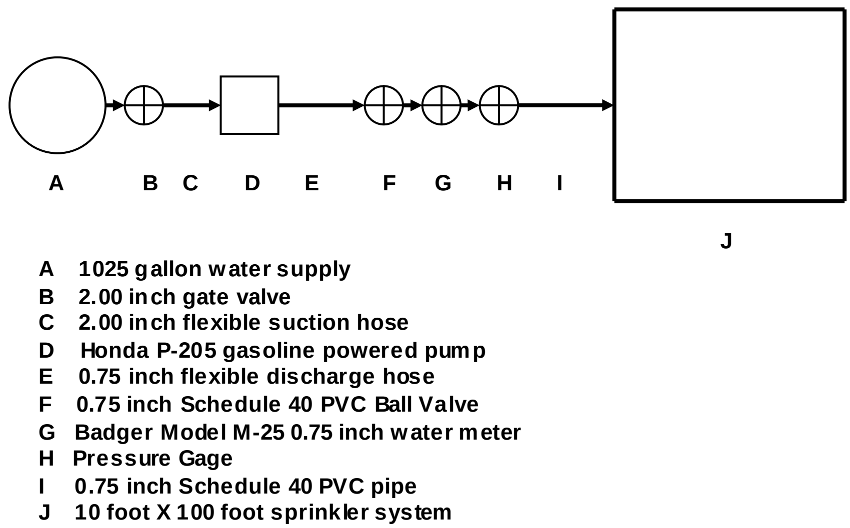


Figure 4.5 Components of the Portable Irrigation System

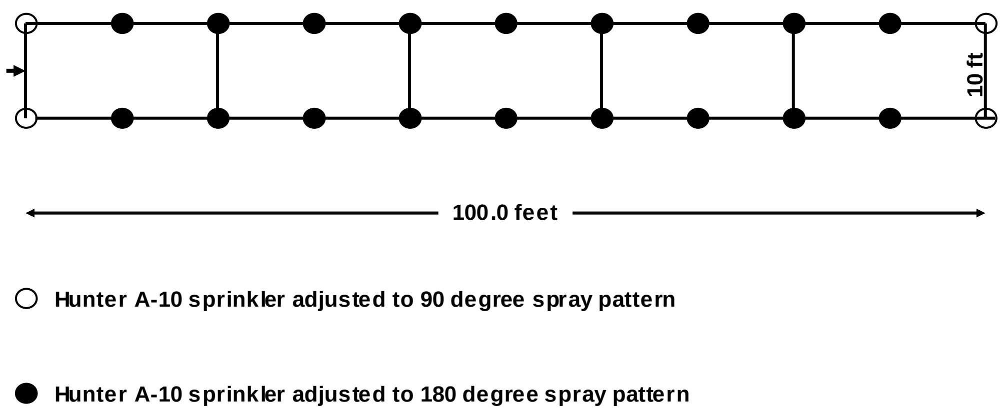


Figure 4.6 Portable Sprinkler System Layout

Figure 4.7 Photographs of the Portable Irrigation System Equipment (top) and an Irrigation Event (bottom) at the Karnes County Field Site

Four tests were performed to determine the effective coverage of the portable sprinkler system used in the field trial. A different 10-ft x 10-ft section of the irrigation system was arbitrarily selected and divided into 100 1ft x 1ft squares at the beginning of each sprinkler test. One 16-ounce plastic cup, weighted with small stones for stability, was placed in the center of each square (Figure 4.8).

Each sprinkler test consisted of applying 0.5-inch of water to the 10-foot by 100-foot rectangle covered by the portable sprinkler system (Figure 4.6). At the end of each test, irrigation water collected in each plastic cup was poured into a graduated cylinder and the volume was recorded.

Christiansen's Uniformity Coefficient (UCC) (Karmeli et al., 1978) was used to determine the efficiency of the portable irrigation system at the end of each of the four tests. Equation 4.5 was used to compute UCC of 72, 75, 76 and 76 for the four tests. A UCC of 70 or higher is adequate for agricultural use (Karmeli et al., 1978).

$$UCC = \{1 - [\sum | X_i - X_{bar} | / n^* X_{bar}] \} * 100 \qquad (4.5)$$

where,

UCC = Christiansen's Uniformity Coefficient (%)
X_i = the ith single observation depth measured (inches)
X_{bar} = the mean of all the individual observations (inches)
n = the total number of observations

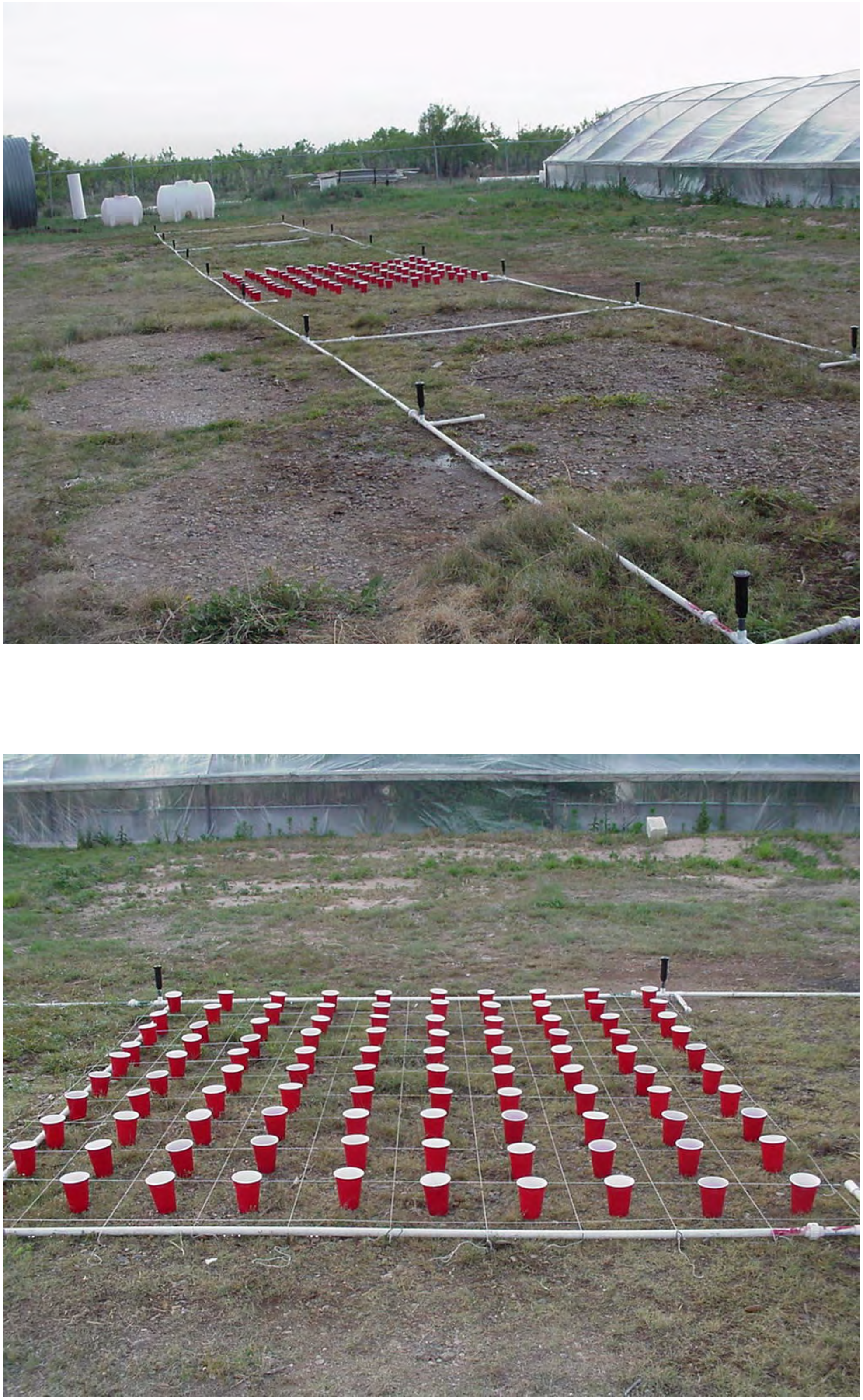


Figure 4.8 A 10 ft x 10 ft Irrigation System Test Section Used for Obtaining Christiansen's Uniformity Coefficient (UCC)

4.6 Soil Characterization

County soil surveys prepared by the United States Department of Agriculture (USDA) were consulted for information regarding soil types at each of the Field test sites. The Lubbock County site was located in an area consisting of Amarillo Fine Sandy Loam (0 to 1% slope), with a soil pH range of from 6.0 to 7.8 (USDA, 1979). The Karnes County site was located in an area consisting of Coy Clay Loam (1 to 3% slope), with a soil pH range from 7.9 to 8.4 (USDA, 2000). The Falls County site was located in an area consisting of Weswood Silt Clay Loam (0 to 1% slope), with a soil pH range of from 7.9 to 8.4 (USDA, 1978).

The ROW at the Lubbock County and Karnes County field sites had been recently disturbed as a result of pipeline construction, whereas the soil at the Falls County site had been disturbed as a result of road construction. Because the soil at each field test site was drastically disturbed (Booze-Daniels et al., 2000), no specific soil classification was assumed. Textural classification (Table 4.9) for soil at each of the field test sites was determined at the Soil, Water and Forage Lab at TAMU.

Table 4.9 Textural Classification for Soil at the Three Field Sites

County	Location	Sand (%)	Silt (%)	Clay (%)	Textural Class
Lubbock	FM 3020, 0.1 mile west of the intersection with FM 835	54	22	24	Sandy Clay Loam
Karnes	FM 81, 5.4 miles south of Runge	40	20	40	Clay Loam
Falls	FM 712, 0.3 mile west of the Brazos River Bridge	38	28	34	Clay Loam

When an irrigation or rainfall event occurs, water enters the soil matrix through the surface and is moved downward through the profile by gravity. The rate at which water is able to move into a given soil is governed by the structure of the soil, soil texture, soil chemistry, water chemistry, and water temperature (Fedler and Borrelli, 2001). The characteristics presented above collectively define the hydraulic conductivity of a soil, which is an estimate of the ability of a given soil to accept water. Hydraulic conductivity is a flux, which is determined by the rate at which water covering a unit area moves downward into the soil profile. Hydraulic conductivity is typically reported in units of length per unit time (inches/hour, centimeters/hour, or meters/second).

Water infiltrates into a given soil most efficiently when the pore space of that soil is filled with water, and when an infinitely thin layer of water ponds on the surface of the soil (Chow et al., 1988). Under ideal conditions for movement of water into a soil, the base intake rate is quantified as the saturated hydraulic conductivity of that soil (Karmeli et al., 1978). In 1982, Rawls et al. compiled a set of relationships for predicting water retention volume for particular tensions and saturated hydraulic conductivities based on soil properties for 11 USDA soil texture classes. Saxton et al. (1986) developed a method for estimating saturated hydraulic conductivity, which was based on soil texture. If the sand and clay fractions are known, then Equation 4.6 can be used to find the water content at saturation.

$$\Theta = 0.332 - 7.251E\text{-}4(\%\ sand) + 0.1276\ \log_{10}(\%clay) \quad (4.6)$$

where,

Θ = soil moisture content, (ft^3/ft^3)
sand = percent of sand in the soil (percent)
clay = percent of clay in the soil (percent)

Equation 4.7 estimates the saturated hydraulic conductivity in inches/hour. Table 4.10 presents the estimated soil moisture content and estimated hydraulic conductivity for the soils at the three field test sites.

$$K = 0.3937\{\exp\ [A + (B / \Theta)]\} \quad (4.7)$$

where,

A = 12.012 – 0.0755(sand)
B = -3.8950 + 0.03671(sand) – 0.1103(clay) + 8.7546E-4$(clay)^2$
K = saturated hydraulic conductivity, (in/hr)
Θ = soil moisture content, (ft^3/ft^3)
sand = percentage of sand in the soil (percent)
clay = percentage of clay in the soil (percent)

Table 4.10 Estimated Saturated Soil Moisture and Hydraulic Conductivity at the Three Field Test Sites

County	Textural Class	Sand (%)	Silt (%)	Clay (%)	Estimated Soil Moisture Content (ft^3/ft^3)	Estimated Hydraulic Conductivity (in/hr)
Lubbock	Sandy Clay Loam	54	22	24	0.4690	0.19
Karnes	Clay Loam	40	20	40	0.5074	0.07
Falls	Clay Loam	38	28	34	0.4999	0.10

Soil samples were collected on March 15 and June 23, 2003 at the Lubbock County site, on April 18 and June 24, 2003 at the Karnes County site, and on April 19 and June 25, 2003 at the Falls County site. The purpose of the soil sampling was to determine if treatment application caused changes in selected macronutrients, micronutrients, salinity, electrical conductivity, and pH over the life of the experiment. Soil Samples were analyzed for pH, nitrate-nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, zinc, iron, copper, manganese, boron, salinity, and electrical conductivity. Table 4.11 presents the routine soil fertility analysis before treatments were applied. Table 4.12 presents a detailed salinity analysis for each field site before treatment application.

Collection of soil samples from the FM 81 and the FM 712 field test sites was delayed because Karnes and Falls Counties of Texas are located within a USDA Regulated Area (USDA, 2002). The red imported fire ant (*Solenopsis invicta Buren)* is the invading species of concern for the USDA (2002), and the spread of Broomrape (*Orobanche ramosa*) is of concern to the Texas Department of Agriculture (Bhatkar, 2003; Chandler, 2003).

After confirming that the Soil, Water and Forage Lab at Texas A&M University (TAMU) was authorized to accept soil samples from any county in the State of Texas (Provin, 2003), Texas Tech researchers established a procedure designed to minimize the possibility of spreading the species of concern to other areas of the state. Equipment used at the Karnes County site was power washed in Karnes City after each site visit. Before returning to Lubbock, equipment used at the Falls County site was power washed in Marlin. Soil samples collected at the Karnes and Falls County sites were placed in sealed metal containers for transport to the Soil, Water and Forage Lab at TAMU.

Table 4.11 Routine Fertility Analyses for Each Field Site Prior to Treatment Application[a]

Field Site	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Lubbock	8.5	12	56	432	31883	1047	52	4	4	0.63	0.54	0.34	399
Karnes	8.1	14	37	793	52380	422	71	15	19	1.07	0.93	0.87	273
Falls	7.9	18	86	461	19580	407	49	12	23	0.83	1.50	0.75	210

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

Table 4.12 Detailed Salinity Analyses for Each Field Site Prior to Treatment Application[a,b]

Field Site	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Lubbock	8.1	0.796	4.65	0.35	1.86	0.41	4.4	64
Karnes	7.6	0.836	1.51	0.63	10.38	0.77	0.6	11
Falls	7.8	0.821	1.73	0.46	9.81	1.18	0.8	13

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

[b] The detailed salinity test is performed using a saturated paste extract

4.7 Soil Moisture

A typical soil consists of solid, liquid, and gaseous components. The solid components are particles of sand, silt, and clay mixed with organic matter, and represent approximately one-half the volume of a given amount of bulk soil. Since individual particles and larger aggregates do not fit perfectly together, spaces exist within the soil matrix. The spaces are known as soil pores, and make up the other half of the soil matrix. Water and air fill the pore spaces in varying percentages, completing a dynamic system. For example, a saturated soil contains soil particles, organic matter, and water, while a dehydrated soil contains only soil particles, organic matter, and air. The saturated soil has a volumetric water content (VWC) of from 40 to 60% (Hillel, 1998), which means that the soil is at maximum water holding capacity. Conversely, a dehydrated soil has a VWC of 0%. Figure 4.9 illustrates an idealized volume composition of a loam surface soil when conditions are good for plant growth. A Field Scout™ TDR 300 Soil Moisture Meter manufactured by Spectrum Technologies, Inc., Plainfield, IL was used to obtain VWC readings during the field trial. The TDR 300 was fitted with two parallel 8-inch wave guides spaced 1.97 inches apart, and was accurate to plus or minus 3% VWC at electrical conductivity of less than 2mS/cm (Spectrum, 2003).

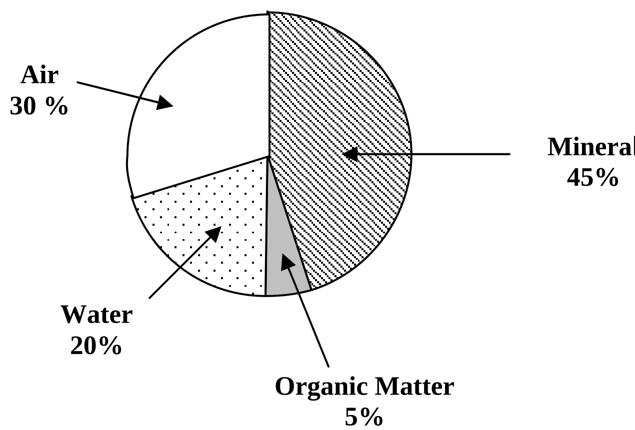


Figure 4.9 Idealized Volume Composition of a Loam Soil
(Adapted from Brady and Weil, 2002, page 17)

A tipping bucket rain collector was installed at each field site during initial site preparation. The rain gage conformed to guidelines established by the World Meteorological Organization, and was accurate to plus or minus 2% (Spectrum, 2003). The rain gage at the Falls County field site was damaged during the period June 5 to June 24, 2003; therefore precipitation recorded by the National Weather Service at Waco, Texas (NOAA, 2003) was used to estimate rainfall at the Falls county field site for that period. Cumulative rainfall and supplemental irrigation for the Lubbock, Karnes, and Falls County sites are shown in Figures 4.10, 4.11, and 4.12, respectively. Figure 4.13 presents the total amount of moisture received at each site during the field trial (March 15 through June 25, 2003).

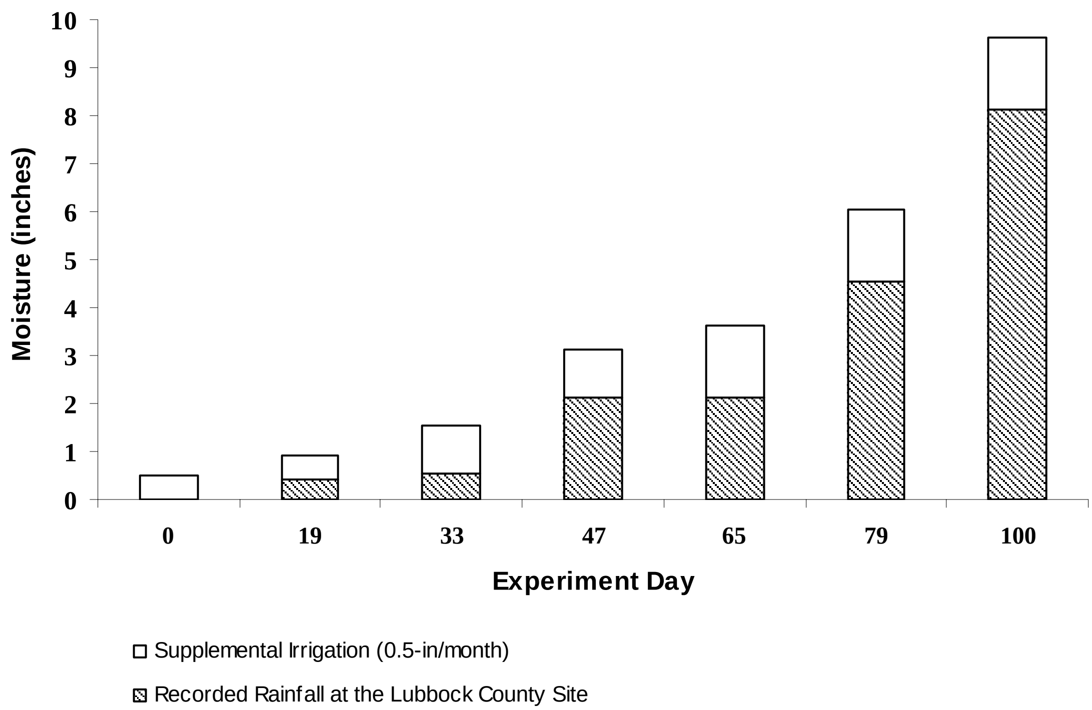


Figure 4.10 Cumulative Rainfall and Irrigation at the Lubbock County Field Site

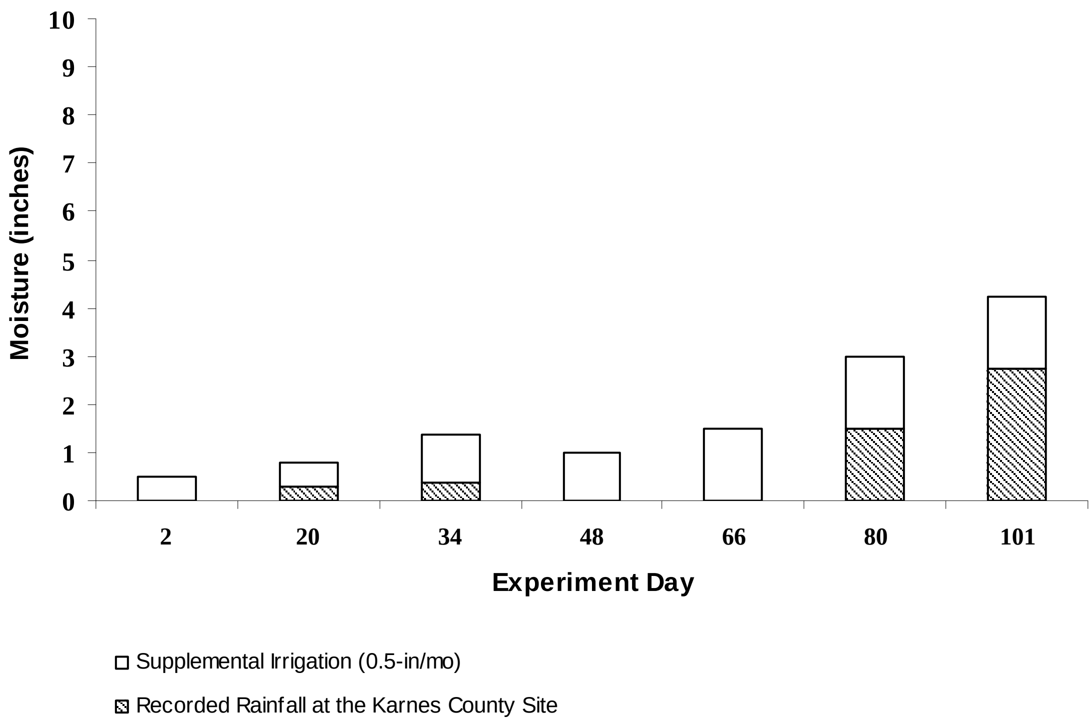
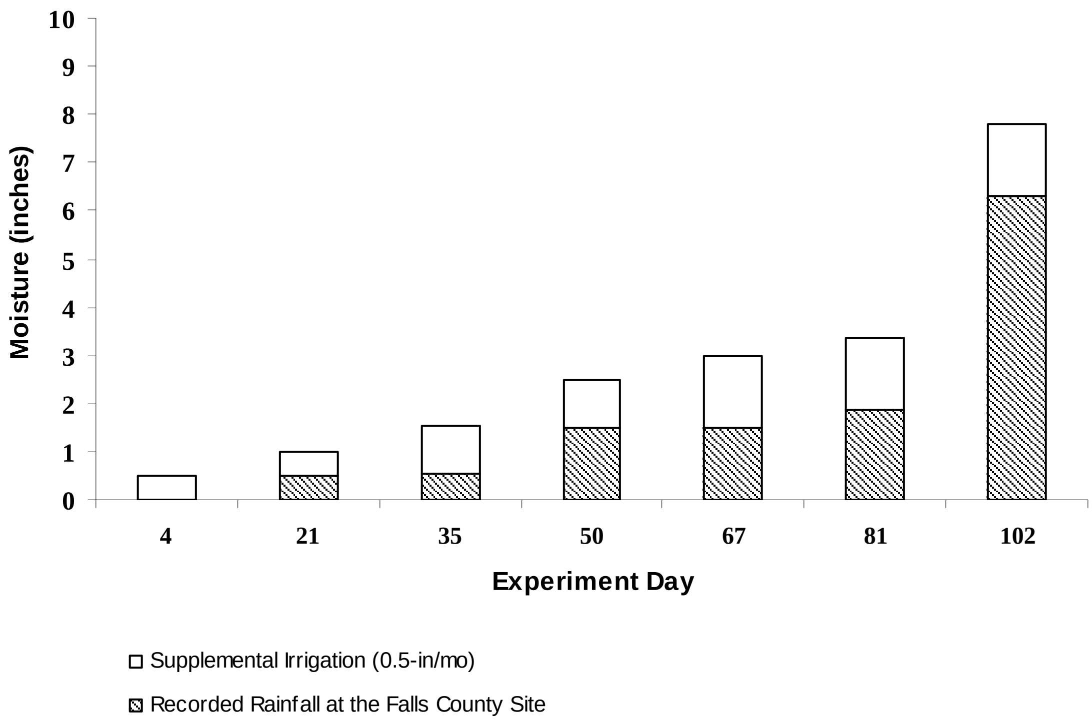


Figure 4.11 Cumulative Rainfall and Irrigation at the Karnes County Field Site



Note: The rain gage at the Falls County Site was damaged after the field visit on Day 81. Rainfall for Days 82 through 102 was estimated from *Preliminary Local Climatological Data for Waco, TX* (WS Form F-6) for June, 2003 (NOAA, 2003).

Figure 4.12 Cumulative Rainfall and Irrigation at the Falls County Field Site

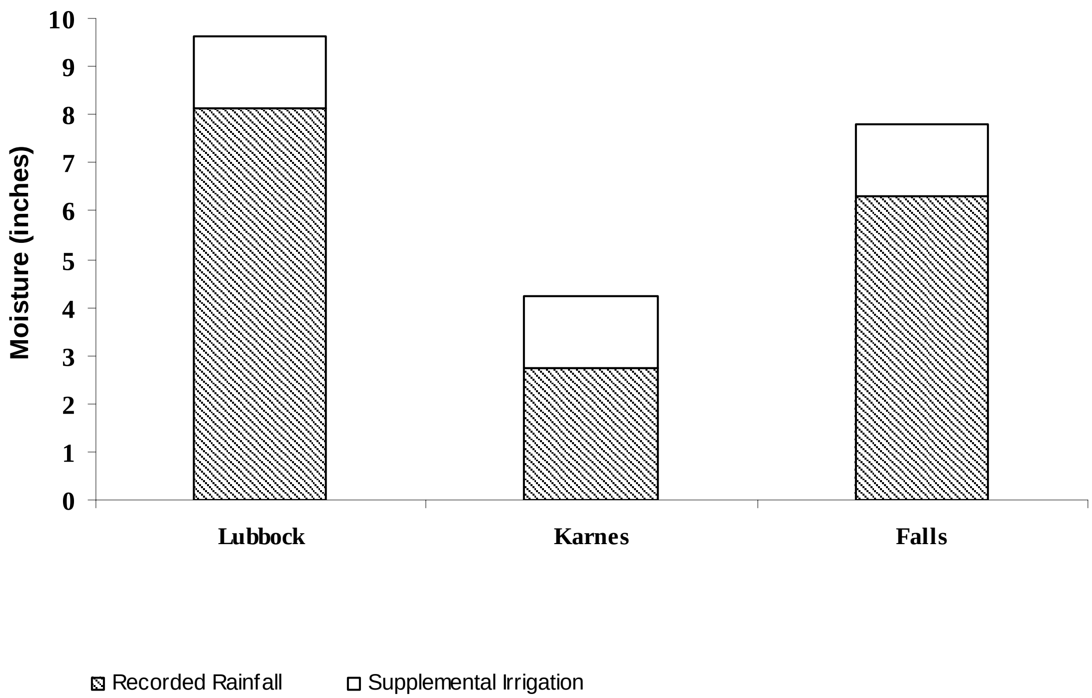


Figure 4.13 Moisture Received at the Three Field Test Sites During the Period March 15 through June 25, 2003

4.8 Vegetation

A digital photographic record showing the representative vegetative quadrat at each sub-plot at each field site was prepared as a part of the study. An interactive computer program allows a comparison of vegetative cover at a specified field site, or between field sites. Table 4.13 presents the experiment days on which photographs were taken. An asterisk (*) denotes photographs included in the digital record.

The representative quadrat for observation of vegetative growth was a 2-ft x 2-ft square located in the center of each sub-plot. A schedule 40 PVC template (Figure 4.14) was used to locate this quadrat. Figures 4.15 shows the template on a sub-plot treated with cellulose fiber mulch (T3) at the Lubbock County field site. Figure 4.16 shows a digital photograph of the representative vegetative quadrat on a sub-plot treated with cellulose fiber mulch (T3) and a sub-plot treated with soil retention blanket (T1).

Estimates of vegetative cover used in statistical analyses were based on one standard spectrographic signature or palette developed using ERDAS Imagine, Version 8.6 (Leica, 2003) and selected digital photographs taken during the field trial with a Sony® Cybershot DSC-S75 camera. Vegetative coverage at the end of the field trial was estimated by applying the standard signature to the digital photograph of the representative vegetative quadrat on each sub-plot on the final day of the field trial (day 100 for the Lubbock County site, day 101 for the Karnes County site, and day 102 for the Falls County site).

Table 4.13 Digital Photograph Schedule

Date	Experiment Day	Field Site
03/15/2003	00	Lubbock
03/17/2003	02	Karnes
03/18/2003	03	Falls
04/03/2003	19	Lubbock
04/05/2003	20	Karnes
04/06/2003	21	Falls
04/17/2003*	33	Lubbock
04/18/2003*	34	Karnes
04/19/2003*	35	Falls
05/01/2003	47	Lubbock
05/02/2003	48	Karnes
05/04/2003	50	Falls
05/19/2003*	65	Lubbock
05/20/2003*	66	Karnes
05/21/2003*	67	Falls
06/02/2003*	79	Lubbock
06/03/2003*	80	Karnes
06/04/2003*	81	Falls
06/23/2003*	100	Lubbock
06/24/2003*	101	Karnes
06/25/2003*	102	Falls

* denotes photographs included in the digital record

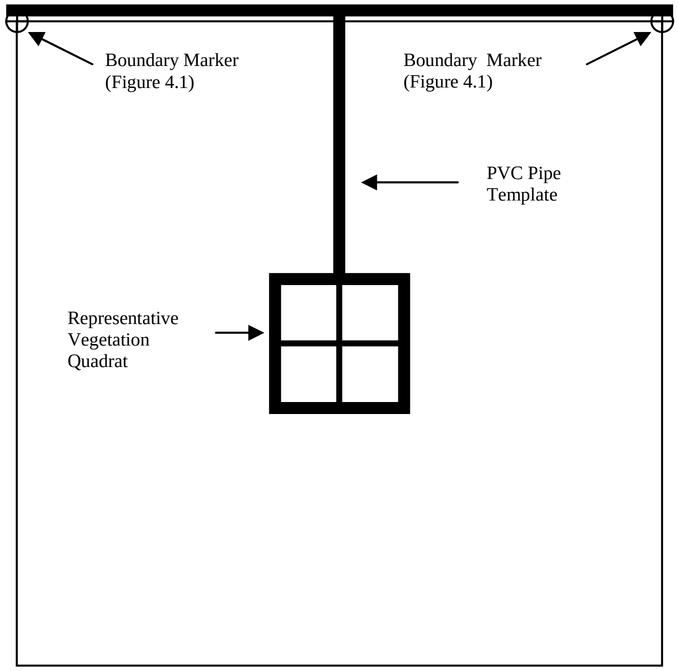


Figure 4.14 Drawing of Template Used to Locate a Designated Vegetation Quadrat

Figure 4.15 Designated Vegetation Quadrat on a Sub-Plot Treated With Cellulose Fiber Mulch at the Lubbock County Field Site

Figure 4.16 Digital Photographs of Representative Vegetation Quadrats on Sub-Plots Treated With Cellulose Fiber Mulch (top) and Soil Retention Blanket (bottom)

CHAPTER V

OBSERVATIONS AND ANALYSES

5.1 Climatology

Preliminary Climatological Data Reports (WS Form F-6) (NOAA, 2002; 2003) from National Weather Service (NWS) reporting stations in Lubbock, Victoria, and Waco, Texas were selected as representative data for the typical climate of the area in which the Lubbock, Karnes, and Falls County field sites, respectively, were located. Precipitation and ambient air temperature records were reviewed in order to determine if climatological conditions for the period beginning in November 2002 and ending in June 2003 corresponded to historical norms.

Lubbock NWS data indicated higher than normal temperature for November 2002 through May 2003, followed by below normal temperature for June 2003. Nine inches of precipitation was recorded for November 2002 through June 2003, which is 0.93-inch less rainfall than is normal for these calendar months. Table 5.1 shows selected temperature and precipitation data from the Forms F-6 for Lubbock for November 2002 through June 2003. Figure 5.1 presents ambient air temperature recorded at the NWS station in Lubbock during the field trial (March 15 through June 25, 2003). Figure 5.2 shows the experiment days on which precipitation events were recorded at the NWS station in Lubbock during the field trial (March 15 through June 25, 2003).

Table 5.1 Selected Temperature and Precipitation Data from the Lubbock, TX NWS Station for the Period November 2002 through June 2003[a]

Month	Mean Maximum Temperature (^oF)	Mean Minimum Temperature (^oF)	Mean Monthly Temperature (^oF)	Departure From Normal (^oF)	Precipitation (inches)	Departure From Normal (inches)
November 2002	59.8	35.1	47.4	-0.7	0.38	-0.33
December 2002	54.1	29.7	41.9	+2.2	1.57	+0.90
January 2003	57.7	26.5	42.1	+4.0	0.04	-0.46
February 2003	57.5	29.1	43.3	0.0	0.06	-0.65
March 2003	69.5	36.8	53.2	+2.0	0.25	-0.51
April 2003	78.3	47.6	63.0	+3.0	1.12	-0.17
May 2003	85.5	56.5	71.0	+1.8	1.31	-1.00
June 2003	86.6	62.2	74.4	-2.7	4.27	+1.29

[a]*Preliminary Climatological Data Reports (WS Forms F-6)* (NOAA, 2002; 2003)

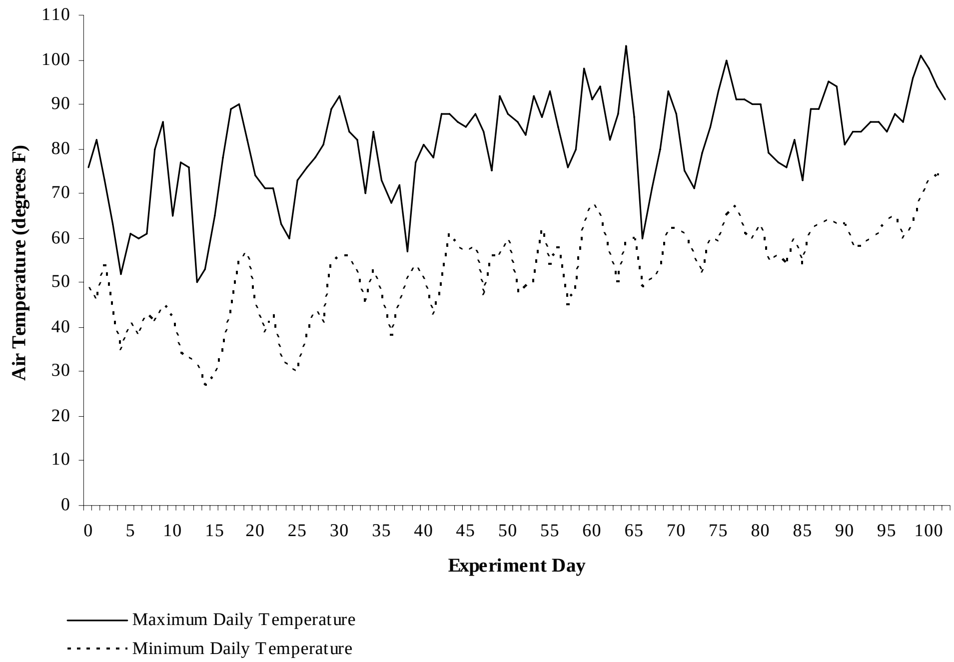


Figure 5.1 Maximum and Minimum Ambient Air Temperature at the Lubbock, TX NWS Station from March 15 through June 25, 2003

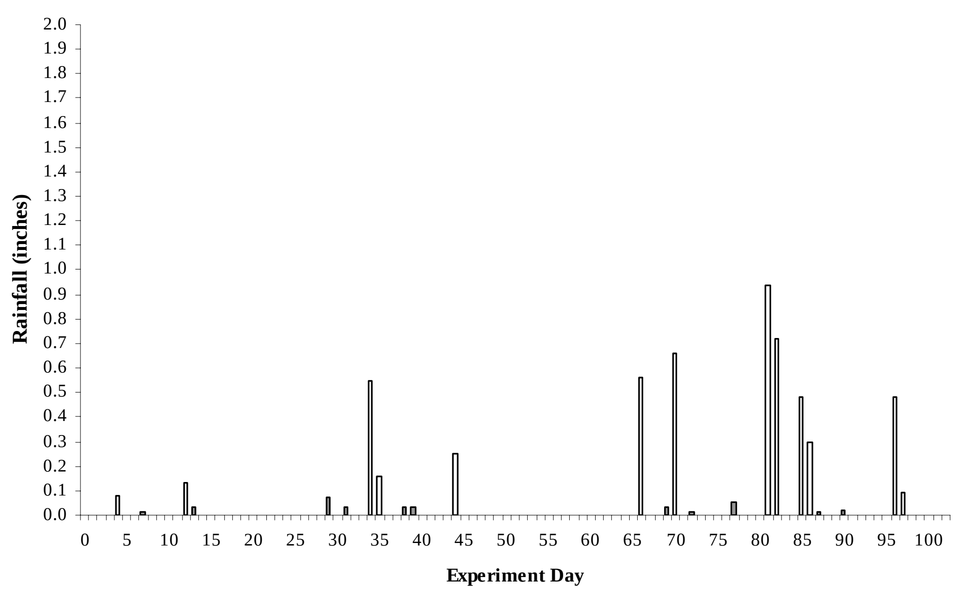


Figure 5.2 Precipitation Events Recorded at the Lubbock, TX NWS Station from March 15 through June 25, 2003

The NWS station in Lubbock, TX is located approximately 10 miles north of the Lubbock County field site. Data presented in Table 5.2, indicate a spatial variation between precipitation amounts recorded at the Lubbock County field site and precipitation amounts recorded by the NWS station in Lubbock, TX, but show that the overall rainfall pattern depicted by the NWS data was representative of conditions occurring at the Lubbock County site.

Table 5.2 Comparison of Precipitation Amounts Recorded at the Lubbock County Field Site to Precipitation Recorded at the Lubbock, Texas NWS Station

Experiment Day	Precipitation Recorded at the Lubbock County Site[a] (inches)	Precipitation Recorded at the Lubbock, TX NWS Station[b] (inches)
19	0.41	0.25
33	0.12	0.10
47	1.61	1.02
65	0.00	0.00
79	2.39	1.31
100	3.61	3.04
Total	8.14	5.72

[a] Precipitation measurements were recorded on the indicated experiment day

[b] The NWS records precipitation amounts on a daily basis. Cumulative precipitation at specific experiment days was obtained from the *Preliminary Local Climatological Data for Lubbock, TX* (NOAA, 2003)

Temperature data from the Victoria NWS station indicated cooler than normal temperature for November 2002 through March 2003, whereas the temperature for April through June 2003 was above normal. Normal precipitation for the period November through June is 24.89 inches, but only 17.22 inches was recorded. Rainfall for November 2002 through June 2003 was 7.67 inches below normal. Table 5.3 shows selected temperature and precipitation data from the Forms F-6 for Victoria for November 2002 through June 2003. Figure 5.3 presents ambient air temperature recorded at the NWS station in Victoria during the field trial (March 15 through June 25, 2003). Figure 5.4 shows the experiment days on which precipitation events were recorded at the NWS station in Victoria during the field trial (March 15 through June 25, 2003).

Table 5.3 Selected Temperature and Precipitation Data from the Victoria, TX NWS Station for the Period November 2002 through June 2003[a]

Month	Mean Maximum Temperature (^oF)	Mean Minimum Temperature (^oF)	Mean Monthly Temperature (^oF)	Departure From Normal (^oF)	Precipitation (inches)	Departure From Normal (inches)
November 2002	70.9	48.7	59.8	-2.9	3.83	+1.19
December 2002	66.6	45.3	56.0	-0.8	2.62	+0.15
January 2003	61.5	41.0	51.3	-1.9	2.05	-0.39
February 2003	64.5	45.6	55.1	-1.6	1.65	-0.39
March 2003	72.5	50.7	62.2	-1.5	1.10	-1.15
April 2003	81.3	60.7	71.0	+1.3	0.28	-2.69
May 2003	91.8	71.1	81.4	+4.8	0.08	-5.04
June 2003	93.1	72.4	82.8	+0.5	5.61	+0.65

[a]*Preliminary Climatological Data Reports (WS Forms F-6)* (NOAA, 2002; 2003)

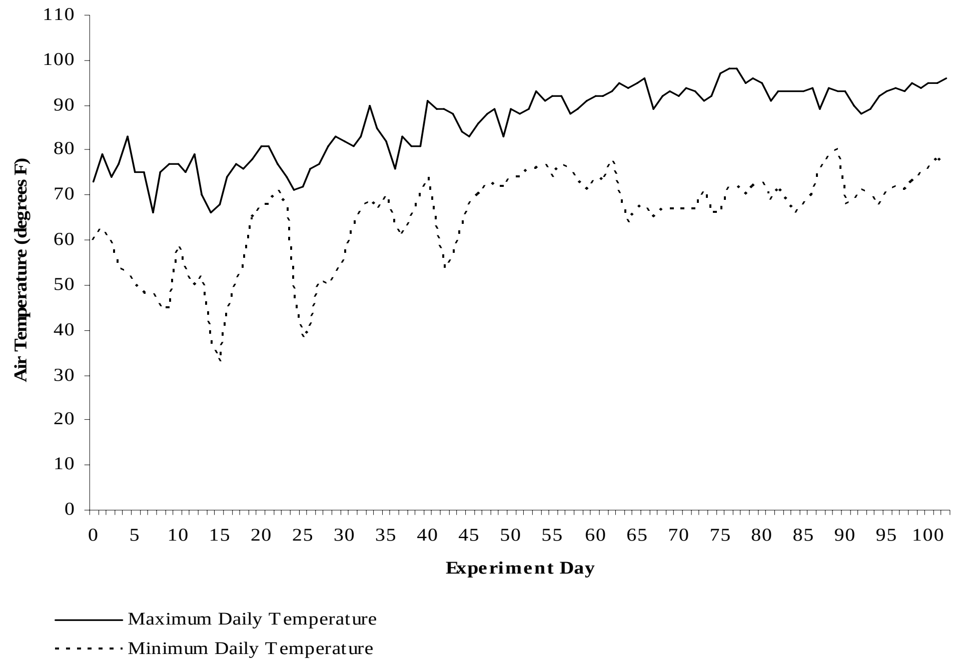


Figure 5.3 Maximum and Minimum Ambient Air Temperature at the Victoria, TX NWS Station from March 15 through June 25, 2003

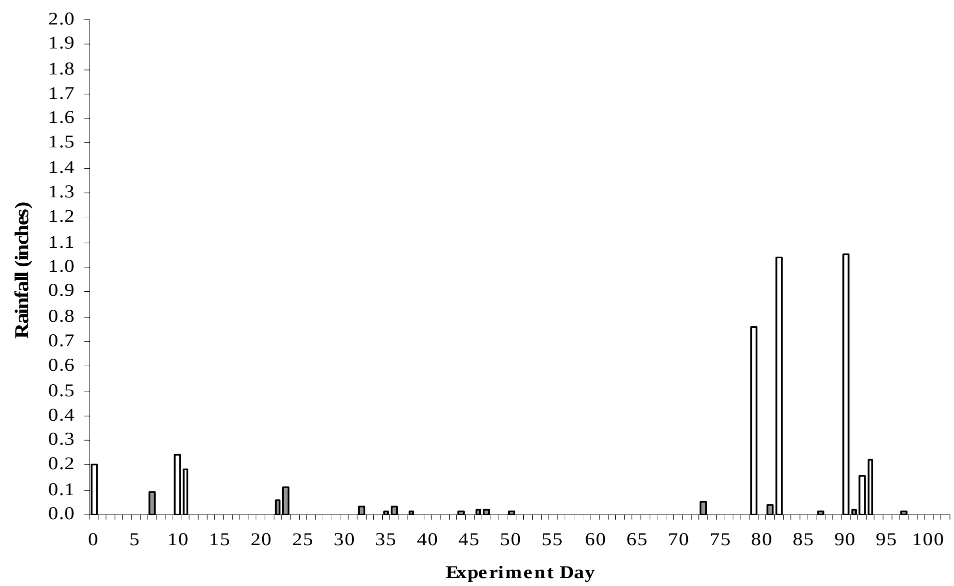


Figure 5.4 Precipitation Events Recorded at the Victoria, TX NWS Station from March 15 through June 25, 2003

The NWS station in Victoria, TX is located approximately 45 miles east of the Karnes County field site. Data presented in Table 5.4, indicate a spatial variation between precipitation amounts recorded at the Karnes County field site and precipitation amounts recorded by the NWS station in Victoria, TX, but show that the overall rainfall pattern depicted by the NWS data was representative of conditions occurring at the Karnes County site.

Table 5.4 Comparison of Precipitation Amounts Recorded at the Karnes County Field Site to Precipitation Recorded at the Victoria, Texas NWS Station

Experiment Day	Precipitation Recorded at the Karnes County Site[a] (inches)	Precipitation Recorded at the Victoria, TX NWS Station[b] (inches)
20	0.28	0.71
34	0.08	0.20
48	0.00	0.10
66	0.00	0.01
80	1.13	0.81
101	1.23	2.55
Total	2.72	4.38

[a] Precipitation measurements were recorded on the indicated experiment day

[b] The NWS records precipitation amounts on a daily basis. Cumulative precipitation at specific experiment days was obtained from the *Preliminary Local Climatological Data for Lubbock, TX* (NOAA, 2003)

Records from the Waco NWS station indicate normal temperature for November 2002 through January 2003, below normal temperature for February and March, higher than normal temperature for April and May, and lower than normal temperature in June. Recorded precipitation for November 2002 through June 2003 was 21.74 inches, or 0.97-inch less than the normal of 22.71 inches. Table 5.5 shows selected temperature and precipitation data from the Forms F-6 for Waco for November 2002 through June 2003. Figure 5.5 presents ambient air temperature recorded at the NWS station in Waco during the field trial (March 15 through June 25, 2003). Figure 5.6 shows the experiment days on which precipitation events were recorded at the NWS station in Waco during the field trial (March 15 through June 25, 2003).

Table 5.5 Selected Temperature and Precipitation Data from the Waco, TX NWS Station for the Period November 2002 through June 2003[a]

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Monthly Temperature (°F)	Departure From Normal (°F)	Precipitation (inches)	Departure From Normal (inches)
November 2002	67.3	43.5	55.4	-1.4	1.35	-1.26
December 2002	59.6	39.6	49.6	+1.3	7.63	+4.87
January 2003	56.8	36.3	46.6	+0.5	0.57	-1.33
February 2003	56.5	38.7	47.6	-3.2	2.56	+0.13
March 2003	68.2	46.8	57.5	-1.0	1.35	-1.13
April 2003	80.5	55.2	67.9	+2.0	0.94	-2.05
May 2003	86.6	66.2	76.4	+2.3	2.76	-1.70
June 2003	90.1	69.1	79.6	-1.7	4.58	+1.50

[a] *Preliminary Climatological Data Reports (WS Forms F-6)* (NOAA, 2002; 2003)

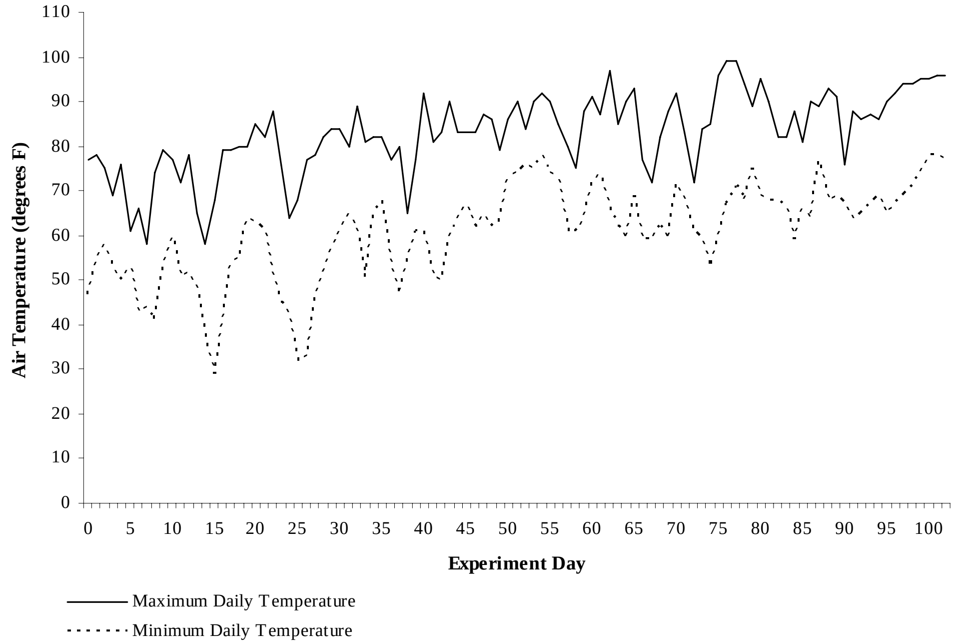


Figure 5.5 Maximum and Minimum Ambient Air Temperature at the Waco, TX NWS Station from March 15 through June 25, 2003

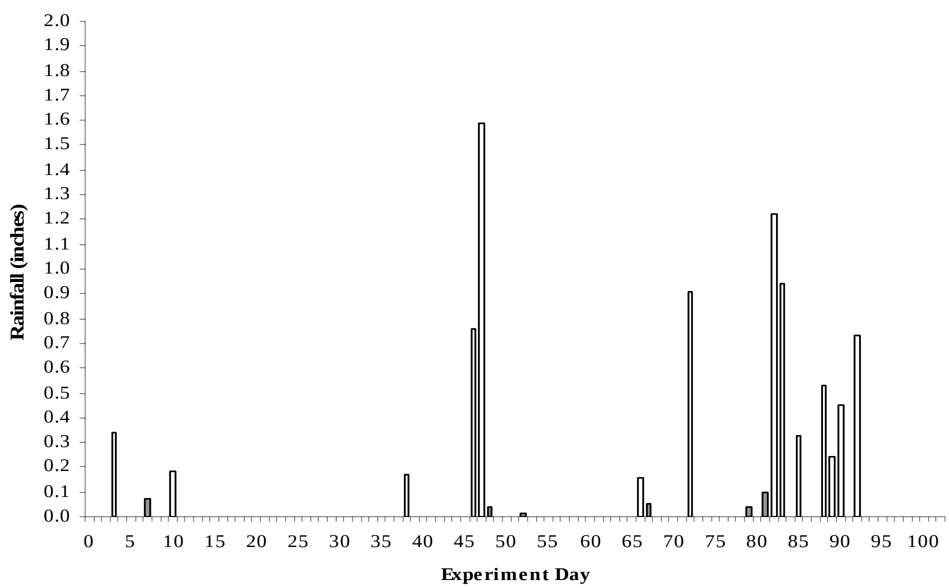


Figure 5.6 Precipitation Events Recorded at the Waco, TX NWS Station from March 15 through June 25, 2003

The NWS station in Waco, TX is located approximately 30 miles north of the Falls County field site. Data presented in Table 5.6, indicate a spatial variation between precipitation amounts recorded at the Falls County field site and precipitation amounts recorded by the NWS station in Waco, TX, but show that the overall rainfall pattern depicted by the NWS data was representative of conditions occurring at the Falls County site.

Table 5.6 Comparison of Precipitation Amounts Recorded at the Falls County Field Site to Precipitation Recorded at the Waco, Texas NWS Station

Experiment Day	Precipitation Recorded at the Falls County Site[a] (inches)	Precipitation Recorded at the Waco, TX NWS Station[b] (inches)
21	0.51	0.59
35	0.02	0.00
50	0.95	2.56
67	0.01	0.17
81	0.38	1.00
102	4.54[c]	4.54
Total	6.41	8.86

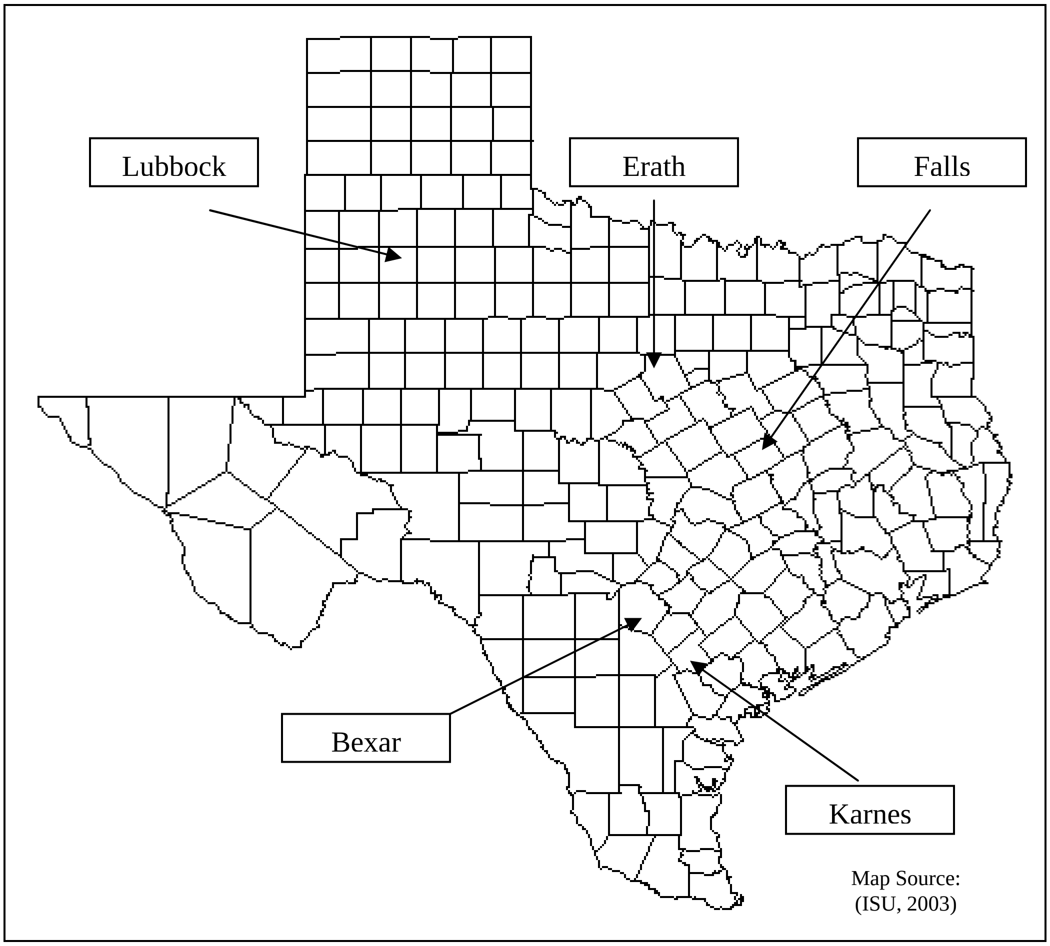
[a] Precipitation measurements were recorded on the indicated experiment day

[b] The NWS records precipitation amounts on a daily basis. Cumulative precipitation at specific experiment days was obtained from the *Preliminary Local Climatological Data for Lubbock, TX* (NOAA, 2003)

[c] The rain gage at the Falls County site was damaged between day 82 and day 102. The *Preliminary Local Climatological Data for Waco TX* (NOAA, 2003) were used to estimate rainfall amounts at the Falls County site for that period.

5.2 Compost

Approximately 18 cubic yards of compost was needed for each field site. The average cost of $9.33/yd^3 was reasonable, but transportation charges of $2.25 per loaded mile (effective March, 2003) suggested that regional producers would be the most cost-effective sources of compost for this project. Back to Nature, the source of cotton burr compost used in Lubbock County was approximately one mile from the field site, and agreed to deliver the material at no charge. Producers Compost in Erath County provided dairy cattle compost for use at the Falls County site, and Garden Ville in Bexar County provided biosolids compost for the Karnes County site. Figure 5.7 shows the proximity of the compost producers to the field sites.



Back to Nature in Lubbock County was the source for compost used at the Lubbock County site
Garden Ville in Bexar County was the source for compost used at the Karnes County site
Producers Compost in Erath County was the source for compost used at the Falls County site

Figure 5.7 Regional Sources for Compost Used at the Lubbock, Karnes, and Falls County Field Sites

Laboratory analysis of the composts used in the project was performed at the Soil, Water and Forage Lab at TAMU. Samples were collected from the bulk compost delivered to each site at the beginning of the field trial, and from sub-plots treated with a 4.00-inch layer of compost on both irrigated and non-irrigated main plots at the end of the project. Compost samples were analyzed for total nitrogen, phosphorus, potassium, calcium, magnesium, sodium, zinc, iron, copper, manganese and moisture content. Nitrogen, phosphorus, potassium, calcium, magnesium, and moisture content were reported on a percent dry basis, whereas sodium, zinc, iron, copper, and manganese were reported on a parts-per-million (ppm) basis.

Analysis of the bulk compost indicated that the cotton burr compost had higher nitrogen, potassium, and magnesium concentrations than either the biosolids compost or the dairy cattle compost. Bulk biosolids compost had higher concentrations of phosphorus, zinc, iron, and copper than either the cotton burr compost or the dairy cattle compost. The biosolids compost and the dairy cattle compost had comparable concentrations of calcium and manganese. The sodium concentration was highest in the biosolids compost, but was comparable to the dairy cattle compost. Cotton burr compost had the lowest sodium concentration.

Bulk biosolids compost had the highest moisture content (56.2%), followed by dairy cattle compost (23.8%), and cotton burr compost (19.4%). Compost samples collected from irrigated main plots at the end of the field trial showed moisture content of 25.9% for biosolids compost, 17.2% for dairy cattle compost, and 10.2% for cotton burr compost. Moisture content for compost samples collected from non-irrigated main plots at the end of the field trial was 21.2% for biosolids compost, 15.1% for dairy cattle compost, and 9.3% for cotton burr compost.

Laboratory test results for compost samples collected from irrigated sub-plots treated with a 4.00-inch layer of cotton burr compost show a decrease in nitrogen, phosphorus, potassium, and magnesium concentrations, but show increases in the concentration of calcium, sodium, copper, and manganese. Compost samples collected from irrigated sub-plots treated with a 4.00-inch layer of biosolids compost showed no change in nitrogen, iron, and copper concentration, decreases in phosphorus and zinc concentration, and increases in potassium, magnesium, sodium, and manganese concentrations. Compost samples collected from irrigated sub-plots treated with a 4.00-inch layer of dairy cattle compost showed increased concentration of sodium and manganese, and decreases in all other constituents.

Nitrogen, phosphorus, potassium, magnesium, zinc, and iron concentrations from compost samples collected from non-irrigated sub-plots treated with a 4.00-inch layer of cotton burr compost typically showed a decrease in concentration, whereas calcium, sodium, copper, and manganese concentrations increased. Compost samples collected from non-irrigated sub-plots treated with a 4.00-inch layer of biosolids compost showed a decrease in concentrations of nitrogen, phosphorus, zinc, iron, and copper, but increases in concentrations of potassium, calcium, magnesium, sodium, and manganese. Decreases in nitrogen, phosphorus, potassium, calcium, zinc, iron, and copper were indicated from compost samples collected from non-irrigated sub-plots treated with a 4.00-inch layer of dairy cattle compost, but the concentrations of sodium and manganese increased. There was no change in the concentration of magnesium. Tables 5.7, 5.8, and 5.9 present laboratory test results for compost used at the Lubbock, Karnes, and Falls County sites, respectively.

Table 5.7 Selected Constituents of Cotton Burr Compost Applied at the Lubbock County Field Test Site[a]

	N	P	K	Ca	Mg	Na	Zn	Fe	Cu	Mn	H_2O
	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(%)
Bulk 03/15/03	1.64	0.28	3.17	2.29	0.52	1927	46	267	9	120	19.4
Irrigated Main Plots 06/23/03	1.11	0.25	1.75	2.72	0.40	2435	41	222	15	150	10.2
Non-irrigated Main Plots 06/23/03	1.20	0.22	1.80	2.99	0.43	2311	31	184	11	141	9.3

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

Table 5.8 Selected Constituents of Biosolids Compost Applied at the Karnes County Field Test Site[a]

	N	P	K	Ca	Mg	Na	Zn	Fe	Cu	Mn	H_2O
	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(%)
Bulk 03/17/03	1.07	1.42	0.44	3.68	0.18	1741	444	692	223	148	56.2
Irrigated Main Plots 06/24/03	1.08	1.24	0.70	4.01	0.27	2404	367	686	228	244	25.9
Non-irrigated Main Plots 06/24/03	0.88	0.99	0.79	5.02	0.26	2352	293	472	182	348	21.2

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

Table 5.9 Selected Constituents of Dairy Cattle Compost Applied at the Falls County Field Test Site[a]

	N	P	K	Ca	Mg	Na	Zn	Fe	Cu	Mn	H_2O
	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	Dry Basis (%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(%)
Bulk 03/19/03	0.46	0.33	1.33	3.27	0.26	2342	88	309	29	155	23.8
Irrigated Main Plots 06/25/03	0.23	0.13	1.21	1.95	0.20	2549	47	267	13	282	17.2
Non-irrigated Main Plots 06/25/03	0.42	0.26	1.15	2.95	0.26	2798	75	299	21	244	15.1

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

5.3 Soil Chemistry

A routine fertility analysis and a detailed salinity analysis were performed on soil samples collected from each field site at the beginning and at the end of the field trial. Results of the fertility analyses and the detailed salinity analyses were used to empirically determine if the applied treatments caused changes in selected soil parameters. A comparison of the beginning and ending values of pH, macronutrients, and micronutrients, and was used to indicate changes in soil chemistry. A general or "thumb" rule established a change in pH of 1.0 or more, or a 100% or greater difference in the beginning and ending concentration of a specific nutrient as evidence that a treatment had affected soil chemistry. Table 5.10 was used to determine if treatments had created saline, sodic, or saline-sodic soil conditions.

Table 5.10 Selected Characteristics of Salt-Affected Soils[a]

Classification	Electrical Conductivity[b,c] EC_e	Soil pH[c]	Sodium Adsorption Ratio[d]	Soluble Sodium Percentage[c]
Saline	>4.0	<8.5	<13	<15
Sodic	<4.0	>8.5	>13	>15
Saline-Sodic	>4.0	<8.5	>13	>15

[a] Adapted from Havlin et al., page 75, (1999)
[b] Conductivity of the solution extracted from a saturated paste
[c] *Handbook # 60,* Ch 1, pp. 4 and 5. (Richards, 1954)
[d] Brady and Weil, page 427, (2002)

Data for the Lubbock County site indicated an increase in the concentration of manganese in the soil under all irrigated treatments, and increases in concentrations of phosphorus, potassium, and sulfur for soil under the compost manufactured topsoil (T4) and the 4.00-inch layer of cotton burr compost (T9). The same pattern was indicated for non-irrigated treatments with one exception. Non-irrigated sub-plots treated with compost manufactured topsoil (T4) also showed an increase in boron concentration. There was no indication that treatments had contributed to development of salt affected soils. Tables 5.11 and 5.12 present pH and selected constituents for irrigated and non-irrigated treatments (respectively) at the Lubbock County site. Tables 5.13 and 5.14 present a detailed salinity analyses for irrigated and non-irrigated treatments.

Table 5.11 Effects of Irrigated Treatments on Selected Soil Parameters at the Lubbock County Field Site[a]

	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Site	8.5	12	56	432	31883	1047	52	4.00	4.00	0.63	0.54	0.34	399
T0	8.5	9	56	368	28266	823	59	2.50	11.83	0.07	0.40	0.38	339
T1	8.4	14	59	400	26692	735	66	2.67	10.53	0.15	0.57	0.38	311
T2	8.4	4	68	484	28869	868	66	2.63	13.90	0.14	0.47	0.38	301
T3	8.4	15	62	491	26568	802	65	3.30	12.98	0.23	0.53	0.41	319
T4	8.4	22	158	1410	24221	875	180	3.36	16.64	0.55	0.70	0.37	373
T5	8.4	12	65	496	26823	788	74	2.60	14.17	0.05	0.48	0.41	349
T6	8.5	12	62	524	24974	711	75	2.67	13.61	0.18	0.47	0.40	360
T7	8.4	14	64	581	23901	662	82	2.62	14.13	0.15	0.46	0.41	341
T8	8.3	20	73	623	22928	663	82	2.67	16.37	0.13	0.57	0.41	340
T9	8.4	15	86	1019	28655	924	125	2.80	15.65	0.45	0.50	0.38	328

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.12 Effects of Non-Irrigated Treatments on Selected Soil Parameters at the Lubbock County Field Site[a]

	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Site	8.5	12	56	432	31883	1047	52	4.00	4.00	0.63	0.54	0.34	399
T0	8.5	12	57	391	30210	1037	59	2.34	11.36	0.16	0.38	0.38	316
T1	8.3	24	79	500	32794	987	84	2.66	13.12	0.19	0.48	0.37	339
T2	8.5	6	64	451	31318	1010	68	2.59	12.44	0.09	0.43	0.37	279
T3	8.5	21	73	493	32692	935	77	2.51	11.95	0.05	0.44	0.37	307
T4	8.4	22	184	1736	28427	1106	199	3.93	19.14	1.44	0.78	0.37	331
T5	8.5	14	66	475	32955	1027	75	2.38	12.18	0.87	0.43	0.38	327
T6	8.5	17	77	578	33847	1024	87	2.53	12.25	0.04	0.47	0.38	310
T7	8.5	12	81	754	32964	1096	99	2.83	12.56	0.13	0.43	0.38	309
T8	8.3	17	83	703	34590	1110	96	2.59	13.18	0.17	0.46	0.36	319
T9	8.5	21	123	1270	36564	1209	148	3.20	15.67	0.38	0.57	0.39	303

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.13 Detailed Salinity Analysis for Irrigated Treatments at the Lubbock County Site[a,b]

	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Site	8.1	0.796	4.65	0.35	1.86	0.41	4.4	64
T0	8.2	1.239	4.98	1.85	3.78	1.00	3.3	44
T1	8.3	1.762	6.74	7.33	7.47	2.61	3.2	35
T2	8.3	0.827	6.47	2.56	7.37	1.98	3.3	43
T3	8.0	0.901	4.85	1.11	5.11	1.33	2.7	39
T4	8.1	2.187	10.57	4.09	10.37	3.15	4.3	40
T5	8.4	0.950	6.05	0.87	4.71	0.94	3.8	50
T6	8.2	1.096	6.39	1.06	4.80	0.97	3.9	48
T7	8.3	1.121	6.26	0.94	4.43	0.95	3.9	50
T8	8.1	1.170	7.71	2.27	7.83	1.76	3.6	40
T9	8.1	1.501	6.46	3.05	7.66	1.91	3.0	35

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU
[b] The detailed salinity test is performed using a saturated paste extract

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.14 Detailed Salinity Analysis for Non-Irrigated Treatments at the Lubbock County Site[a,b]

	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Site	8.1	0.796	4.65	0.35	1.86	0.41	4.4	64
T0	8.3	0.676	4.47	0.64	2.89	0.61	3.7	52
T1	8.1	0.885	4.90	1.17	4.30	0.99	3.1	44
T2	8.3	1.563	6.72	6.42	6.43	2.78	3.3	38
T3	8.3	2.481	8.18	11.88	7.72	3.61	3.3	28
T4	8.2	1.704	9.05	4.97	6.61	2.46	4.1	41
T5	8.2	1.067	6.39	1.24	4.33	0.94	4.1	50
T6	8.3	1.207	6.60	1.73	5.92	1.47	3.7	42
T7	8.2	1.136	4.51	1.34	3.20	0.85	3.1	43
T8	8.0	1.252	5.76	2.54	6.40	1.75	3.0	35
T9	8.2	2.072	6.05	7.02	9.42	3.22	2.6	26

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU
[b] The detailed salinity test is performed using a saturated paste extract

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Data for the Karnes County site indicated that the concentration of iron in the soil decreased for all irrigated treatments except compost manufactured topsoil (T4), which did not change. Soil zinc concentration decreased under the control (T0), straw mulch-soil retention blanket (T2), and the cellulose fiber mulch (T3) treatments. Nitrate-nitrogen and sulfur concentrations on sub-plots treated with compost manufactured topsoil (T4) and the 1.00-inch layer (T7), 2.00-inch layer (T8), and 4.00-inch layer (T9) of biosolids compost increased, as did the concentration of phosphorus on sub-plots treated with compost manufactured topsoil (T4), and the 0.25-inch (T5), 0.50-inch layer (T6), 1.00-inch layer (T7), 2.00-inch layer (T8), and 4.00-inch layer (T9) of biosolids compost. The most dramatic increase was indicated for soil zinc (+400%) and soil copper (+250%) on sub-plots treated with compost manufactured topsoil (T4). The pattern described for the irrigated treatments at the Karnes County site was also observed for non-irrigated treatments. There was no indication that treatments applied at the Karnes County site contributed to the development of salt affected soils. Tables 5.15 and 5.16 present pH and selected constituents for irrigated and non-irrigated treatments (respectively) at the Karnes County site. Tables 5.17 and 5.18 present a detailed salinity analyses for irrigated and non-irrigated treatments.

Table 5.15 Effects of Irrigated Treatments on Selected Soil Parameters at the Karnes County Field Site[a]

	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Site	8.1	14	37	793	52380	422	71	15	19	1.07	0.93	0.87	273
T0	8.3	12	35	474	63730	402	67	6	16	0.83	0.45	0.77	350
T1	8.4	22	40	530	61069	369	83	6	17	0.84	0.55	0.69	290
T2	8.2	16	36	537	61783	394	80	7	15	0.85	0.44	0.69	275
T3	8.2	20	34	476	64017	398	73	7	13	0.80	0.35	0.67	282
T4	7.9	41	356	524	60428	475	377	16	16	1.37	4.74	3.05	292
T5	8.2	17	86	495	67204	440	104	9	16	1.01	0.93	1.10	308
T6	8.3	19	90	453	63747	409	124	6	13	0.95	0.91	1.00	264
T7	8.0	44	137	522	60444	417	264	9	16	1.14	1.67	1.38	283
T8	8.1	43	93	473	63811	423	207	5	10	0.93	1.08	1.01	328
T9	8.0	89	140	529	59536	422	247	7	11	1.05	1.47	1.25	371

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil

T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.16 Effects of Non-Irrigated Treatments on Selected Soil Parameters at the Karnes County Field Site[a]

	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Site	8.1	14	37	793	52380	422	71	15	19	1.07	0.93	0.87	273
T0	8.4	16	32	472	64433	407	64	7	15	0.80	0.39	0.75	345
T1	8.2	33	36	478	65431	418	84	7	13	0.81	0.50	0.68	313
T2	8.4	17	37	501	68672	442	78	4	11	0.84	0.35	0.60	305
T3	8.2	33	34	491	65175	408	84	5	14	0.88	0.45	0.70	278
T4	8.0	48	327	528	58555	445	322	11	19	1.35	3.60	2.45	276
T5	8.2	19	77	509	67152	432	105	6	16	0.91	0.93	1.00	248
T6	8.3	20	78	472	66477	421	120	7	12	0.88	0.84	0.88	281
T7	8.1	23	74	501	64405	441	162	8	15	0.93	1.02	1.03	272
T8	8.2	44	90	511	62756	452	211	7	11	1.13	1.36	1.03	282
T9	8.1	93	186	571	60277	447	291	10	12	1.11	2.09	1.63	264

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.17 Detailed Salinity Analysis for Irrigated Treatments at the Karnes County Site[a,b]

	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Site	7.6	0.836	1.51	0.63	10.38	0.77	0.6	11
T0	8.1	0.566	2.5	0.3	5.8	0.4	1.5	29
T1	7.8	0.738	2.1	0.4	6.8	0.5	1.1	22
T2	8.0	0.652	2.2	0.4	6.7	0.5	1.2	23
T3	7.8	0.706	2.7	0.3	5.9	0.4	1.5	29
T4	7.7	1.960	3.3	0.6	26.3	2.5	0.9	11
T5	7.7	0.836	2.9	0.3	8.1	0.6	1.6	27
T6	7.7	0.991	2.7	0.3	9.4	0.8	1.3	22
T7	7.6	1.797	3.2	0.6	21.9	1.7	0.9	12
T8	7.7	1.287	2.8	0.5	14.3	1.2	1.0	15
T9	7.6	1.997	3.2	0.7	23.9	2.0	0.9	11

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU
[b] The detailed salinity test is performed using a saturated paste extract

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.18 Detailed Salinity Analysis for Non-Irrigated Treatments at the Karnes County Site[a,b]

	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Site	7.6	0.836	1.51	0.63	10.38	0.77	0.6	11
T0	7.8	0.597	2.1	0.3	5.6	0.4	1.3	26
T1	7.7	0.647	2.0	0.3	5.9	0.5	1.1	23
T2	7.8	0.578	2.1	0.3	5.0	0.5	1.3	27
T3	7.8	0.696	2.2	0.3	6.7	0.5	1.2	23
T4	7.6	1.910	3.0	0.8	25.1	2.2	0.8	10
T5	7.9	0.788	2.1	0.3	8.1	0.6	1.2	22
T6	7.8	0.883	2.1	0.3	8.7	0.7	1.1	20
T7	7.7	1.114	2.3	0.4	12.2	1.0	0.9	15
T8	7.7	1.290	2.9	0.5	15.8	1.5	1.0	15
T9	7.6	2.097	2.7	0.8	25.8	2.3	0.7	9

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU
[b] The detailed salinity test is performed using a saturated paste extract

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Data for the Falls County site indicated that concentration of nitrate-nitrogen increased on irrigated sub-plots treated with compost manufactured topsoil (T4), and the 1.00-inch (T7), 2.00-inch layer (T8), and 4.00-inch layer (T9) of dairy cattle compost. Soil phosphorus increased on sub-plots treated with compost manufactured topsoil (T4), and the 0.50-inch-layer (T6) 1.00-inch (T7), 2.00-inch layer (T8), and 4.00-inch layer (T9) of dairy cattle compost. Concentration of soil sulfur increased on sub-plots treated with compost manufactured topsoil (T4), and the 2.00-inch layer (T8), and 4.00-inch layer (T9) of dairy cattle compost. Soil under the straw mulch-soil retention blanket (T2) and cellulose fiber mulch (T3) had decreases in zinc concentration, whereas soil under the straw mulch-soil retention blanket (T2) and sub-plots treated with compost manufactured topsoil (T4) had decreases in manganese concentration. The pattern described for irrigated treatments generally held for non-irrigated treatments.

On non-irrigated main plots soil manganese and zinc concentrations decreased under the control (T0), soil retention blanket (T1), and straw mulch-soil retention blanket (T2); the concentration of soil zinc decreased on sub-plots treated with compost manufactured topsoil (T4). There is no indication that treatments applied at the Falls County site contributed to development of salt affected soils. Tables 5.19 and 5.20 present pH and selected constituents for irrigated and non-irrigated treatments (respectively) at the Falls County site. Tables 5.21 and 5.22 present a detailed salinity analyses for irrigated and non-irrigated treatments.

Table 5.19 Effects of Irrigated Treatments on Selected Soil Parameters at the Falls County Field Site[a]

	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Site	7.9	18	86	461	19580	407	49	12	23	0.83	1.50	0.75	210
T0	8.1	16	60	267	12964	297	41	11	16	0.61	0.93	0.90	212
T1	8.1	27	70	298	14104	330	52	10	14	0.67	0.90	0.72	244
T2	8.1	18	69	301	14761	325	45	8	9	0.63	0.45	0.70	235
T3	8.1	25	68	301	16285	335	49	11	14	0.63	0.70	0.86	238
T4	8.1	52	228	601	16687	444	94	12	11	0.84	2.24	0.81	297
T5	8.1	26	155	429	15357	387	60	11	14	0.69	1.10	0.82	258
T6	8.1	29	180	523	15105	396	72	12	13	0.75	2.37	0.76	269
T7	8.1	35	170	516	16404	400	77	12	13	0.79	1.36	0.89	293
T8	8.1	44	251	747	16418	459	101	14	13	0.95	1.82	0.85	313
T9	8.0	55	199	834	14455	417	135	16	13	0.84	1.96	0.94	374

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.20 Effects of Non-Irrigated Treatments on Selected Soil Parameters at the Falls County Field Site[a]

	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Site	7.9	18	86	461	19580	407	49	12	23	0.83	1.50	0.75	210
T0	8.1	21	63	273	13626	327	42	10	11	0.70	0.54	0.75	224
T1	8.1	25	59	251	12321	322	44	12	11	0.71	0.48	0.78	232
T2	8.1	17	62	306	13095	329	44	12	10	0.65	0.73	0.77	247
T3	8.0	26	59	280	14871	339	54	14	21	0.71	0.73	0.99	224
T4	8.2	45	205	541	16000	431	88	14	12	0.98	1.50	0.80	300
T5	8.1	26	109	358	15852	355	55	14	14	0.82	1.02	0.85	244
T6	8.2	28	143	420	16313	416	65	11	13	0.82	1.10	0.80	267
T7	8.1	35	241	625	16685	468	79	13	11	1.05	1.84	0.76	289
T8	8.0	36	110	592	15633	381	88	15	14	0.86	1.10	0.95	311
T9	8.0	64	193	768	14282	439	134	17	14	0.92	1.72	0.91	382

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.21 Detailed Salinity Analyses for Irrigated Treatments at the Falls County Site[a,b]

	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Site	7.8	0.821	1.73	0.46	9.81	1.18	0.8	13
T0	7.7	0.668	1.03	0.19	6.54	0.68	0.5	12
T1	7.8	0.766	1.21	0.27	7.56	0.89	0.6	12
T2	7.8	0.676	0.88	0.21	6.56	0.75	0.5	11
T3	7.6	0.661	0.89	0.20	6.45	0.67	0.5	12
T4	7.7	1.294	3.36	0.89	11.59	1.73	1.3	19
T5	7.9	1.015	1.75	0.42	9.37	1.20	0.8	14
T6	7.9	1.126	2.47	0.68	10.29	1.45	1.1	17
T7	7.8	1.083	2.49	0.60	9.44	1.15	1.1	19
T8	7.7	1.436	4.40	1.65	11.42	1.86	1.7	22
T9	7.7	1.380	6.84	2.01	15.93	2.36	2.2	25

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU
[b] The detailed salinity test is performed using a saturated paste extract

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.22 Detailed Salinity Analysis for Non-Irrigated Treatments at the Falls County Site[a,b]

	pH	EC_{se} mmhos/cm	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Sodium Adsorption Ratio	Soluble Sodium Percentage
Site	7.8	0.821	1.73	0.46	9.81	1.18	0.8	13
T0	8.0	0.702	0.80	0.16	5.01	0.53	0.5	12
T1	7.9	0.818	1.15	0.17	7.86	0.94	0.5	11
T2	7.8	0.771	1.07	0.24	7.67	0.90	0.5	11
T3	8.0	0.839	1.06	0.20	8.08	0.89	0.5	10
T4	7.9	1.377	4.14	0.87	12.61	1.90	1.5	21
T5	7.9	0.940	1.59	0.31	9.02	1.11	0.7	13
T6	7.9	1.107	2.79	0.64	9.91	1.56	1.2	19
T7	7.9	1.192	3.19	0.90	11.40	1.87	1.2	18
T8	7.9	1.387	4.02	0.88	12.01	1.55	1.6	22
T9	7.8	1.970	6.68	1.61	17.05	2.53	2.1	24

[a] Values are from routine soil analysis performed at the Soil, Water and Forage Lab at TAMU
[b] The detailed salinity test is performed using a saturated paste extract

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

5.4 The Statistical Model

SAS version 8.02 (SAS, 2003) was used to perform an analysis of variance (ANOVA) for soil pH, soil moisture, selected nutrients and vegetative cover at each of the field sites. The model included fixed effects of irrigation (main plots), treatment (sub-plots), and interaction of main plot and sub-plot treatments, and the random effects of block x irrigation x treatment. Fixed effects in the model were considered significant at $P < 0.05$ for the F-test. The ANOVA employed the SAS Proc Mixed utility; differences among treatments were separated by the PDIFF option in SAS.

5.5 Effects of Treatments on Soil Chemistry

Application of compost manufactured topsoil (T4) to sub-plots included disking, placement of a one-inch layer of compost on the disked surface, and incorporation of the compost into the top four inches of the soil profile with a rotary tiller. Sub-plots treated with compost manufactured topsoil (T4) are the only experimental units on which compost was incorporated. Incorporation resulted in a more complete tillage of the top four inches of the soil profile, and thoroughly mixed the compost with soil particles. Therefore, soil samples collected from sub-plots treated with compost manufactured topsoil (T4) were expected to have higher nutrient concentrations than soil samples collected from plots upon which compost was applied as mulch, or upon which other treatments were applied.

Statistical analysis ($P < 0.05$) of laboratory test results for soil samples collected at the Lubbock County site indicated a treatment effect for nitrate-nitrogen, phosphorus, potassium, iron, manganese, boron, and zinc; an irrigation effect was indicated for magnesium; a treatment effect and an irrigation effect were indicated for sulfur. No effects or interactions were indicated for calcium or copper, or soil pH.

Sub-plots treated with cotton burr compost manufactured topsoil (T4) at the Lubbock County site typically had higher concentrations of nitrate-nitrogen, phosphorous, potassium, sulfur, iron, manganese, boron, and zinc than was found in soil samples collected from all other treatments. Soil samples collected from sub-plots treated with a 4.00-inch layer of cotton burr compost (T9) had concentrations of nitrate-nitrogen, phosphorous, potassium, sulfur, iron, manganese, and zinc comparable to the concentrations found in soil from sub-plots treated with compost manufactured topsoil (T4). Boron concentration under a 4.00-inch layer of cotton burr compost (T9) was lower than for compost manufactured topsoil (T4), whereas concentrations of calcium and magnesium were higher. Table 5.23 shows the effects of treatments on selected nutrients at the Lubbock County site. Tables 5.24 through 5.31 present treatment differences between treatments for nitrate-nitrogen, phosphorus, potassium, sulfur, iron, manganese, boron, and zinc.

Table 5.23 Effects of Treatments on Selected Nutrients at the Lubbock County Site[a]

ID	NO_{3-} (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)
T0	11	56	380	29238	930	59	2	12	0.11	0.39	0.38
T1	19	69	450	29743	861	75	3	12	0.18	0.52	0.37
T2	5	66	467	30094	939	67	3	13	0.12	.045	0.37
T3	18	68	492	29630	868	71	3	12	0.14	.048	0.39
T4	22	171	1573	26324	990	189	4	18	1.00	0.74	0.37
T5	13	65	486	29889	908	74	2	13	0.46	0.46	0.39
T6	14	70	551	29411	868	81	3	13	0.11	0.47	0.40
T7	14	73	668	28432	879	91	3	13	0.14	0.44	0.40
T8	18	78	663	28759	886	89	3	15	0.15	0.51	0.39
T9	18	105	1144	32610	1066	136	3	16	0.42	0.54	0.39
SEM[b]	3	13	91	2280	74	8	0.2	1	0.17	0.05	0.02

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.24 Treatment Differences for Soil Nitrate-Nitrogen at the Lubbock County Field Site[a]

	NO_3	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
	(ppm)	11	19	5	18	22	13	14	14	18	18
T0	11	0	-9 [c]	6	-7	-11 [c]	-2	-4	-3	-8	-7
T1	19	-	0	14 [c]	1	-2	6	5	6	1	1
T2	5	-	-	0	-13 [c]	-17 [c]	-8	-9 [c]	-9 [c]	-13 [c]	-13 [c]
T3	18	-	-	-	0	-4	5	4	5	0	0
T4	22	-	-	-	-	0	9 [c]	7	8 [c]	4	4
T5	13	-	-	-	-	-	0	-1	-1	-5	-5
T6	14	-	-	-	-	-	-	0	1	-4	-4
T7	14	-	-	-	-	-	-	-	0	-5	-5
T8	18	-	-	-	-	-	-	-	-	0	0
T9	18	-	-	-	-	-	-	-	-	-	0
SEM[b]	3										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.25 Treatment Differences for Soil Phosphorus at the Lubbock County Field Site[a]

	P	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
	(ppm)	56	69	66	68	171	65	70	73	78	105
T0	56	0	-13	-10	-12	-115 [c]	-9	-14	-17	-22	-49 [c]
T1	69	-	0	3	1	-102 [c]	4	-1	-4	-9	-36
T2	66	-	-	0	-2	-105 [c]	1	-4	-7	-12	-39 [c]
T3	68	-	-	-	0	-103 [c]	3	-2	-5	-10	-37
T4	171	-	-	-	-	0	106 [c]	101 [c]	98 [c]	93 [c]	67 [c]
T5	65	-	-	-	-	-	0	-5	-8	-13	-39 [c]
T6	70	-	-	-	-	-	-	0	-3	-8	-35
T7	73	-	-	-	-	-	-	-	0	-5	-32
T8	78	-	-	-	-	-	-	-	-	0	-27
T9	105	-	-	-	-	-	-	-	-	-	0
SEM[b]	13										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.26 Treatment Differences for Soil Potassium at the Lubbock County Field Site[a]

	K	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		380	450	467	492	1573	486	551	668	663	1145
T0	380	0	-71	-88	-112	-1193 [c]	-106	-171	-288 [c]	-283 [c]	-765 [c]
T1	450	-	0	-17	-42	-1122 [c]	-36	-101	-217	-213	-694 [c]
T2	467	-	-	0	-25	-1106 [c]	-19	-84	-200	-196	-677 [c]
T3	492	-	-	-	0	-1081 [c]	6	-59	-176	-171	-653 [c]
T4	1573	-	-	-	-	0	1087 [c]	1022 [c]	905 [c]	910 [c]	428 [c]
T5	486	-	-	-	-	-	0	-65	-182	-177	-659 [c]
T6	551	-	-	-	-	-	-	0	-117	-112	-594 [c]
T7	668	-	-	-	-	-	-	-	0	5	-477 [c]
T8	663	-	-	-	-	-	-	-	-	0	-482 [c]
T9	1145	-	-	-	-	-	-	-	-	-	0
SEM[b]	91										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.27 Treatment Differences for Soil Sulfur at the Lubbock County Field Site[a]

	S	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
	ppm	59	75	67	71	189	75	81	91	89	137
T0	59	0	-16	-8	-12	-130[c]	-15	-22	-32[c]	-30[c]	-77[c]
T1	75	-	0	8	4	-114[c]	1	-6	-16	-14	-61[c]
T2	67	-	-	0	-4	-122[c]	-7	-14	-24	-22	-69[c]
T3	71	-	-	-	0	-118[c]	-4	-10	-20	-18	-66[c]
T4	189	-	-	-	-	0	115[c]	108[c]	99[c]	101[c]	53[c]
T5	75	-	-	-	-	-	0	-7	-16	-14	-62[c]
T6	81	-	-	-	-	-	-	0	-10	-8	-56[c]
T7	91	-	-	-	-	-	-	-	0	2	-46[c]
T8	89	-	-	-	-	-	-	-	-	0	-48[c]
T9	137	-	-	-	-	-	-	-	-	-	0
SEM[b]	8										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.28 Treatment Differences for Soil Iron at the Lubbock County Field Site[a]

	Fe	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		2.42	2.66	2.61	2.91	3.64	2.49	2.60	2.72	2.63	3.00
T0	2.42	0.00	-0.24	-0.19	-0.49	-1.22[c]	-0.07	-0.18	-0.30	-0.21	-0.58[c]
T1	2.66	-	0.00	0.05	-0.25	-0.98[c]	0.17	0.06	-0.06	0.03	-0.34
T2	2.61	-	-	0.00	-0.30	-1.03[c]	0.12	0.01	-0.11	-0.02	-0.39
T3	2.91	-	-	-	0.00	-0.73[c]	0.42	0.31	0.19	0.28	-0.09
T4	3.64	-	-	-	-	0.00	1.15[c]	1.04[c]	0.92[c]	1.01[c]	0.64[c]
T5	2.49	-	-	-	-	-	0.00	-0.11	-0.23	-0.14	-0.51
T6	2.60	-	-	-	-	-	-	0.00	-0.12	-0.03	-0.40
T7	2.72	-	-	-	-	-	-	-	0.00	0.09	-0.28
T8	2.63	-	-	-	-	-	-	-	-	0.00	-0.37
T9	3.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.19										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.29 Treatment Differences for Soil Manganese at the Lubbock County Field Site[a]

	Mn	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		11.60	11.82	13.17	12.46	17.89	13.17	12.93	13.35	14.77	15.66
T0	11.60	0.00	-0.22	-1.57	-0.86	-6.29 [c]	-1.57	-1.33	-1.75	-3.17 [c]	-4.06 [c]
T1	11.82	-	0.00	-1.35	-0.64	-6.07 [c]	-1.35	-1.11	-1.53	-2.95 [c]	-3.84 [c]
T2	13.17	-	-	0.00	0.71	-4.72 [c]	0.00	0.24	-0.18	-1.60	-2.49
T3	12.46	-	-	-	0.00	-5.43 [c]	-0.71	-0.47	-0.89	-2.31	-3.20 [c]
T4	17.89	-	-	-	-	0.00	4.72 [c]	4.96 [c]	4.54 [c]	3.12 [c]	2.23
T5	13.17	-	-	-	-	-	0.00	0.24	-0.18	-1.60	-2.49
T6	12.93	-	-	-	-	-	-	0.00	-0.42	-1.84	-2.73
T7	13.35	-	-	-	-	-	-	-	0.00	-1.42	-2.31
T8	14.77	-	-	-	-	-	-	-	-	0.00	-0.89
T9	15.66	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.97										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.30 Treatment Differences for Soil Boron at the Lubbock County Field Site[a]

	B	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.11	0.18	0.12	0.14	1.00	0.46	0.11	0.14	0.15	0.42
T0	0.11	0.00	-0.07	-0.01	-0.03	-0.89 [c]	-0.35	0.00	-0.03	-0.04	-0.31
T1	0.18	-	0.00	0.06	0.04	-0.82 [c]	-0.28	0.07	0.04	0.03	-0.24
T2	0.12	-	-	0.00	-0.02	-0.88 [c]	-0.34	0.01	-0.02	-0.03	-0.30
T3	0.14	-	-	-	0.00	-0.86 [c]	-0.32	0.03	0.00	-0.01	-0.28
T4	1.00	-	-	-	-	0.00	0.54 [c]	0.89 [c]	0.86 [c]	0.85 [c]	0.58 [c]
T5	0.46	-	-	-	-	-	0.00	0.35	0.32	0.31	0.04
T6	0.11	-	-	-	-	-	-	0.00	-0.03	-0.04	-0.31
T7	0.14	-	-	-	-	-	-	-	0.00	-0.01	-0.28
T8	0.15	-	-	-	-	-	-	-	-	0.00	-0.27
T9	0.42	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.17										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.31 Treatment Differences for Soil Zinc at the Lubbock County Field Site[a]

	Zn	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.39	0.52	0.45	0.48	0.74	0.46	0.47	0.44	0.52	0.54
T0	0.39	0.00	-0.13	-0.06	-0.09	-0.35 [c]	-0.07	-0.08	-0.05	-0.13	-0.15
T1	0.52	-	0.00	0.07	0.04	-0.22 [c]	0.06	0.05	0.08	0.00	-0.02
T2	0.45	-	-	0.00	-0.03	-0.29 [c]	-0.01	-0.02	0.01	-0.07	-0.09
T3	0.48	-	-	-	0.00	-0.26 [c]	0.02	0.01	0.04	-0.04	-0.06
T4	0.74	-	-	-	-	0.00	0.28 [c]	0.27 [c]	0.30 [c]	0.22 [c]	0.20 [c]
T5	0.46	-	-	-	-	-	0.00	-0.01	0.02	-0.06	-0.08
T6	0.47	-	-	-	-	-	-	0.00	0.03	-0.05	-0.07
T7	0.44	-	-	-	-	-	-	-	0.00	-0.08	-0.10
T8	0.52	-	-	-	-	-	-	-	-	0.00	-0.02
T9	0.54	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.05										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Significant (P < 0.05) treatment effects were indicated for nitrate-nitrogen, phosphorus, potassium, magnesium, sulfur, iron, boron, zinc, and copper, an irrigation interaction was indicated for soil pH, but no effects or interactions were indicated for calcium or manganese at the Karnes County field site. The irrigation interaction for soil pH was statistically significant (P < 0.05; SEM = 0.07), but the differences (between 0.1 and 0.2 on the pH scale) were not significant from a soil chemistry or biological perspective.

Sub-plots treated with biosolids compost manufactured topsoil (T4) at the Karnes County site typically had higher concentrations of nitrate-nitrogen, phosphorus, magnesium, sulfur, iron, manganese, boron, zinc, and copper than was found in soil samples collected from all other treatments. Calcium concentration for compost manufactured topsoil (T4) was lower than for all other treatments. Soil under the 1.00-inch layer (T7), the 2.00-inch layer (T8), and the 4.00-inch layer (T9) of biosolids compost had comparable concentrations of sulfur, which were higher than all treatments except compost manufactured topsoil (T4). Concentrations of boron, zinc, and copper were higher for sub-plots treated with a 4.00-inch layer of biosolids compost (T9) than for soil under the control (T0), soil retention blanket (T1), straw mulch-soil retention blanket (T2), and cellulose fiber mulch (T3). Table 5.32 shows the effects of treatments on selected nutrients at the Karnes County site. Tables 5.33 through 5.41 present treatment differences between treatments for nitrate-nitrogen, phosphorus, potassium, magnesium, sulfur, iron, boron, zinc, and copper.

Table 5.32 Effects of Treatments on Selected Nutrients at the Karnes County Field Site[a]

ID	NO_{3-} (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)
T0	14	34	473	64081	404	65	6	16	0.82	0.82	0.76
T1	28	38	504	63250	394	84	6	15	0.83	0.83	0.69
T2	16	36	519	65227	418	79	6	13	0.84	0.84	0.65
T3	26	34	484	64596	403	79	6	14	0.84	0.84	0.69
T4	44	342	526	59491	460	350	13	18	1.36	1.36	2.75
T5	18	82	502	67178	436	104	8	16	0.96	0.96	1.05
T6	19	84	462	65112	415	122	6	12	0.91	0.91	0.94
T7	33	105	511	62425	429	213	8	16	1.03	1.03	1.20
T8	43	91	492	63284	438	209	6	10	1.03	1.03	1.02
T9	91	163	550	59907	435	269	9	11	1.08	1.08	1.44
SEM[b]	6	25	18	2867	17	23	1.39	2.17	0.09	0.09	0.20

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.33 Treatment Differences for Soil Nitrate-Nitrogen at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		14	28	16	26	44	18	19	33	43	91
T0	14	0	-14	-2	-12	-30 [c]	-4	-5	-19 [c]	-29 [c]	-77 [c]
T1	28	-	0	11	2	-17	10	9	-6	-16	-64 [c]
T2	16	-	-	0	-10	-28 [c]	-2	-3	-17	-27 [c]	-75 [c]
T3	26	-	-	-	0	-18	8	7	-7	-17	-65 [c]
T4	44	-	-	-	-	0	26 [c]	25 [c]	11	1	-47 [c]
T5	18	-	-	-	-	-	0	-1	-15	-25 [c]	-73 [c]
T6	19	-	-	-	-	-	-	0	-14	-24 [c]	-72 [c]
T7	33	-	-	-	-	-	-	-	0	-10	-58 [c]
T8	43	-	-	-	-	-	-	-	-	0	-48 [c]
T9	91	-	-	-	-	-	-	-	-	-	0
SEM[b]	6										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.34 Treatment Differences for Soil Phosphorus at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		34	38	36	34	342	82	84	105	91	163
T0	34	0	-4	-2	0	-308 [c]	-48	-50	-71	-57	-129 [c]
T1	38	-	0	2	4	-304 [c]	-44	-46	-67	-53	-125 [c]
T2	36	-	-	0	2	-306 [c]	-46	-48	-69	-55	-127 [c]
T3	34	-	-	-	0	-308 [c]	-48	-50	-71	-57	-129 [c]
T4	342	-	-	-	-	0	260 [c]	258 [c]	237 [c]	251 [c]	179 [c]
T5	82	-	-	-	-	-	0	-2	-23	-9	-81 [c]
T6	84	-	-	-	-	-	-	0	-21	-7	-79 [c]
T7	105	-	-	-	-	-	-	-	0	14	-58
T8	91	-	-	-	-	-	-	-	-	0	-72
T9	163	-	-	-	-	-	-	-	-	-	0
SEM[b]	25										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.35 Treatment Differences for Soil Potassium at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		473	504	519	484	526	502	462	511	492	550
T0	473	0	-31	-46 [c]	-11	-53 [c]	-29	11	-38	-19	-77 [c]
T1	504	-	0	-15	20	-22	2	42	-7	12	-46 [c]
T2	519	-	-	0	35	-7	17	57 [c]	8	27	-31
T3	484	-	-	-	0	-42	-18	22	-27	-8	-66 [c]
T4	526	-	-	-	-	0	24	64 [c]	15	34	-24
T5	502	-	-	-	-	-	0	40	-9	10	-48 [c]
T6	462	-	-	-	-	-	-	0	-49 [c]	-30	-88 [c]
T7	511	-	-	-	-	-	-	-	0	19	-39
T8	492	-	-	-	-	-	-	-	-	0	-58 [c]
T9	550	-	-	-	-	-	-	-	-	-	0
SEM[b]	18										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.36 Treatment Differences for Soil Magnesium at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		404	394	418	403	460	436	415	429	438	435
T0	404	0	10	-14	1	-56 [c]	-32	-11	-25	-34	-31
T1	394	-	0	-24	-9	-66 [c]	-42 [c]	-21	-35 [c]	-44 [c]	-41 [c]
T2	418	-	-	0	15	-42 [c]	-18	3	-11	-20	-17
T3	403	-	-	-	0	-57 [c]	-33	-12	-26	-35	-32
T4	460	-	-	-	-	0	24	45 [c]	31	22	25
T5	436	-	-	-	-	-	0	21	7	-2	1
T6	415	-	-	-	-	-	-	0	-14	-23	-20
T7	429	-	-	-	-	-	-	-	0	-9	-6
T8	438	-	-	-	-	-	-	-	-	0	3
T9	435	-	-	-	-	-	-	-	-	-	0
SEM[b]	17										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.37 Treatment Differences for Soil Sulfur at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
	ppm	65	84	79	79	350	104	122	213 [c]	209 [c]	269 [c]
T0	65	0	-19	-14	-14	-285 [c]	-39	-57	-148 [c]	-144 [c]	-204 [c]
T1	84	-	0	5	5	-266 [c]	-20	-38	-129 [c]	-125 [c]	-185 [c]
T2	79	-	-	0	0	-271 [c]	-25	-43	-134 [c]	-130 [c]	-190 [c]
T3	79	-	-	-	0	-271 [c]	-25	-43	-134 [c]	-130 [c]	-190 [c]
T4	350	-	-	-	-	0	246 [c]	228 [c]	137 [c]	141 [c]	81 [c]
T5	104	-	-	-	-	-	0	-18	-109 [c]	-105 [c]	-165 [c]
T6	122	-	-	-	-	-	-	0	-91 [c]	-87 [c]	-147 [c]
T7	213	-	-	-	-	-	-	-	0	4	-56
T8	209	-	-	-	-	-	-	-	-	0	-60
T9	269	-	-	-	-	-	-	-	-	-	0
SEM[b]	23										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.38 Treatment Differences for Soil Iron at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		6.30	6.49	5.74	5.79	13.48	7.58	6.41	8.45	6.16	8.57
T0	6.30	0.00	-0.19	0.56	0.51	-7.18 [c]	-1.28	-0.11	-2.15	0.14	-2.27
T1	6.49	-	0.00	0.75	0.70	-6.99 [c]	-1.09	0.08	-1.96	0.33	-2.08
T2	5.74	-	-	0.00	-0.05	-7.74 [c]	-1.84	-0.67	-2.71	-0.42	-2.83
T3	5.79	-	-	-	0.00	-7.69 [c]	-1.79	-0.62	-2.66	-0.37	-2.78
T4	13.48	-	-	-	-	0.00	5.90 [c]	7.07 [c]	5.03 [c]	7.32 [c]	4.91 [c]
T5	7.58	-	-	-	-	-	0.00	1.17	-0.87	1.42	-0.99
T6	6.41	-	-	-	-	-	-	0.00	-2.04	0.25	-2.16
T7	8.45	-	-	-	-	-	-	-	0.00	2.29	-0.12
T8	6.16	-	-	-	-	-	-	-	-	0.00	-2.41
T9	8.57	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	1.39										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.39 Treatment Differences for Soil Boron at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.82	0.83	0.84	0.84	1.36	0.96	0.91	1.03	1.03	1.08
T0	0.82	0.00	-0.01	-0.02	-0.02	-0.54 [c]	-0.14	-0.09	-0.21	-0.21	-0.26 [c]
T1	0.83	-	0.00	-0.01	-0.01	-0.53 [c]	-0.13	-0.08	-0.20	-0.20	-0.25 [c]
T2	0.84	-	-	0.00	0.00	-0.52 [c]	-0.12	-0.07	-0.19	-0.19	-0.24 [c]
T3	0.84	-	-	-	0.00	-0.52 [c]	-0.12	-0.07	-0.19	-0.19	-0.24 [c]
T4	1.36	-	-	-	-	0.00	0.40 [c]	0.45 [c]	0.33 [c]	0.33 [c]	0.28 [c]
T5	0.96	-	-	-	-	-	0.00	0.05	-0.07	-0.07	-0.12
T6	0.91	-	-	-	-	-	-	0.00	-0.12	-0.12	-0.17
T7	1.03	-	-	-	-	-	-	-	0.00	0.00	-0.05
T8	1.03	-	-	-	-	-	-	-	-	0.00	-0.05
T9	1.08	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.09										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.40 Treatment Differences for Soil Zinc at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.42	0.53	0.40	0.40	4.17	0.93	0.84	1.35	1.22	1.78
T0	0.42	0.00	-0.11	0.02	0.02	-3.75 [c]	-0.51	-0.42	-0.93	-0.80	-1.36 [c]
T1	0.53	-	0.00	0.13	0.13	-3.64 [c]	-0.40	-0.31	-0.82	-0.69	-1.25 [c]
T2	0.40	-	-	0.00	0.00	-3.77 [c]	-0.53	-0.44	-0.95	-0.82	-1.38 [c]
T3	0.40	-	-	-	0.00	-3.77 [c]	-0.53	-0.44	-0.95	-0.82	-1.38 [c]
T4	4.17	-	-	-	-	0.00	3.24 [c]	3.33 [c]	2.82 [c]	2.95 [c]	2.39 [c]
T5	0.93	-	-	-	-	-	0.00	0.09	-0.42	-0.29	-0.85
T6	0.84	-	-	-	-	-	-	0.00	-0.51	-0.38	-0.94
T7	1.35	-	-	-	-	-	-	-	0.00	0.13	-0.43
T8	1.22	-	-	-	-	-	-	-	-	0.00	-0.56
T9	1.78	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.35										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.41 Treatment Differences for Soil Copper at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.76	0.69	0.65	0.69	2.75	1.05	0.94	1.20	1.02	1.44
T0	0.76	0.00	0.07	0.11	0.07	-1.99 [c]	-0.29	-0.18	-0.44	-0.26	-0.68 [c]
T1	0.69	-	0.00	0.04	0.00	-2.06 [c]	-0.36	-0.25	-0.51	-0.33	-0.75 [c]
T2	0.65	-	-	0.00	-0.04	-2.10 [c]	-0.40	-0.29	-0.55	-0.37	-0.79 [c]
T3	0.69	-	-	-	0.00	-2.06 [c]	-0.36	-0.25	-0.51	-0.33	-0.75 [c]
T4	2.75	-	-	-	-	0.00	1.70 [c]	1.81 [c]	1.55 [c]	1.73 [c]	1.31 [c]
T5	1.05	-	-	-	-	-	0.00	0.11	-0.15	0.03	-0.39
T6	0.94	-	-	-	-	-	-	0.00	-0.26	-0.08	-0.50
T7	1.20	-	-	-	-	-	-	-	0.00	0.18	-0.24
T8	1.02	-	-	-	-	-	-	-	-	0.00	-0.42
T9	1.44	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.20										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Nitrogen, phosphorus, potassium, magnesium, sulfur, and zinc concentrations were significantly ($P < 0.05$) affected by treatments at the Falls County site. An irrigation effect was indicated for boron, but no effects or interactions were indicated for soil pH, calcium, iron, or manganese.

At the Falls County site, soil collected from sub-plots treated with dairy cattle compost manufactured topsoil (T4), a 1.00-inch layer (T7), a 2.00-inch layer (T8), and a 4.00-inch layer (T9) of dairy cattle compost contained higher concentrations of phosphorus, potassium, magnesium, sulfur, boron, and zinc, than soil obtained from sub-plots to which the control (T0), soil retention blanket (T1), straw mulch-soil retention blanket (T2), and cellulose fiber mulch (T3) treatments were applied. The concentrations of phosphorus, magnesium, and boron were comparable for the four treatments listed above. Sub-plots treated with a 4.00-inch layer of dairy cattle compost (T9) contained higher concentrations of nitrate-nitrogen, potassium, and sulfur than the other treatments. Table 5.42 shows the effects of treatments on selected nutrients at the Falls County site. Tables 5.43 through 5.49 present treatment differences between treatments for nitrate-nitrogen, phosphorus, potassium, magnesium, sulfur, boron, and zinc, respectively.

Table 5.42 Effects of Treatments on Selected Nutrients at the Falls County Field Site[a]

ID	NO_3 (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)	Cu (ppm)
T0	19	61	270	13295	313	42	11	14	0.65	0.74	0.83
T1	26	64	275	13213	326	48	11	12	0.69	0.69	0.75
T2	18	65	303	13928	327	45	10	9	0.64	0.59	0.74
T3	25	64	290	15578	337	52	12	17	0.67	0.72	0.93
T4	49	216	571	16344	438	91	13	11	0.91	1.88	0.81
T5	26	132	394	15604	371	57	12	14	0.76	1.06	0.84
T6	28	162	471	15709	406	69	11	13	0.78	1.74	0.78
T7	35	206	571	16545	434	78	13	12	0.92	1.60	0.82
T8	40	181	670	16026	420	94	15	13	0.91	1.46	0.90
T9	60	196	801	14369	428	134	16	14	0.88	1.84	0.92
SEM[b]	4	33	68	1784	29	7	2	2	0.06	0.33	0.07

[a] Least squares means; $n = 60$; $P < 0.05$
[b] Pooled standard error of the treatment means

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.43 Treatment Differences for Soil Nitrate-Nitrogen at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		19	26	18	25	49	26	28	35	40	60
T0	19	0	-7	1	-6	-30[c]	-7	-9	-16[c]	-21[c]	-41[c]
T1	26	-	0	8	1	-23[c]	0	-2	-9	-14[c]	-34[c]
T2	18	-	-	0	-7	-31[c]	-8	-10	-17[c]	-22[c]	-42[c]
T3	25	-	-	-	0	-24[c]	-1	-3	-10	-15[c]	-35[c]
T4	49	-	-	-	-	0	23[c]	21[c]	14[c]	9	-11
T5	26	-	-	-	-	-	0	-2	-9	-14[c]	-34[c]
T6	28	-	-	-	-	-	-	0	-7	-12	-32[c]
T7	35	-	-	-	-	-	-	-	0	-5	-25[c]
T8	40	-	-	-	-	-	-	-	-	0	-20[c]
T9	60	-	-	-	-	-	-	-	-	-	0
SEM[b]	4										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.44 Treatment Differences for Soil Phosphorus at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		61	64	65	64	216	132	162	206	181	196
T0	61	0	-3	-4	-3	-155[c]	-71	-101[c]	-145[c]	-120[c]	-135[c]
T1	64	-	0	-1	0	-152[c]	-68	-98[c]	-142[c]	-117[c]	-132[c]
T2	65	-	-	0	1	-151[c]	-67	-97[c]	-141[c]	-116[c]	-131[c]
T3	64	-	-	-	0	-152[c]	-68	-98[c]	-142[c]	-117[c]	-132[c]
T4	216	-	-	-	-	0	84	54[c]	10[c]	35[c]	20[c]
T5	132	-	-	-	-	-	0	-30	-74	-49	-64
T6	162	-	-	-	-	-	-	0	-44	-19	-34
T7	206	-	-	-	-	-	-	-	0	25	10
T8	181	-	-	-	-	-	-	-	-	0	-15
T9	196	-	-	-	-	-	-	-	-	-	0
SEM[b]	33										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.45 Treatment Differences for Soil Potassium at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		270	275	303	290	571	394	471	571	670	801
T0	270	0	-5	-33	-20	-301 [c]	-124	-201 [c]	-301 [c]	-400 [c]	-531 [c]
T1	275	-	0	-28	-15	-296 [c]	-119	-196 [c]	-296 [c]	-395 [c]	-526 [c]
T2	303	-	-	0	13	-268 [c]	-91	-168	-268 [c]	-367 [c]	-498 [c]
T3	290	-	-	-	0	-281 [c]	-104	-181	-281 [c]	-380 [c]	-511 [c]
T4	571	-	-	-	-	0	177	100	0	-99	-230 [c]
T5	394	-	-	-	-	-	0	-77	-177	-276 [c]	-407 [c]
T6	471	-	-	-	-	-	-	0	-100	-199 [c]	-330 [c]
T7	571	-	-	-	-	-	-	-	0	-99	-230 [c]
T8	670	-	-	-	-	-	-	-	-	0	-131
T9	801	-	-	-	-	-	-	-	-	-	0
SEM[b]	68										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.46 Treatment Differences for Soil Magnesium at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		313	326	327	337	438	371	406	434	420	428
T0	313	0	-13	-14	-24	-125 [c]	-58	-93 [c]	-121 [c]	-107 [c]	-115 [c]
T1	326	-	0	-1	-11	-112 [c]	-45	-80	-108 [c]	-94 [c]	-102 [c]
T2	327	-	-	0	-10	-111 [c]	-44	-79	-107 [c]	-93 [c]	-101 [c]
T3	337	-	-	-	0	-101 [c]	-34	-69	-97 [c]	-83	-91 [c]
T4	438	-	-	-	-	0	67	32	4	18	10
T5	371	-	-	-	-	-	0	-35	-63	-49	-57
T6	406	-	-	-	-	-	-	0	-28	-14	-22
T7	434	-	-	-	-	-	-	-	0	14	6
T8	420	-	-	-	-	-	-	-	-	0	-8
T9	428	-	-	-	-	-	-	-	-	-	0
SEM[b]	29										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.47 Treatment Differences for Soil Sulfur at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
	ppm	42	48	45	52	91	57	69	78	94	134
T0	42	0	-6	-3	-10	-49 [c]	-15	-27 [c]	-36 [c]	-52 [c]	-92 [c]
T1	48	-	0	3	-4	-43 [c]	-9	-21 [c]	-30 [c]	-46 [c]	-86 [c]
T2	45	-	-	0	-7	-46 [c]	-12	-24 [c]	-33 [c]	-49 [c]	-89 [c]
T3	52	-	-	-	0	-39 [c]	-5	-17	-26 [c]	-42 [c]	-82 [c]
T4	91	-	-	-	-	0	34	22 [c]	13	-3	-43 [c]
T5	57	-	-	-	-	-	0	-12	-21 [c]	-37 [c]	-77 [c]
T6	69	-	-	-	-	-	-	0	-9	-25 [c]	-65 [c]
T7	78	-	-	-	-	-	-	-	0	-16	-56 [c]
T8	94	-	-	-	-	-	-	-	-	0	-40 [c]
T9	134	-	-	-	-	-	-	-	-	-	0
SEM[b]	7										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.48 Treatment Differences for Soil Boron at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.65	0.69	0.64	0.67	0.91	0.76	0.78	0.92	0.91	0.88
T0	0.65	0.00	-0.04	0.01	-0.02	-0.26 [c]	-0.11	-0.13	-0.27 [c]	-0.26 [c]	-0.23 [c]
T1	0.69	-	0.00	0.05	0.02	-0.22 [c]	-0.07	-0.09	-0.23 [c]	-0.22 [c]	-0.19 [c]
T2	0.64	-	-	0.00	-0.03	-0.27 [c]	-0.12	-0.14	-0.28 [c]	-0.27 [c]	-0.24 [c]
T3	0.67	-	-	-	0.00	-0.24 [c]	-0.09	-0.11	-0.25 [c]	-0.24 [c]	-0.21 [c]
T4	0.91	-	-	-	-	0.00	0.15	0.13	-0.01	0.00	0.03
T5	0.76	-	-	-	-	-	0.00	-0.02	-0.16	-0.15	-0.12
T6	0.78	-	-	-	-	-	-	0.00	-0.14	-0.13	-0.10
T7	0.92	-	-	-	-	-	-	-	0.00	0.01	0.04
T8	0.91	-	-	-	-	-	-	-	-	0.00	0.03
T9	0.88	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.03										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.49 Treatment Differences for Soil Zinc at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		0.74	0.69	0.59	0.72	1.88	1.06	1.74	1.60	1.46	1.84
T0	0.74	0.00	0.05	0.15	0.02	-1.14 [c]	-0.32	-1.00 [c]	-0.86	-0.72	-1.10 [c]
T1	0.69	-	0.00	0.10	-0.03	-1.19 [c]	-0.37	-1.05 [c]	-0.91	-0.77	-1.15 [c]
T2	0.59	-	-	0.00	-0.13	-1.29 [c]	-0.47	-1.15 [c]	-1.01 [c]	-0.87	-1.25 [c]
T3	0.72	-	-	-	0.00	-1.16 [c]	-0.34	-1.02 [c]	-0.88	-0.74	-1.12 [c]
T4	1.88	-	-	-	-	0.00	0.82	0.14	0.28	0.42	0.04
T5	1.06	-	-	-	-	-	0.00	-0.68	-0.54	-0.40	-0.78
T6	1.74	-	-	-	-	-	-	0.00	0.14	0.28	-0.10
T7	1.60	-	-	-	-	-	-	-	0.00	0.14	-0.24
T8	1.46	-	-	-	-	-	-	-	-	0.00	-0.38
T9	1.84	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

5.6 Effects of Treatments on Soil Temperature

Except for the Falls County site on day 21, soil temperature readings were taken at the field sites on each of the seven field visits. A Reotemp® heavy-duty 6-inch point stem soil thermometer, accurate to plus or minus 1% (approximately 1^{o} F) (Meadows, 2003), was used to take one soil temperature reading at each of the 60 sub-plots at each field site during each visit. Soil temperature differences were considered to be statistically significant ($P < 0.05$) if the difference in soil temperature for two compared treatments was greater than 1^{o} F.

Statistical analysis for soil temperature at the Lubbock County site indicated that there was a treatment effect, a day effect, a treatment x day interaction, and an irrigation x day interaction. No significant treatment differences ($P < 0.05$) were indicated for soil temperature on experiment day 47. Table 5.50 shows the effects of treatments on soil temperature at the Lubbock County site. Tables 5.51 through 5.55 present differences between treatments on experiment days 19, 33, 65, 79, and 100, respectively.

Soil temperature on sub-plots treated with a 4.00-inch layer of cotton burr compost (T9) was lower than soil temperature under all other treatments, except at day 47 and day 79. On day 79 soil temperature under the 4.00-inch layer of cotton burr compost (T9) was higher than soil temperature under the control (T0), cellulose fiber mulch (T3), and the 1.00-inch layer of cotton burr mulch (T7). Soil temperature under the straw mulch-soil retention blanket was neither consistently higher nor was it consistently lower than soil temperature under the other treatments.

Soil under straw-soil retention blanket had a lower temperature than soil on sub-plots treated with cellulose fiber (T3), compost manufactured topsoil (T4), 0.25-inch (T5) or 0.50-inch layers of cotton burr compost on day 19, whereas soil temperature on sub-plots treated with cellulose fiber mulch (T3), compost manufactured topsoil (T4), and the 0.50-inch (T6), 1.00-inch (T7), and 2.00-inch (T8) layers of cotton burr compost was lower than for soil under straw-soil retention blanket (T2) on day 33. On day 100 soil under the straw /soil retention blanket (T2) was lower than soil under cellulose fiber (T3), the 0.25-inch layer (T5), the 0.50-inch layer (T6), and the 1.00-inch layer (T7) of cotton burr compost.

Table 5.50 Effects of Treatments on Soil Temperature at the Lubbock County Field Site[a]

ID	03/15/03 Day 0	04/04/03 Day 19	04/17/03 Day 33	05/01/03 Day 47	05/19/03 Day 65	06/02/03 Day 79	06/23/03 Day 100
T0	58	65.66	63.33	63.83	80.00	71.50	77.67
T1	58	65.67	65.33	64.67	81.33	72.17	76.83
T2	58	64.00	64.83	64.17	80.50	72.67	75.50
T3	58	65.33	63.33	64.17	80.33	71.67	77.17
T4	58	65.33	63.66	65.00	78.50	72.00	76.33
T5	58	65.33	64.17	64.17	79.83	71.83	77.00
T6	58	66.00	63.50	64.00	80.00	72.17	77.17
T7	58	64.66	63.33	64.50	81.83	71.67	76.67
T8	58	63.33	63.17	64.33	80.50	71.83	76.50
T9	58	62.33	62.17	64.17	78.33	72.83	75.83
SEM[b]	0	0.40	0.40	0.40	0.40	0.40	0.40

[a] Least squares means; n = 60; $P < 0.05$.

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.51 Treatment Differences for Soil Temperature on Day 19 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		65.66	65.67	64.00	65.33	65.33	65.33	66.00	64.66	63.33	62.33
T0	65.66	0.00	-0.01	1.66[c]	0.33	0.33	0.33	-0.34	1.00	2.33[c]	3.33[c]
T1	65.67	-	0.00	1.67[c]	0.34	0.34	0.34	-0.33	1.01	2.34[c]	3.34[c]
T2	64.00	-	-	0.00	-1.33[c]	-1.33[c]	-1.33[c]	-2.00[c]	-0.66	0.67	1.67[c]
T3	65.33	-	-	-	0.00	0.00	0.00	-0.67	0.67	2.00[c]	3.00[c]
T4	65.33	-	-	-	-	0.00	0.00	-0.67	0.67	2.00[c]	3.00[c]
T5	65.33	-	-	-	-	-	0.00	-0.67	0.67	2.00[c]	3.00[c]
T6	66.00	-	-	-	-	-	-	0.00	1.34[c]	2.67[c]	3.67[c]
T7	64.66	-	-	-	-	-	-	-	0.00	1.33[c]	2.33[c]
T8	63.33	-	-	-	-	-	-	-	-	0.00	1.00
T9	62.33	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.40										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.52 Treatment Differences for Soil Temperature on Day 33 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		63.33	65.33	64.83	63.33	63.66	64.17	63.50	63.33	63.17	62.17
T0	63.33	0.00	-2.00[c]	-1.50[c]	0.00	-0.33	-0.84	-0.17	0.00	0.16	1.16[c]
T1	65.33	-	0.00	0.50	2.00[c]	1.67[c]	1.16[c]	1.83[c]	2.00[c]	2.16[c]	3.16[c]
T2	64.83	-	-	0.00	1.50[c]	1.17[c]	0.66	1.33[c]	1.50[c]	1.66[c]	2.66[c]
T3	63.33	-	-	-	0.00	-0.33	-0.84	-0.17	0.00	0.16	1.16[c]
T4	63.66	-	-	-	-	0.00	-0.51	0.16	0.33	0.49	1.49[c]
T5	64.17	-	-	-	-	-	0.00	0.67	0.84	1.00	2.00[c]
T6	63.50	-	-	-	-	-	-	0.00	0.17	0.33	1.33[c]
T7	63.33	-	-	-	-	-	-	-	0.00	0.16	1.16[c]
T8	63.17	-	-	-	-	-	-	-	-	0.00	1.00
T9	62.17	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.40										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.53 Treatment Differences for Soil Temperature on Day 65 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		80.00	81.33	80.50	80.33	78.50	79.83	80.00	81.83	80.50	78.33
T0	80.00	0.00	-1.33 [c]	-0.50	-0.33	1.50 [c]	0.17	0.00	-1.83 [c]	-0.50	1.67 [c]
T1	81.33	-	0.00	0.83	1.00	2.83 [c]	1.50 [c]	1.33 [c]	-0.50	0.83	3.00 [c]
T2	80.50	-	-	0.00	0.17	2.00 [c]	0.67	0.50	-1.33 [c]	0.00	2.17 [c]
T3	80.33	-	-	-	0.00	1.83 [c]	0.50	0.33	-1.50 [c]	-0.17	2.00 [c]
T4	78.50	-	-	-	-	0.00	-1.33 [c]	-1.50 [c]	-3.33 [c]	-2.00 [c]	0.17
T5	79.83	-	-	-	-	-	0.00	-0.17	-2.00 [c]	-0.67	1.50 [c]
T6	80.00	-	-	-	-	-	-	0.00	-1.83 [c]	-0.50	1.67 [c]
T7	81.83	-	-	-	-	-	-	-	0.00	1.33 [c]	3.50 [c]
T8	80.50	-	-	-	-	-	-	-	-	0.00	2.17 [c]
T9	78.33	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.40										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.54 Treatment Differences for Soil Temperature on Day 79 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		71.50	72.17	72.67	71.67	72.00	71.83	72.17	71.67	71.83	72.83
T0	71.50	0.00	-0.67	-1.17 [c]	-0.17	-0.50	-0.33	-0.67	-0.17	-0.33	-1.33 [c]
T1	72.17	-	0.00	-0.50	0.50	0.17	0.34	0.00	0.50	0.34	-0.66
T2	72.67	-	-	0.00	1.00	0.67	0.84	0.50	1.00	0.84	-0.16
T3	71.67	-	-	-	0.00	-0.33	-0.16	-0.50	0.00	-0.16	-1.16 [c]
T4	72.00	-	-	-	-	0.00	0.17	-0.17	0.33	0.17	-0.83
T5	71.83	-	-	-	-	-	0.00	-0.34	0.16	0.00	-1.00
T6	72.17	-	-	-	-	-	-	0.00	0.50	0.34	-0.66
T7	71.67	-	-	-	-	-	-	-	0.00	-0.16	-1.16 [c]
T8	71.83	-	-	-	-	-	-	-	-	0.00	-1.00
T9	72.83	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.40										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.55 Treatment Differences for Soil Temperature on Day 100 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		77.67	76.83	75.50	77.17	76.33	77.00	77.17	76.67	76.50	75.83
T0	77.67	0.00	0.84	2.17 [c]	0.50	1.34 [c]	0.67	0.50	1.00	1.17 [c]	1.84 [c]
T1	76.83	-	0.00	1.33 [c]	-0.34	0.50	-0.17	-0.34	0.16	0.33	1.00
T2	75.50	-	-	0.00	-1.67 [c]	-0.83	-1.50 [c]	-1.67 [c]	-1.17 [c]	-1.00	-0.33
T3	77.17	-	-	-	0.00	0.84	0.17	0.00	0.50	0.67	1.34 [c]
T4	76.33	-	-	-	-	0.00	-0.67	-0.84	-0.34	-0.17	0.50
T5	77.00	-	-	-	-	-	0.00	-0.17	0.33	0.50	1.17 [c]
T6	77.17	-	-	-	-	-	-	0.00	0.50	0.67	1.34 [c]
T7	76.67	-	-	-	-	-	-	-	0.00	0.17	0.84
T8	76.50	-	-	-	-	-	-	-	-	0.00	0.67
T9	75.83	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.40										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Statistical analysis indicated a treatment effect, a day effect, and a treatment x day interaction at the Karnes County field site. Table 5.56 shows the effects of treatments on soil temperature at the Karnes County site. Tables 5.57 through 5.62 present differences between treatments on experiment days 20, 34, 48, 66, 80, and 101, respectively.

During the first 80 days of the experiment, soil under the 2.00-inch layer (T8) and the 4.00-inch layer (T9) of biosolids compost had lower measured temperature than soil under all other treatments, with the 2.00-inch layer (T8) being as effective as the 4.00-inch layer (T9) in influencing the soil temperature regime. The effect of both the 2.00-inch layer (T8) and the 4.00-inch layer (T9) of biosolids compost was negligible by experiment day 101.

Soil temperature measured on control (T0) sub-plots and on sub-plots treated with the soil retention blanket (T1) was comparable for the duration of the experiment, and was typically higher than for soil under all other treatments until experiment day 80. From experiment day 34 to experiment day 101 soil temperature under the straw mulch/soil retention blanket (T2) was lower than that under other treatments, and was comparable to soil temperature under the 2.00-inch layer (T8) and the 4.00-inch layer (T9) of biosolids compost.

Table 5.56 Effects of Treatments on Soil Temperature at the Karnes County Field Site[a]

ID	03/17/03 Day 2	04/05/03 Day 20	04/18/03 Day 34	05/02/03 Day 48	05/20/03 Day 66	06/03/03 Day 80	06/24/03 Day 101
T0	63	72.00	78.67	77.83	83.50	85.17	84.67
T1	63	72.00	79.67	78.67	85.50	85.33	83.83
T2	63	71.00	75.67	76.67	82.67	82.50	82.00
T3	63	71.50	78.67	77.17	82.83	84.17	84.17
T4	63	70.50	76.67	76.83	82.33	85.00	83.67
T5	63	71.83	77.67	77.83	83.67	85.00	84.67
T6	63	71.17	76.67	77.50	82.83	84.67	84.00
T7	63	70.33	76.00	76.50	82.17	84.50	83.67
T8	63	69.83	73.67	75.67	81.00	84.00	83.33
T9	63	69.17	72.00	75.17	80.83	83.00	84.00
SEM[b]	0	0.33	0.33	0.33	0.33	0.33	0.33

[a] Least squares means; n = 60; P < 0.05.

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.57 Treatment Differences for Soil Temperature on Day 20 at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		72.00	72.00	71.00	71.50	70.50	71.83	71.17	70.33	69.83	69.17
T0	72.00	0.00	0.00	1.00[c]	0.50	1.50[c]	0.17	0.83	1.67[c]	2.17[c]	2.83[c]
T1	72.00	-	0.00	1.00[c]	0.50	1.50[c]	0.17	0.83	1.67[c]	2.17[c]	2.83[c]
T2	71.00	-	-	0.00	-0.50	0.50	-0.83	-0.17	0.67	1.17[c]	1.83[c]
T3	71.50	-	-	-	0.00	1.00[c]	-0.33	0.33	1.17[c]	1.67[c]	2.33[c]
T4	70.50	-	-	-	-	0.00	-1.33[c]	-0.67	0.17	0.67	1.33[c]
T5	71.83	-	-	-	-	-	0.00	0.66	1.50[c]	2.00[c]	2.66[c]
T6	71.17	-	-	-	-	-	-	0.00	0.84	1.34[c]	2.00[c]
T7	70.33	-	-	-	-	-	-	-	0.00	0.50	1.16[c]
T8	69.83	-	-	-	-	-	-	-	-	0.00	0.66
T9	69.17	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.58 Treatment Differences for Soil Temperature on Day 34 at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		78.67	79.67	75.67	78.67	76.67	77.67	76.67	76.00	73.67	72.00
T0	78.67	0.00	-1.00[c]	3.00[c]	0.00	2.00[c]	1.00[c]	2.00[c]	2.67[c]	5.00[c]	6.67[c]
T1	79.67	-	0.00	4.00[c]	1.00[c]	3.00[c]	2.00[c]	3.00[c]	3.67[c]	6.00[c]	7.67[c]
T2	75.67	-	-	0.00	-3.00[c]	-1.00[c]	-2.00[c]	-1.00[c]	-0.33	2.00[c]	3.67[c]
T3	78.67	-	-	-	0.00	2.00[c]	1.00[c]	2.00[c]	2.67[c]	5.00[c]	6.67[c]
T4	76.67	-	-	-	-	0.00	-1.00[c]	0.00	0.67	3.00[c]	4.67[c]
T5	77.67	-	-	-	-	-	0.00	1.00[c]	1.67[c]	4.00[c]	5.67[c]
T6	76.67	-	-	-	-	-	-	0.00	0.67	3.00[c]	4.67[c]
T7	76.00	-	-	-	-	-	-	-	0.00	2.33[c]	4.00[c]
T8	73.67	-	-	-	-	-	-	-	-	0.00	1.67[c]
T9	72.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.59 Treatment Differences for Soil Temperature on Day 48 at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		77.83	78.67	76.67	77.17	76.83	77.83	77.50	76.50	75.67	75.17
T0	77.83	0.00	-0.84	1.16[c]	0.66	1.00[c]	0.00	0.33	1.33[c]	2.16[c]	2.66[c]
T1	78.67	-	0.00	2.00[c]	1.50[c]	1.84[c]	0.84	1.17[c]	2.17[c]	3.00[c]	3.50[c]
T2	76.67	-	-	0.00	-0.50	-0.16	-1.16[c]	-0.83	0.17	1.00[c]	1.50[c]
T3	77.17	-	-	-	0.00	0.34	-0.66	-0.33	0.67	1.50[c]	2.00[c]
T4	76.83	-	-	-	-	0.00	-1.00[c]	-0.67	0.33	1.16[c]	1.66[c]
T5	77.83	-	-	-	-	-	0.00	0.33	1.33[c]	2.16[c]	2.66[c]
T6	77.50	-	-	-	-	-	-	0.00	1.00[c]	1.83[c]	2.33[c]
T7	76.50	-	-	-	-	-	-	-	0.00	0.83	1.33[c]
T8	75.67	-	-	-	-	-	-	-	-	0.00	0.50
T9	75.17	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.60 Treatment Differences for Soil Temperature on Day 66 at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		83.50	85.50	82.67	82.83	82.33	83.67	82.83	82.17	81.00	80.83
T0	83.50	0.00	-2.00[c]	0.83	0.67	1.17[c]	-0.17	0.67	1.33[c]	2.50[c]	2.67[c]
T1	85.50	-	0.00	2.83[c]	2.67[c]	3.17[c]	1.83[c]	2.67[c]	3.33[c]	4.50[c]	4.67[c]
T2	82.67	-	-	0.00	-0.16	0.34	-1.00[c]	-0.16	0.50	1.67[c]	1.84[c]
T3	82.83	-	-	-	0.00	0.50	-0.84	0.00	0.66	1.83[c]	2.00[c]
T4	82.33	-	-	-	-	0.00	-1.34[c]	-0.50	0.16	1.33[c]	1.50[c]
T5	83.67	-	-	-	-	-	0.00	0.84	1.50[c]	2.67[c]	2.84[c]
T6	82.83	-	-	-	-	-	-	0.00	0.66	1.83[c]	2.00[c]
T7	82.17	-	-	-	-	-	-	-	0.00	1.17[c]	1.34[c]
T8	81.00	-	-	-	-	-	-	-	-	0.00	0.17
T9	80.83	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.61 Treatment Differences for Soil Temperature on Day 80 at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		85.17	85.33	82.50	84.17	85.00	85.00	84.67	84.50	84.00	83.00
T0	85.17	0.00	-0.16	2.67[c]	1.00[c]	0.17	0.17	0.50	0.67	1.17[c]	2.17[c]
T1	85.33	-	0.00	2.83[c]	1.16[c]	0.33	0.33	0.66	0.83	1.33[c]	2.33[c]
T2	82.50	-	-	0.00	-1.67[c]	-2.50[c]	-2.50[c]	-2.17[c]	-2.00[c]	-1.50[c]	-0.50
T3	84.17	-	-	-	0.00	-0.83	-0.83	-0.50	-0.33	0.17	1.17[c]
T4	85.00	-	-	-	-	0.00	0.00	0.33	0.50	1.00[c]	2.00[c]
T5	85.00	-	-	-	-	-	0.00	0.33	0.50	1.00[c]	2.00[c]
T6	84.67	-	-	-	-	-	-	0.00	0.17	0.67	1.67[c]
T7	84.50	-	-	-	-	-	-	-	0.00	0.50	1.50[c]
T8	84.00	-	-	-	-	-	-	-	-	0.00	1.00[c]
T9	83.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Table 5.62 Treatment Differences for Soil Temperature on Day 101 at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		84.67	83.83	82.00	84.17	83.67	84.67	84.00	83.67	83.33	84.00
T0	84.67	0.00	0.84	2.67 [c]	0.50	1.00 [c]	0.00	0.67	1.00 [c]	1.34 [c]	0.67
T1	83.83	-	0.00	1.83 [c]	-0.34	0.16	-0.84	-0.17	0.16	0.50	-0.17
T2	82.00	-	-	0.00	-2.17 [c]	-1.67 [c]	-2.67 [c]	-2.00 [c]	-1.67 [c]	-1.33 [c]	-2.00 [c]
T3	84.17	-	-	-	0.00	0.50	-0.50	0.17	0.50	0.84	0.17
T4	83.67	-	-	-	-	0.00	-1.00 [c]	-0.33	0.00	0.34	-0.33
T5	84.67	-	-	-	-	-	0.00	0.67	1.00 [c]	1.34 [c]	0.67
T6	84.00	-	-	-	-	-	-	0.00	0.33	0.67	0.00
T7	83.67	-	-	-	-	-	-	-	0.00	0.34	-0.33
T8	83.33	-	-	-	-	-	-	-	-	0.00	-0.67
T9	84.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.33										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Statistical analysis (P < 0.05) indicated a treatment effect, a day effect, an irrigation effect, and a treatment x day interaction at the Falls County site. No significant differences (P < 0.05) were indicated for soil temperature on day 50 at the Falls County site. Table 5.63 shows the effects of treatments on soil temperature at the Falls County site. Tables 5.64 through 5.67 present differences between treatments on experiment days 35, 67, 81, and 102, respectively.

Dairy cattle compost applied to sub-plots at the Falls County site did not influence the soil temperature regime to the extent of either the cotton burr compost applied at the Lubbock County site or the biosolids compost applied at the Karnes County site. With the exception of experiment day 67, soil temperature under the 2.00-inch layer (T8) and the 4.00-inch layer of dairy cattle compost was comparable to soil temperature under all other treatments. On experiment days 67 and 81 soil temperature on sub-plots under the soil retention blanket t (T1) was higher than for all other treatments. Soil under the straw mulch-soil retention blanket treatment (T2) had lower temperature than all other treatments on experiment day 101.

Table 5.63 Effects of Treatments on Soil Temperature at the Falls County Field Site[a]

ID	03/18/03 Day 3	04/06/03 Day 21[b]	04/19/03 Day 35	05/04/03 Day 50	05/21/03 Day 67	06/04/03 Day 81	06/23/03 Day 102
T0	61	-	73.00	74.00	79.33	82.50	83.00
T1	61	-	73.67	75.00	80.50	84.00	83.33
T2	61	-	72.67	74.17	79.17	81.67	81.17
T3	61	-	73.83	74.17	78.83	82.50	83.17
T4	61	-	73.00	74.67	79.33	82.17	83.33
T5	61	-	73.33	74.50	78.67	82.50	83.33
T6	61	-	72.67	74.67	79.00	82.17	83.00
T7	61	-	73.33	74.17	78.67	82.33	83.17
T8	61	-	73.33	74.17	78.00	82.50	82.50
T9	61	-	72.17	74.33	78.00	83.00	82.67
SEM[b]	0	-	0.41	0.41	0.41	0.41	0.41

[a] Least squares means; n = 60; P < 0.05
[b] No soil temperature readings were taken on day 21

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.64 Treatment Differences for Soil Temperature on Day 35 at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		73.00	73.67	72.67	73.83	73.00	73.33	72.67	73.33	73.33	72.17
T0	73.00	0.00	-0.67	0.33	-0.83	0.00	-0.33	0.33	-0.33	-0.33	0.83
T1	73.67	-	0.00	1.00	-0.16	0.67	0.34	1.00	0.34	0.34	1.50 [c]
T2	72.67	-	-	0.00	-1.16 [c]	-0.33	-0.66	0.00	-0.66	-0.66	0.50
T3	73.83	-	-	-	0.00	0.83	0.50	1.16 [c]	0.50	0.50	1.66 [c]
T4	73.00	-	-	-	-	0.00	-0.33	0.33	-0.33	-0.33	0.83
T5	73.33	-	-	-	-	-	0.00	0.66	0.00	0.00	1.16 [c]
T6	72.67	-	-	-	-	-	-	0.00	-0.66	-0.66	0.50
T7	73.33	-	-	-	-	-	-	-	0.00	0.00	1.16 [c]
T8	73.33	-	-	-	-	-	-	-	-	0.00	1.16 [c]
T9	72.17	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.41										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.65 Treatment Differences for Soil Temperature on Day 67 at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		79.33	80.50	79.17	78.83	79.33	78.67	79.00	78.67	78.00	78.00
T0	79.33	0.00	-1.17	0.16	0.50	0.00	0.66	0.33	0.66	1.33 [c]	1.33 [c]
T1	80.50	-	0.00	1.33 [c]	1.67 [c]	1.17 [c]	1.83 [c]	1.50 [c]	1.83 [c]	2.50 [c]	2.50 [c]
T2	79.17	-	-	0.00	0.34	-0.16	0.50	0.17	0.50	1.17 [c]	1.17 [c]
T3	78.83	-	-	-	0.00	-0.50	0.16	-0.17	0.16	0.83	0.83
T4	79.33	-	-	-	-	0.00	0.66	0.33	0.66	1.33 [c]	1.33 [c]
T5	78.67	-	-	-	-	-	0.00	-0.33	0.00	0.67	0.67
T6	79.00	-	-	-	-	-	-	0.00	0.33	1.00	1.00
T7	78.67	-	-	-	-	-	-	-	0.00	0.67	0.67
T8	78.00	-	-	-	-	-	-	-	-	0.00	0.00
T9	78.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.41										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.66 Treatment Differences for Soil Temperature on Day 81 at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		82.50	84.00	81.67	82.50	82.17	82.50	82.17	82.33	82.50	83.00
T0	82.50	0.00	-1.50 [c]	0.83	0.00	0.33	0.00	0.33	0.17	0.00	-0.50
T1	84.00	-	0.00	2.33 [c]	1.50 [c]	1.83 [c]	1.50 [c]	1.83 [c]	1.67 [c]	1.50 [c]	1.00
T2	81.67	-	-	0.00	-0.83	-0.50	-0.83	-0.50	-0.66	-0.83	-1.33 [c]
T3	82.50	-	-	-	0.00	0.33	0.00	0.33	0.17	0.00	-0.50
T4	82.17	-	-	-	-	0.00	-0.33	0.00	-0.16	-0.33	-0.83
T5	82.50	-	-	-	-	-	0.00	0.33	0.17	0.00	-0.50
T6	82.17	-	-	-	-	-	-	0.00	-0.16	-0.33	-0.83
T7	82.33	-	-	-	-	-	-	-	0.00	-0.17	-0.67
T8	82.50	-	-	-	-	-	-	-	-	0.00	-0.50
T9	83.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.41										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

Table 5.67 Treatment Differences for Soil Temperature on Day 102 at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		83.00	83.33	81.17	83.17	83.33	83.33	83.00	83.17	82.50	82.67
T0	83.00	0.00	-0.33	1.83 [c]	-0.17	-0.33	-0.33	0.00	-0.17	0.50	0.33
T1	83.33	-	0.00	2.16 [c]	0.16	0.00	0.00	0.33	0.16	0.83	0.66
T2	81.17	-	-	0.00	-2.00 [c]	-2.16 [c]	-2.16 [c]	-1.83 [c]	-2.00 [c]	-1.33 [c]	-1.50 [c]
T3	83.17	-	-	-	0.00	-0.16	-0.16	0.17	0.00	0.67	0.50
T4	83.33	-	-	-	-	0.00	0.00	0.33	0.16	0.83	0.66
T5	83.33	-	-	-	-	-	0.00	0.33	0.16	0.83	0.66
T6	83.00	-	-	-	-	-	-	0.00	-0.17	0.50	0.33
T7	83.17	-	-	-	-	-	-	-	0.00	0.67	0.50
T8	82.50	-	-	-	-	-	-	-	-	0.00	-0.17
T9	82.67	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	0.41										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

5.7 Effects of Treatment on Soil Moisture

A Field Scout™ Model 300 Time Domain Reflectometry (TDR) unit equipped with parallel 8-inch wave guides spaced 1.97 inches apart was used to collect one volumetric water content (VWC) reading from each sub-plot at each field site on each of the seven visits made during the field trial (Table 4.11). The Field Scout™ has accuracy of plus or minus 3% VWC when electrical conductivity is less than 2 mS/cm (Spectrum, 2003). Soil characteristics and field site conditions interfered with the use of the TDR unit, and may have negatively influenced the accuracy of soil moisture readings obtained at the Karnes and Falls County sites. The Lubbock site contained large quantities of gravel, cobbles, and boulders, whereas the Karnes County site consisted of a highly plastic soil in which large cracks formed. Soil at the Falls County site was compacted, underlain in places by a dense clay pan, contained large quantities of gravel and cobbles, and the top four-inch soil layer tended to a state resembling adobe brick during dry periods.

A pipeline running parallel to the roadway was buried beneath the Karnes County site, and may have contributed to distortion of TDR readings. One hypothesis suggests that electrical fields generated by anti-corrosion (cathodic protection) devices, and interference caused by movement of fluid through the pipeline may have affected the speed at which electrical impulses traveled along the 8-inch wave guides of the TDR instrument.

The density of the soil, coupled with large quantities of gravel and cobbles at the Falls County site may have compromised the ability of the TDR instrument to process data. Under optimum conditions, the parallel wave guides remain approximately 1.97 inches apart when inserted into the soil. Field observations indicated that the electrodes were frequently forced out of parallel alignment, and the space between them was more or less than 1.97 inches. The TDR wave guides were also observed to be occasionally out of parallel alignment at the Lubbock site due to the presence of gravel and cobbles, but to a lesser degree than at the Falls County site. A representative of Spectrum Technologies, Inc. indicated that slight misalignment of the wave guides is not believed to introduce large errors in VWC readings (Kieffer, 2003).

Review of the TDR readings taken at the Karnes and Falls County sites revealed numerous VWC readings greater than 100%, whereas no TDR reading approached 100% at the Lubbock site. Consultation with representatives of Spectrum Technologies, Inc. (Wozniak, 2003; Kieffer, 2003) revealed that the Field Scout™ Model 300 frequently returns VWC readings of more than 100% in soils having high clay content, but provides more accurate VWC readings in soils having a large sand fraction. The clay content at the Karnes and Falls County sites was 40% and 34%, respectively, whereas the sand fraction at the Lubbock County site was 54% (Table 4.10). Investigators concluded that the VWC data from the Karnes and Falls County sites was not reliable, and that it should not be subjected to statistical analysis. Since no anomalous readings were found, VWC data collected from the Lubbock County site was determined to be relevant, and was subjected to statistical analysis.

Statistical analysis indicated that there was a treatment effect, a day effect, a treatment x day interaction, and a treatment x irrigation x day interaction. If the volumetric water content (VWC) of the soil under two treatments being compared was 7.5% or more, then the difference was statistically significant. No significant differences ($P < 0.05$) caused by treatment effects or interactions were indicated on experiment days 0, 19, 33, or 65. A 4.00-inch layer of cotton burr compost (T9) typically had higher VWC than all other treatments, except for compost manufactured topsoil (T4). Table 5.68 shows the effects of treatments on soil moisture at the Lubbock County site. Tables 5.69, 5.70, and 5.71 present differences between treatments on experiment days 47, 79, and 100, respectively.

Table 5.68 Effects of Treatments on Soil Moisture at the Lubbock County Field Site[a]

ID	03/15/03 Day 0	04/04/03 Day 19	04/17/03 Day 33	05/01/03 Day 47	05/19/03 Day 65	06/02/03 Day 79	06/23/03 Day 100
T0	18.67	16.33	13.83	16.67	16.50	17.00	12.50
T1	19.17	15.33	12.67	21.50	13.17	25.33	10.00
T2	21.00	16.17	16.33	26.33	17.33	17.83	9.00
T3	19.83	17.00	16.17	23.83	18.67	21.50	9.83
T4	21.00	14.67	15.83	25.17	16.00	42.00	27.00
T5	19.33	17.00	14.00	21.50	17.67	19.33	12.00
T6	19.67	13.50	13.83	19.67	15.00	22.83	12.17
T7	17.67	17.33	16.33	22.00	18.00	26.50	11.83
T8	18.83	17.83	19.00	22.67	14.83	28.17	14.17
T9	22.67	18.17	18.83	31.67	13.67	54.17	30.33
SEM[b]	2.68	2.68	2.68	2.68	2.68	2.68	2.68

[a] Least squares means; $n = 60$; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.69 Treatment Differences for Soil Moisture on Day 47 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		16.67	21.50	26.33	23.83	25.17	21.50	19.67	22.00	22.67	31.67
T0	16.67	0.00	-4.83	-9.66[c]	-7.16	-8.50[c]	-4.83	-3.00	-5.33	-6.00	-15.00[c]
T1	21.50	-	0.00	-4.83	-2.33	-3.67	0.00	1.83	-0.50	-1.17	-10.17[c]
T2	26.33	-	-	0.00	2.50	1.16	4.83	6.66	4.33	3.66	-5.34
T3	23.83	-	-	-	0.00	-1.34	2.33	4.16	1.83	1.16	-7.84[c]
T4	25.17	-	-	-	-	0.00	3.67	5.50	3.17	2.50	-6.50
T5	21.50	-	-	-	-	-	0.00	1.83	-0.50	-1.17	-10.17[c]
T6	19.67	-	-	-	-	-	-	0.00	-2.33	-3.00	-12.00[c]
T7	22.00	-	-	-	-	-	-	-	0.00	-0.67	-9.67[c]
T8	22.67	-	-	-	-	-	-	-	-	0.00	-9.00
T9	31.67	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	2.68										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.70 Treatment Differences for Soil Moisture on Day 79 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		17.00	25.33	17.83	21.50	42.00	19.33	22.83	26.50	28.17	54.17
T0	17.00	0.00	-8.33[c]	-0.83	-4.50	-25.00[c]	-2.33	-5.83	-9.50[c]	-11.17[c]	-37.17[c]
T1	25.33	-	0.00	7.50[c]	3.83	-16.67[c]	6.00	2.50	-1.17	-2.84	-28.84[c]
T2	17.83	-	-	0.00	-3.67	-24.17[c]	-1.50	-5.00	-8.67[c]	-10.34[c]	-36.34[c]
T3	21.50	-	-	-	0.00	-20.50[c]	2.17	-1.33	-5.00	-6.67	-32.67[c]
T4	42.00	-	-	-	-	0.00	22.67[c]	19.17[c]	15.50[c]	13.83[c]	-12.17[c]
T5	19.33	-	-	-	-	-	0.00	-3.50	-7.17	-8.84[c]	-34.84[c]
T6	22.83	-	-	-	-	-	-	0.00	-3.67	-5.34	-31.34[c]
T7	26.50	-	-	-	-	-	-	-	0.00	-1.67	-27.67[c]
T8	28.17	-	-	-	-	-	-	-	-	0.00	-26.00[c]
T9	54.17	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	2.68										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.71 Treatment Differences for Soil Moisture on Day 100 at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		12.50	10.00	9.00	9.83	27.00	12.00	12.17	11.83	14.17	30.33
T0	12.50	0.00	2.50	3.50	2.67	-14.50 [c]	0.50	0.33	0.67	-1.67	-17.83 [c]
T1	10.00	-	0.00	1.00	0.17	-17.00 [c]	-2.00	-2.17	-1.83	-4.17	-20.33 [c]
T2	9.00	-	-	0.00	-0.83	-18.00 [c]	-3.00	-3.17	-2.83	-5.17	-21.33 [c]
T3	9.83	-	-	-	0.00	-17.17 [c]	-2.17	-2.34	-2.00	-4.34	-20.50 [c]
T4	27.00	-	-	-	-	0.00	15.00 [c]	14.83 [c]	15.17 [c]	12.83 [c]	-3.33
T5	12.00	-	-	-	-	-	0.00	-0.17	0.17	-2.17	-18.33 [c]
T6	12.17	-	-	-	-	-	-	0.00	0.34	-2.00	-18.16 [c]
T7	11.83	-	-	-	-	-	-	-	0.00	-2.34	-18.50 [c]
T8	14.17	-	-	-	-	-	-	-	-	0.00	-16.16 [c]
T9	30.33	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	2.68										

[a] Least squares means; n = 60; $P < 0.05$
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

5.8 Effects of Treatment on Vegetative Cover

Vegetative coverages used in statistical analyses were based on one standard spectrographic signature or palette that was created using ERDAS Imagine version 8.6 (Leica, 2003) and digital photographs taken at each of the three sites during the field trial. Vegetative coverage for a given sub-plot was estimated by applying the standard signature to the digital photograph of the representative vegetative quadrat at that sub-plot on the final day of the field trial (day 100 for the Lubbock County site, day 101 for the Karnes County site, and day 102 for the Falls County site).

Statistical analysis indicated treatment effects and an irrigation x treatment interaction at the Lubbock County site. A between treatment difference of 11% or more was considered significant ($P < 0.05$). Winds of 60 mph (NOAA, 2003) occurred at the Lubbock County site on April 15, 2003. Compost was displaced, sand was deposited on sub-plots, and vegetation was sheared off at the soil surface. Table 5.72 shows treatment differences for vegetative cover on irrigated sub-plots, and Table 5.73 presents differences for vegetative cover on non-irrigated sub-plots at the Lubbock County site.

The straw-soil retention blanket treatment (T2) had higher vegetative cover (43%) than all other irrigated treatments. Irrigated sub-plots treated with cellulose fiber (T3) had greater vegetative cover (32%) than all other irrigated treatments, except for the straw mulch-soil retention blanket treatment (T2). Compost manufactured topsoil (T4), 0.50-inch cotton burr compost (T6), and 4.00-inch cotton burr compost (T9) had the lowest vegetative cover (8%). Irrigated sub-plots treated with soil retention blanket (T1), straw-soil retention blanket (T2), and cellulose fiber mulch (T3) exhibited higher vegetative coverage than all treatments on non-irrigated sub-plots.

On non-irrigated sub-plots, the straw-soil retention blanket treatment (T2) and the soil retention blanket (T1) exhibited greater vegetative cover than all other non-irrigated treatments at the Lubbock

County site. Straw mulch-soil retention blanket (T2) had 32% vegetative coverage; soil retention blanket (T1) had 22%. The remaining treatments had a range of coverage of from 4% to 8%.

Table 5.72 Treatment Differences for Vegetative Cover on Irrigated Sub-Plots at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		15.33	23.66	43.33	31.66	7.66	16.66	7.66	17.33	16.66	8.00
T0	15.33	0.00	-8.33	-28.00 [c]	-16.33 [c]	7.67	-1.33	7.67	-2.00	-1.33	7.33
T1	23.66	-	0.00	-19.67 [c]	-8.00	16.00 [c]	7.00	16.00 [c]	6.33	7.00	15.66 [c]
T2	43.33	-	-	0.00	11.67 [c]	35.67 [c]	26.67 [c]	35.67 [c]	26.00 [c]	26.67 [c]	35.33 [c]
T3	31.66	-	-	-	0.00	24.00 [c]	15.00 [c]	24.00 [c]	14.33 [c]	15.00 [c]	23.66 [c]
T4	7.66	-	-	-	-	0.00	-9.00	0.00	-9.67	-9.00	-0.34
T5	16.66	-	-	-	-	-	0.00	9.00	-0.67	0.00	8.66
T6	7.66	-	-	-	-	-	-	0.00	-9.67	-9.00	-0.34
T7	17.33	-	-	-	-	-	-	-	0.00	0.67	9.33
T8	16.66	-	-	-	-	-	-	-	-	0.00	8.66
T9	8.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	4.66										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Table 5.73 Treatment Differences for Vegetative Cover on Non-Irrigated Sub-Plots at the Lubbock County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		4.00	22.33	31.66	5.66	5.66	6.66	4.00	7.33	5.66	8.00
T0	4.00	0.00	-18.33 [c]	-27.66 [c]	-1.66	-1.66	-2.66	0.00	-3.33	-1.66	-4.00
T1	22.33	-	0.00	-9.33	16.67 [c]	16.67 [c]	15.67 [c]	18.33 [c]	15.00 [c]	16.67 [c]	14.33 [c]
T2	31.66	-	-	0.00	26.00 [c]	26.00 [c]	25.00 [c]	27.66 [c]	24.33 [c]	26.00 [c]	23.66 [c]
T3	5.66	-	-	-	0.00	0.00	-1.00	1.66	-1.67	0.00	-2.34
T4	5.66	-	-	-	-	0.00	-1.00	1.66	-1.67	0.00	-2.34
T5	6.66	-	-	-	-	-	0.00	2.66	-0.67	1.00	-1.34
T6	4.00	-	-	-	-	-	-	0.00	-3.33	-1.66	-4.00
T7	7.33	-	-	-	-	-	-	-	0.00	1.67	-0.67
T8	5.66	-	-	-	-	-	-	-	-	0.00	-2.34
T9	8.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	4.66										

[a] Least squares means; n = 60; P < 0.05
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Cotton Burr Compost (0.25-inch layer)
T6 = Cotton Burr Compost (0.50-inch layer)
T7 = Cotton Burr Compost (1.00-inch layer)
T8 = Cotton Burr Compost (2.00-inch layer)
T9 = Cotton Burr Compost (4.00-inch layer)

Statistical analysis of vegetative cover at the Karnes County site indicated treatment effects and irrigation effects, but no irrigation x treatment interaction. A between treatment difference of 18% or more was considered significant. Table 5.74 shows treatment differences for vegetative coverage at the Karnes County Site.

Karnes County sub-plots treated with straw-soil retention blanket (T2) had higher vegetative coverage (47%) than sub-plots treated with cellulose fiber mulch (T3) (21%), a 0.25-inch layer of biosolids compost (T5) (29%), or a 2.00-inch layer of biosolids compost (T8) (29%). Compost manufactured topsoil (T4) had more vegetative coverage (53%) than the control (T1), cellulose fiber (T3), and 0.25-inch (T5), 0.50-inch (T6), and 2.00-inch (T8) biosolids compost (22%, 21%, 29%, 32%, and <1%, respectively). All other treatments produced greater vegetative coverage than the 4.00-inch layer of biosolids compost (T9), which had <1% vegetative cover.

Table 5.74 Treatment Differences for Vegetative Cover at the Karnes County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		22.16	35.00	47.33	20.66	52.83	28.83	32.83	36.83	29.00	0.83
T0	22.16	0.00	-12.84	-25.17 [c]	1.50	-30.67 [c]	-6.67	-10.67	-14.67	-6.84	21.33 [c]
T1	35.00	-	0.00	-12.33	14.34	-17.83	6.17	2.17	-1.83	6.00	34.17 [c]
T2	47.33	-	-	0.00	26.67 [c]	-5.50	18.50 [c]	14.50	10.50	18.33 [c]	46.50 [c]
T3	20.66	-	-	-	0.00	-32.17 [c]	-8.17	-12.17	-16.17	-8.34	19.83 [c]
T4	52.83	-	-	-	-	0.00	24.00 [c]	20.00 [c]	16.00	23.83 [c]	52.00 [c]
T5	28.83	-	-	-	-	-	0.00	-4.00	-8.00	-0.17	28.00 [c]
T6	32.83	-	-	-	-	-	-	0.00	-4.00	3.83	32.00 [c]
T7	36.83	-	-	-	-	-	-	-	0.00	7.83	36.00 [c]
T8	29.00	-	-	-	-	-	-	-	-	0.00	28.17 [c]
T9	0.83	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	6.95										

[a] Least squares means; n = 60; $P < 0.05$.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; $P < 0.05$

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Biosolids Compost (0.25-inch layer)
T6 = Biosolids Compost (0.50-inch layer)
T7 = Biosolids Compost (1.00-inch layer)
T8 = Biosolids Compost (2.00-inch layer)
T9 = Biosolids Compost (4.00-inch layer)

Statistical analysis of vegetative cover at the Falls County site indicated an irrigation effect, but no treatment effects and no irrigation x treatment interaction (P < 0.05). Vegetation coverage at the Falls County site was poor for all treatments, ranging from no vegetative cover to 14% vegetative coverage. The control (T0), 0.25-inch layer of dairy manure compost mulch (T5), 0.50-inch-layer of dairy manure compost mulch (T6), and straw mulch/soil retention blanket (T2), had comparable vegetative coverage (11%, 14%, 12%, and 10%, respectively). Table 5.75 presents differences between treatments at the Falls County site.

Table 5.75 Treatment Differences for Vegetative Cover on at the Falls County Field Site[a]

		T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
		10.66	2.00	9.50	2.66	0.33	13.50	11.83	1.16	6.66	0.00
T0	10.66	0.00	8.66	1.16	8.00	10.33	-2.84	-1.17	9.50	4.00	10.66
T1	2.00	-	0.00	-7.50	-0.66	1.67	-11.50	-9.83	0.84	-4.66	2.00
T2	9.50	-	-	0.00	6.84	9.17	-4.00	-2.33	8.34	2.84	9.50
T3	2.66	-	-	-	0.00	2.33	-10.84	-9.17	1.50	-4.00	2.66
T4	0.33	-	-	-	-	0.00	-13.17	-11.50	-0.83	-6.33	0.33
T5	13.50	-	-	-	-	-	0.00	1.67	12.34	6.84	13.50
T6	11.83	-	-	-	-	-	-	0.00	10.67	5.17	11.83
T7	1.16	-	-	-	-	-	-	-	0.00	-5.50	1.16
T8	6.66	-	-	-	-	-	-	-	-	0.00	6.66
T9	0.00	-	-	-	-	-	-	-	-	-	0.00
SEM[b]	5.61										

[a] Least squares means; n = 60; P < 0.05.
[b] Pooled standard error of the treatment means
[c] Significant difference between treatments; P < 0.05

T0 = No Surface Protection
T1 = Soil Retention Blanket
T2 = Straw Mulch-Soil Retention Blanket
T3 = Cellulose Fiber Mulch
T4 = Compost Manufactured Topsoil
T5 = Dairy Cattle Compost (0.25-inch layer)
T6 = Dairy Cattle Compost (0.50-inch layer)
T7 = Dairy Cattle Compost (1.00-inch layer)
T8 = Dairy Cattle Compost (2.00-inch layer)
T9 = Dairy Cattle Compost (4.00-inch layer)

CHAPTER VI

CONCLUSIONS

The research underlying this report consisted of an investigation designed to determine if the establishment of vegetation on highway rights-of-way could be improved by the application of compost as mulch compared to various traditional methods of protection. A review of scientific literature and field trials in three diverse geographical regions of the state of Texas defined the research component of the experiment. Physical evidence, visual observations, and laboratory analyses were combined with descriptive and inferential statistical methods to form the investigative component. The body of evidence collected supports the following conclusions.

1. One-half-inch of supplemental irrigation per month provided no beneficial effects on the establishment of roadside vegetation in the Texas Blackland Prairie, on the Northern Rio Grande Plain, or on the Southern High Plains regions of the State of Texas during a dry year.

2. Soil moisture was more effectively conserved by application of straw mulch held in place by jute netting (T2), by the compost manufactured topsoil (T4), or by the application of a 4.0-inch layer of compost mulch (T9) than for other treatments applied during the study.

3. Soil temperature was reduced by application of straw mulch held in place by jute netting (T2), or by the application of a 2.0-inch (T8) to 4.0-inch (T9) layer of compost mulch, when compared to other treatments applied during the study.

4. The emergence and establishment of perennial grasses was retarded or even prevented by the application of compost mulch in excess of 1-inch in depth.

5. A 4.0-inch layer of mature compost mulch prevented most annual and invading plants from reestablishing subsequent to tillage of soil at each of the three field test sites observed during the study.

CHAPTER VII

RECOMMENDATION FOR FURTHER RESEARCH

7.1 Overview

The experiment just completed evaluated the effect of 10 different treatments on the establishment of roadside vegetation in microenvironments. Evaluation of the effects of each treatment within a 10-foot square provides the basis for selecting one treatment over another, and for further investigation into practical application of each. A logical continuation of research into the use of compost is a large-scale, long-term study at one highway construction location.

Even though the supplemental irrigation showed no beneficial effect on plant emergence and establishment, the fact that these field trials were conducted during a dry year precludes the conclusion that no benefits can be achieved. Results of the field trials indicate that if supplemental irrigation is provided, then it must be applied according to the crop consumptive use.

The 4-inch layer of compost mulch was effective in retaining soil moisture, but compost mulch layers greater than 2-inches retarded or prevented seed emergence and establishment. Soil temperature was also affected by the thickness of a layer of compost mulch, especially during the first few weeks of the field trial. Retardation of the natural soil warming regime, coupled with high volumetric water content, appears to exert a negative influence on seed emergence.

Compost feedstock constituents must be considered when either incorporation of compost into the soil or application of compost as mulch is planned. The quantity and availability of various nutrients is directly determined by the raw materials used in the production of compost. A 1-inch layer of dairy cattle compost used during the field trial contributed approximately 500 lb total N / acre, whereas the cotton burr compost contributed twice that amount. Although only a portion of the nutrients contained in a given compost are available during the year of application, plant requirements and potential environmental contamination must be considered when applying compost to any highway ROW.

Plant selection is another factor affecting the success or failure of either an initial vegetation project or a revegetation effort. Fast growing annuals, such as wheat or rye grass, can be used to stabilize slopes, and can effectively serve as nurse crops for desired perennials. Annuals can also improve the appearance of recently disturbed ROW during the initial establishment year required by the perennials making up the bulk of required TxDOT seed mixes.

7.2 Recommendation

Texas Tech researchers suggest a cooperative TxDOT/TTU implementation project, having a three-year duration. The proposed study could emphasize topsoil replacement, site stabilization, seedbed preparation, plant selection, erosion mitigation practices, development and implementation of a suitable irrigation system, and refinement of best management practices. The general approach could be similar to the approach used in reclamation of land disturbed by strip-mining. All phases of the project will be planned, coordinated, and supervised by members of the TxDOT/TTU co-op team.

The proposed field trial suggests use of one type of general use compost, and includes three replicates of each of 9 randomly applied treatments. Treatments would be applied along both sides of a one-mile section of highway ROW in a selected TxDOT district. Table 7.1 contains suggested treatments.

Table 7.1 Suggested Treatments for the Proposed TxDOT/TTU Cooperative Implementation Project

Treatment	Description	Supplemental Fertilizer
Control 1	No Protective Cover	No
Control 2	No Protective Cover	Yes
Compost Mulch	1.0-inch layer	No
Compost Manufactured Topsoil 1 (CMT 1)	1.0-inch layer tilled into the top 4 inches of soil	No
Compost Manufactured Topsoil 2 (CMT 2)	2.0-inch layer tilled into the top 8 inches of soil	No
Straw Mulch 1	2.5 T/acre ; mechanically crimped;	Yes
Straw Mulch 2	2.5 T/acre; secured by jute netting;	Yes
Combination Treatment 1	CMT 1 covered by Straw Mulch held in place by jute netting	No
Combination Treatment 2	CMT 2 covered by Straw Mulch held in place by jute netting	No

7.3 Benefits Attributable to the Recommended Project

The recommended implementation project builds on the foundation laid during TxDOT Project 0-4571, and should result in the development of cost-effective best management practices (BMP). The project should lead to the conclusion that one of the suggested treatments possesses the attributes needed to qualify it as a TxDOT recommended general-use treatment. Erosion mitigation and vegetation management BMP can be developed or modified to take advantage of the stability created by the selected treatment.