RELATIONSHIP BETWEEN SOIL TESTS, PLANT ANALYSES, AND CORN PRODUCTION ON KEY SOILS IN CIMARRON COUNTY, OKLAHOMA

By

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COUNTY, OKLAHOMA

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CHAPTER I

INTRODUCTION

The simplest method of evaluating the soil fertility status of soils is by soil testing. Plant analysis is valuable in monitoring nutrient levels in plants to determine any problems with plant uptake of soil nutrients. The two diagnostic tools can be used together to summarize the soil fertility of a field or area and to make predictive statements about fertilizer needs. Cimarron County, Oklahoma, has considerable irrigated land with very little fertility evaluation by Oklahoma State University, thus the need for this study.

Interpretation of any soil test is accomplished through correlations between soil test results and known field crop responses to added nutrients. Therefore, calibration studies must precede meaningful interpretations of soil test values.

Plant analyses must also be calibrated with responses obtained from nutrient additions. One of the most popular approaches has been to establish critical concentrations of nutrients in some portion of the plant at some easily identifiable growth stage. Whenever a nutrient drops below the critical concentration, it is assumed that the nutrient is deficient. A plant deficiency means that the soil and/or fertilizer was not capable of furnishing adequate amounts of a nutrient to the plant.

Two types of studies were conducted to evaluate the soil fertility of Cimarron County irrigated lands: (1) nutrient surveys and (2) field studies.

The nutrient survey was conducted to--(1) determine the fertility status of irrigated soils in Cimarron County, Oklahoma, (2) determine nutrient concentration of corn leaves grown on selected irrigated fields in Cimarron County, and (3) determine the relationship between nutrient concentration in corn leaves and the soils on which the corn was growing.

In addition to the nutrient survey, field plots were established on a Portales clay loam in Cimarron County. One plot was initiated to ascertain the causative effect of chlorosis of corn leaves. The other study was conducted to evaluate the effects of three zinc additives in NH_3 when sidedressed to corn.

CHAPTER II

LITERATURE REVIEW

Soil Test Analysis

Soil testing has been given both a restricted and a broadened meaning--restricted in the sense that it has come to mean rapid chemical analysis to assess the available nutrient status of a soil, and broadened to include interpretations, evaluations, and fertilizer recommendations. (Melsted and Peck, 1967).

The goal of soil testing is to provide a guide for soil fertility management using experimentally determined relationships between soil chemical properties and crop growth. These relationships must be defined with a broad enough base to be applicable to many fields, yet specific enough to apply to an individual field. The process of determining the soil-crop relationship is commonly referred to as calibration of chemical soil test values. (Rouse, 1967).

The soil testing program starts with the collection of a representative soil sample from a field. A good sample is the first criterion for a reliable soil test. This basic principle of collecting a representative sample of the field is essential to affirm an accurate chemical analysis on the nutrient status of that field. This does not mean that all the samples must or will yield the same test result, but rather that the results must reflect the true overall variations within the field. Initiating what is known about soil sampling would greatly improve the information provided by soil testing programs. Thomas and Hanway (1968) and Beckett and Webster (1971) point out the significance of lateral and vertical soil variations that affect sampling. Thomas and Hanway (1968) and Fitts and Hanway (1971) also state that sampling is the weakest and yet most important part of soil testing.

Following the soil sample collection and analysis, some kind of a "rating" system for evaluating soil test values is needed for writing fertilizer recommendations for certain yield goals or crop responses. Cope and Rouse (1973) state that the use of descriptive terms such as "low", "medium", and "high" in soil-test calibration have serious limitations. During the period that soil testing has been developing, varying concepts have been associated with these terms. Bray (1945) used relative yield or percentage sufficiency to describe degree of deficiency with 100 assigned to the point of no response. Rouse (1967) proposed the use of a combination of ratings defined in terms of relative yield and a fertility index expressed as percent sufficiency.

Baker and Tucker (1974) assigned each nutrient a specific rating or unit based on mobility. Nitrogen requirement is based on a yield goal of the crop while P and K requirements are based on soil test values and percent sufficiency for each specific crop.

Plant Analysis

Earlier methods of plant analysis were based on the concept that the concentration of a nutrient within the plant at any particular time is an integrated value of all the factors that have influenced the nutrient concentration up to the time the plant sample is taken. (Ulrich and Hills, 1967). That concept in plant analysis was the critical concentration which was defined by Munson and Nelson (1973) as the nutrient concentration in a plant sample below which growth rate, yield, or quality declines significantly. Ulrich and Hills (1967) defined the critical concentration as that concentration of a given form of a specific nutrient within a specified plant part at which plant growth begins to decline. They indicated that one can establish the critical level at the center of the transition zone or at a point at which a specific predetermined yield or growth reduction occurs.

Melsted, Motto, and Peck (1969) determined critical nutrient concentration for 11 essential nutrients for corn, soybean, wheat, and alfalfa. The critical plant composition values, as determined through conducting experiments at a number of locations involving thousands of plant analysis from 1952 to 1967, represented the nutrient composition level in the plant below which a growth stress would be expected to occur. Critical values have limited value since they designate only the lower end of the sufficiency range.

The Ohio State University Plant Analysis Program developed an interpretative plant analysis procedure which used the mean concentration plus or minus a standard deviation as the sufficient range. (Jones, 1967).

Plants are not homogenous in their nutrient element make-up since leaves, stems, and petioles, as well as similar plant parts at a different location on the plant will differ in composition. Therefore, it is essential to select a specific plant part from a definite location during a specific growth stage. Large changes in concentration generally occur early in the initial stages of growth and usually immediately following pollination. Some of these changes occur as the result of the dilution effect as the plant enters its rapid growth period. Since the essential elements do not enter the plant at a constant rate, concentration or dilution will occur, depending on the extent of the difference between plant growth and element absorption. For corn and grain sorghum, only one leaf or plant part per plant is normally collected. Most researchers sample the corn ear leaf or the leaf below the ear leaf during the silking stage of the corn plant.

The concentration values obtained from the plant analysis are usually placed into categories. Jones (1967) and Lockman (1969) published interpretative data for ear leaf analysis for corn within sufficiency ranges.

Numerous researchers have pointed out the complexities associated with interpreting corn leaf analysis. Peck, Walker, and Boone (1969) showed that regression analysis of corn yields with leaf levels of ten elements as independent variables revealed several significant relationships which indicated that the critical level of any particular nutrient varies with leaf levels of other nutrients.

Bennett, Stanford, and Dumenile (1953) showed that nitrogen fertilization significantly increased the phosphorus percentage in the corn leaf from plots of certain experiments which were associated with yield responses shown by determining the regression of yield on the content of these nutrients.

Shear, Crane, and Myers (1946) indicated that if all other factors were constant, plant growth was a function of two nutrition variables, intensity and balance, as they are reflected in the composition of leaves when plants are in the same stages of growth. Thus maximum growth and yield occur only upon coincidence of optimum intensity and balance of nutrients. They considered that leaf composition represented a measure of all environmental factors both internal and external which influenced nutrient accumulation by the plant. Ulrich (1943) suggested that the chemical analysis of the plant or some plant part gives an integrated value of all factors that have influenced its composition.

Hanway (1962) also studied corn growth and composition in relation to different plant parts throughout the life cycle of the corn plant. He followed the N, P, and K content of various corn plant parts over the growing season which showed the variations of each nutrient during the changing growth stages. This study pointed to the heterogenous and ever changing character of the nutrient status of the corn plant.

Soil-Plant Correlation

The effectiveness of soil and plant analysis can be improved through the development of more consistent interpretations originating from field research correlated with analytical laboratory results. Researchers (Walker and Peck, 1970) in Illinois conducted a state-wide survey obtaining early whole plant and midseason leaf sampling to determine the adequacy of nutrient levels for corn and soybeans. Their survey was conducted for three years using both plant analysis and soil testing, and this procedure was found to be effective for assessing progress in fertility programs and the adequacy of nutrition. While they had expected to discover micronutrient deficiencies, the largest number of deficient samples involved N, P, and K.

Irving (1970) stated that plant sampling is usually more convenient than soil sampling, but for a maximum value in fertilizer recommendations, both soil and plant samples should be taken. He recommended that the plant sampling be conducted in a systematic manner and taken at the proper stage of plant development. When both plant and soil samples are used, additional value can be obtained by supplying complementary data between the two analyses. Although plant analysis has often been used in the calibration of soil tests, only a small portion of the data has been published (Jones and Eck, 1973).

Agboola and Corey (1973) ran simple and multiple correlation coefficients between soil pH, organic matter, available phosphorus (P), exchangeable potassium (K), calcium, magnesium, and nine elements in the corn ear-leaf samples including N, P, K, Ca, Mg, B, Cu, Mn, and Zn. There was a positive and significant correlation between organic matter, available K, and exchangeable Ca. The soil pH was highly correlated with exchangeable Ca and K but not with exchangeable Mg or Bray's P. There were highly significant simple and partial correlations between the N in the plants and exchangeable Mg in the soil sample. Positive and significant simple correlations between leaf P and soil pH, available P, and exchangeable Ca and Mg were shown.

Thompson (1962) conducted two experiments to determine the effects of various applications of K and N on the mineral composition of the leaves of corn plants. The general trend of increased K applications to the soil was increased K content of the leaf but reduced Mg, Mn, and Al contents while the changes in P, B, and Cu levels were relatively slight. Nitrogen fertilization generally tended to raise the levels of Mg, Ca, Zn, Cu, and Mn but decreased the levels of K and Al in the leaf.

Jones (1959) plotted corn ear leaf composition versus soil test level for the elements P and K. Soil test interpretations were closely related to the increase in leaf P and K with fertilization. Jones (1968) reviewed several years of applying the plant technique in solving nutrient problems in farmers' fields in midwestern United States. Nitrogen, Mg, and Zn deficiences were the most common nutrient problems found with nitrogen deficiences primarily related to inadequate N rates, improper N application, and late sidedressing. The magnesium deficiences were due to low soil pH, inadequate soil-available Mg, and heavy N and K fertilization. When Zn deficiences were found in the midwestern survey area, they occurred associated with sandy soils having neutral or high pH values with high available P or with exposed subsoils. These observations suggest strong relationships between plant nutrient levels and soil test levels, fertilizer treatments and soil characteristics.

CHAPTER III

METHODS AND MATERIALS

Soil Fertility Survey

This experiment was conducted in Cimarron County, Oklahoma, on irrigated soils. Soils which were planted to corn were selected for the study because more plant analysis data is available for corn and because irrigators have more problems producing high yields of corn. The collection of soil samples began on May 19, 1975, at which time most of the fields had been fertilized and the corn crop had been planted. Since the average annual rainfall of Cimarron County is approximately 17 inches, irrigation of the corn is essential. Soil samples were collected from 106 different field locations as shown in Figure I. Fifteen different soil types were sampled in this survey. A list of the soils is given in Table I.

A list of cooperators and field location descriptions are given in Table II.

Each field location was sampled at three different soil depths (0-8", 8-24", and 24-36") from approximately fifteen locations randomly selected throughout the sampled location. Each soil depth was composited into a subsample

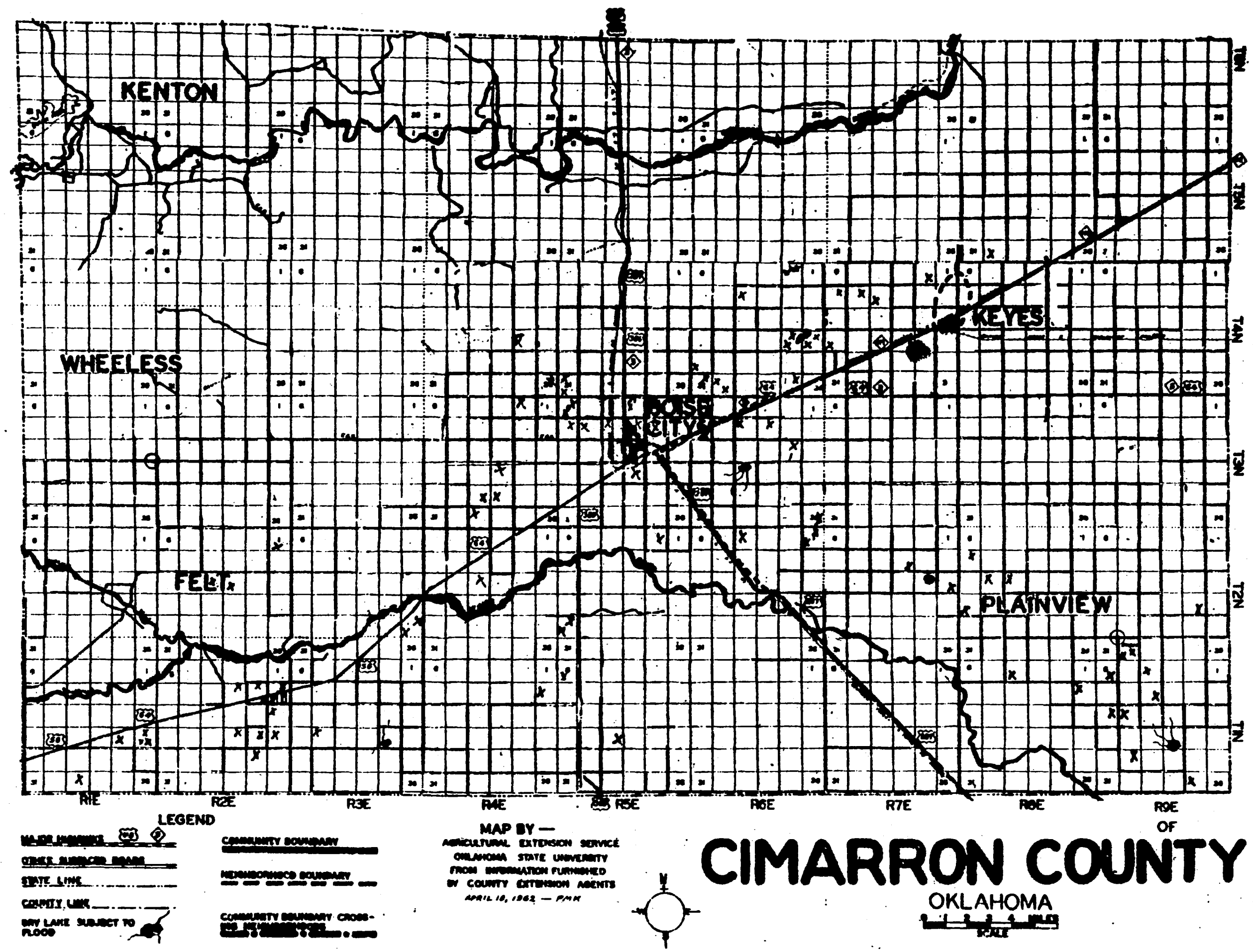

Figure 1. Cimarron County Soil Sample Locations

TABLE I

A LISTING OF THE SOILS SAMPLED IN THE SURVEY

Symbol		Name
1.	Da	Dalhart fine sandy loam, 0-1 percent slopes
2.	Db	Dalhart fine sandy loam, 1-3 percent slopes
3.	Dc	Dalhart fine sandy loam, 0-3 percent slopes eroded
4.	Dd	Dalhart loamy fine sand, 0-3 percent slopes
5.	Mb	Mansker loam, 0-3 percent slopes
6.	Md	Mansker-Dalhart loams, 1-3 percent slopes
7.	Pa	Portales clay loam, 0-1 percent slopes
8.	Pb	Portales clay loam, 1-2 percent slopes
9.	Pc	Potter-Mansker loams, 1-3 percent slopes
10.	Ra	Randall clay
11.	Rb	Richfield clay loam, 0-1 percent slopes
12.	Rc	Richfield clay loam, 1-2 percent slopes
13.	Rd	Richfield fine sandy loam, 0-1 percent slopes
14.	Re	Richfield loam, 0-1 percent slopes
15.	Vb	Vona-Tivoli loamy fine sands

TABLE II

COOPERATOR LIST AND FIELD LOCATION DESCRIPTION

Cooperator	Sample No.	Legal Description
Charles Hawkins	1	S½ of NW¼ of Sec 8 T3N R5E
Boise City, OK	51	S½ of NE¼ of Sec 10 T3N R5E
Roy Imler	2	N½ of NE¼ of Sec 9 T3N R5E
Boise City	3	S½ of NE¼ of Sec 9 T3N R5E
	63	W½ of N½ of SW¼ of Sec 27 T3N R4E
Jr. Heppard	62	N½ of SE¼ of Sec 28 T3N R4E
Boise City	61	W½ of NW¼ of Sec 33 T3N R4E
Jerry Turner	5	N½ of NW¼ of Sec 3 T3N R5E
Boise City	4	N 1/8 of SW¼ of Sec 3 T3N R5E
Tom Nance Ranch	6	SW¼ of Sec 30 T2N R5E
Warren Bushnell	9	Southern part of SE¼ of Sec 19 & NE¼ of Sec 30 T2N R5E
	7	SW¼ of Sec 6 T1N R5E
	8	N½ of NW¼ of Sec 6 T1N R5E
Art Betts	10	N½ of SE¼ of Sec 13 T3N R5E
Keyes	11	N½ of NE¼ of Sec 13 T3N R5E
	33	S½ of NE¼ of Sec 8 T4N R7E
	34	S½ of SE¼ of Sec 10 T2N R7E
Dayle Oyler	12	SE¼ of Sec 13 T2N R7E
Texhoma	13	S½ of NW¼ of Sec 16 T2N R8E
George Towbly Texhoma	14	S½ of NW¼ of Sec 22 T2N R8E
Brown Brothers	15	S½ of NW¼ of Sec 22 T2N R8E
Calvin Brown Boise City	16	NW¼ of Sec 12 T1N R8E
William & Larry Bulls Boise City	17	S½ of NE¼ of Sec 12 T1N R2E

TABLE II continued

Cooperator	Sample No.	Legal Description
George Camilli, Jr. Boise City	18	SW¼ of Sec 15 T2N R2E
	19	N½ of SE¼ of Sec 16 T2N R2E
	20	SW¼ of Sec 1 T2N R2E
Gary Reagan	21	N½ of NW¼ of Sec 13 T1N R2E
	22	E½ of N½ of NE¼ of Sec 22 T1N R2E
Harold James	78	W½ of N½ of NE¼ of Sec 7 T2N R8E
Bud Kincannon Boise City	72	S½ of NW¼ of Sec 17 T2N R8E
Paul Redwine Boise City	73	E½ of S½ of NE¼ of Sec 2 T2N R5E
	74	W½ of N½ of NW¼ of Sec 4 T2N R6E
John Henderson Texhoma	80	S¼ of NW¼ of Sec 35 T1N R9E
Mike Asher Texhoma	81	N 1/3 of NE¼ of Sec 29 T1N R9E
	82	SE¼ of Sec 9 T1N R9E
Cecil Reed Stratford, TX	83	Center of NW¼ of Sec 17 T1N R9E
	84	N½ of NE¼ of Sec 18 T1N R9E
Lane Sparkman Texhoma	85	W½ of SE¼ of Sec 6 T1N R9E
Albert Ferguson Texhoma	86	N½ of SW¼ of Sec 4 T1N R9E
	87	E½ of S½ of SW¼ of Sec 32 T2N R9E
Marvin Elliot Texhoma	88	S 1/3 of NE¼ of Sec 32 T2N R9E
	89	Center of SE¼ of Sec 23 T2N R9E
Jerrie Thrash Texhoma	90	SW¼ of Sec 4 T1N R8E

TABLE II continued

Cooperator	Sample No.	Legal Description
Charles Beckett Boise City	103	Center of SW¼ of Sec 12 T1N R4E
	100	NW¼ of Sec 13 T3N R5E
Bill Shepard Felt	50	SE¼ of Sec 21 T1N R5E
Wesley Sanders Boise City	105	SW¼ of Sec 20 T3N R7E
Wilson Farms	102	NW¼ of Sec 22 T3N R4E
Bob Wilson Boise City	59	SW¼ of Sec 23 T4N R4E
Freddie Miller	43	N½ of SW¼ of Sec 22 T4N R6E
Boise City	44	Center of NE¼ of Sec 22 T4N R6E
Jim Campbell Boise City	45	Center of SW¼ of Sec 12 T3N R5E
	46	Center of NE¼ of Sec 12 T3N R5E
	47	W½ of NE¼ of Sec 1 T3N R5E
Bill Cook	48	N½ of NE¼ of Sec 11 T3N R5E
Boise City	49	Center of SE¼ of Sec 11 T3N R5E
	50	N½ of SW¼ of Sec 11 T3N R5E
Bob Lathrop	58	NE¼ of Sec 36 T4N R4E
Boise City	94	SW¼ of Sec 23 T4N R6E
Ronnie Lathrop	95	SW¼ of Sec 24
Boise City	96	SW¼ of Sec 13 T4N R6E
Charles Payne	93	NE¼ of Sec 35 T4N R6E
Boise City	92	N½ of NE¼ of Sec 10 T3N R6E
George Nall Boise City	98	NW¼ of Sec 9 T3N R6E
Harvey Burleson Boise City	91	E½ of NE¼ of Sec 14 T3N R6E

TABLE II continued

Cooperator	Sample No.	Legal Description
D. A. Machotka	97	W$\frac{1}{2}$ of SW$\frac{1}{4}$ of Sec 30 T4N R6E
Boise City	99	N$\frac{1}{4}$ of SE$\frac{1}{4}$ of Sec 1 T3N R5E
Vic Carey	60	S$\frac{1}{2}$ of NW$\frac{1}{4}$ of Sec 2 T3N R4E
Boise City	55	N$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 6 T3N R5E
	42	S$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 23 T4N R6E
	75	S$\frac{1}{2}$ of NW$\frac{1}{4}$ of Sec 1 T2N R6E
Jim Palmer	56	N$\frac{1}{2}$ of NW$\frac{1}{4}$ of Sec 31 T4N R5E
Boise City	57	S$\frac{1}{4}$ of SW$\frac{1}{4}$ of Sec 31 T4N R5E
	76	S$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 1 T2N R6E
Lloyd French	53	E$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 7 T3N R5E
Boise City	54	W$\frac{1}{2}$ of SE$\frac{1}{4}$ of Sec 6 T3N R5E
Bill James Boise City	52	E$\frac{1}{2}$ of N$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 22 T3N R5E
	77	W$\frac{1}{2}$ of SE$\frac{1}{4}$ of Sec 36 T3N R6E
	101	NE$\frac{1}{4}$ of Sec 16 T2N R4E
Claude Smith	23	SW$\frac{1}{4}$ of Sec 12 T1N R2E
Felt	24	E$\frac{1}{2}$ of N$\frac{1}{2}$ of SE$\frac{1}{4}$ of Sec 24 T1N R1E
	104	W$\frac{1}{2}$ of N$\frac{1}{2}$ of SE$\frac{1}{4}$ of Sec 24 T1N R1E
	25	S$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 24 T1N R1E
Russell McDaniel	26	N$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 10 T1N R2E
Felt	27	W$\frac{1}{2}$ of N$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 11 T1N R2E
	28	E$\frac{1}{2}$ of S$\frac{1}{2}$ of SE$\frac{1}{4}$ of Sec 11 T1N R2E
Lawerence Funk Felt	64	W$\frac{1}{2}$ of S$\frac{1}{2}$ of NE$\frac{1}{4}$ of Sec 33 T1N R1E
	65	N$\frac{1}{2}$ of SW$\frac{1}{4}$ of Sec 23 T1N R1E
Donald May Felt	66	N$\frac{1}{2}$ of SW$\frac{1}{4}$ of Sec 24 T1N R2E
Oscar Montgomery Felt	67	E$\frac{1}{2}$ of N$\frac{1}{2}$ of SE$\frac{1}{4}$ of Sec 23 T1N R2E
Guy Ottinger	68	N$\frac{1}{2}$ of NW$\frac{1}{4}$ of Sec 26 T1N R2E
Boise City	69	NW$\frac{1}{4}$ of Sec 20 T1N R3E

TABLE II continued

Cooperator	Sample No.	Legal Description
Kuehler Farms Felt	70	NE¼ of Sec 25 T2N R3E
	71	E½ of SE¼ of Sec 26 + W½ of SW¼ of Sec 25 T2N R3E
Charles Williams Keyes	29	W½ of SW¼ of Sec 32 T5N R8E
Chris Hunt Keyes	31	W½ of N½ of NE¼ of Sec 11 T4N R7E
Bill Williams Keyes	30	E½ of NE¼ of Sec 7 T4N R7E
Randy & Robin Sellers Boise City	37	E½ of N½ of NW¼ of Sec 2 T4N R6E
	35	E½ of SW¼ of Sec 9 T4N R7E
	36	N½ of NE¼ of Sec 2 T4N R6E
	32	S½ of NW¼ of Sec 2 T4N R6E
Orvle Embry Boise City	38	NW¼ of Sec 9 T4N R6E
Jim Malone Boise City	39	S½ of SE¼ of Sec 32 T4N R6E
	40	Center of SW¼ of Sec 32 T4N R6E
	41	N½ of NE¼ of Sec 31 T4N R6E

and allowed to air dry. Soil samples were also taken from areas showing indications of a plant deficiency. The soil sample collection was completed June 17, 1975. The samples were analyzed for ten essential nutrients plus soil pH by methods of analysis currently in use by the Oklahoma State University Soil and Water Testing Laboratory (Table III). Each soil sample was oven-dried at 40°C for 24 hours, and then ground to pass through a 2mm sieve prior to analysis.

Corn leaf samples were collected at two different periods of time representing early (approximately five weeks after emergence) and late (during silking) growth stages. The leaf samples were collected from the same areas as the soil samples. The method of plant sample collection is described in Table IV. Plant leaf samples were collected from approximately fifteen locations throughout the sampled area and composited. After collection, the plant samples were allowed to air-dry quickly. All samples were oven-dried at 65°C for 24 hours prior to being ground in a Wiley Mill to a fineness to pass through a 1mm stainless screen. The plant samples were analyzed for nine essential nutrients as shown in Table V.

While collecting the second plant samples, irrigation water samples were collected from operating irrigation wells. Sixty-nine samples were collected and analyzed according to USDA Handbook No. 60. (Richards, 1954). The elements analyzed were Ca, Mg, Na, Cl, SO_4, CO_3, HCO_3, and

TABLE III

ANALYTICAL PROCEDURES USED FOR CHEMICAL ANALYSIS OF SOIL SAMPLES

Element	Procedure
pH	1:1 Soil:H_2O solution, measured by glass electrode
NO_3-N	$CaSO_4$ extractant, measured by Orion specific ion electrode
P	Bray 1 (1:20 soil:solution), measured colorimetrically
K	1N ammonium acetate extractant (1:5 soil:solution), measured by flame emission
Ca, Mg K, Na	1N ammonium acetate extractant (1:5 soil:solution), measured by atomic absorption
Fe, Zn, Mn, Cu	.005M DTPA extractant (1:2 soil:solution), measured by atomic absorption
B	Hot water soluble (1:2 soil:.01M $CaCl_2$) measured colorimetrically

TABLE IV

PLANT SAMPLE COLLECTION DATA

Sampling Stage	Collection Date	Plant Part Sampled
1st (24" tall)	June 27-July 3	First fully developed leaf from the top when corn plant was approximately 24" tall
2nd (Silking stage)	Aug. 1-Aug. 15	Leaf below and opposite the ear-leaf when corn plant was silking

TABLE V

ANALYTICAL PROCEDURES USED FOR CHEMICAL ANALYSIS OF PLANT SAMPLE

Element	Procedure
N (%)	Micro-Kjeldahl analysis
P (%)	Nitroperchloric acid digestion measured colorimetrically
K (%)	Nitroperchloric acid digestion, determined by flame emission
Ca, Mg (%)	Nitroperchloric acid digestion, determined by atomic absorption after adding $LaCl_2$
Fe, Zn, Mn, Cu (ppm)	Nitroperchloric acid digestion, determined by atomic absorption

NO_3. Other analysis included pH, sodium adsorption ratio, and conductivity.

Zinc-Anhydrous Ammonia Field Plot

A field plot experiment was conducted to evaluate the effects of three NH_3-Zn additives on corn yields and plant composition. Three different formulations of anhydrous ammonia combined with a zinc additive were furnished by the Phillips Petroleum Corporation, Bartlesville, Oklahoma. The field plot was established on June 26, 1975, when the corn plants were approximately 12 inches tall.

The experimental plot was a randomized complete block design. Each block was replicated four times. A special anhydrous ammonia applicator was used to sidedress the zinc-NH_3 formulations. Table VI gives the amount of the formulations applied.

Soil samples were collected from each check block and analyzed as described in the survey. Plant samples were collected from each block as also described in the survey. The experimental plot was harvested on October 7, 1975, to obtain both corn forage and grain yields.

The NH_3-Zn additive plot, located on a Portales clay loam, was chosen since there were corn plants growing that showed a deficiency symptom of alternating dark green and light green stripes located mainly on the upper leaves. Duplicate foliar spray plots were established to confirm the deficient nutrient. Ferrous sulfate, $CuSO_4$, K_2SO_4,

TABLE VI

$ZN\text{-}NH_3$ ADDITIVES

Formulation	Rate of $Zn\text{-}NH_3$ (lbs./A)	%Zn in NH_3
3	266	0.2384
7	266	0.2384
9	266	0.2384

$ZnSO_4$, and $MnSO_4$ solutions (five percent) were applied at a rate of 20 gallons per acre on the corn plant leaves with a hand sprayer. The K_2SO_4 solution was applied to check for a possible sulfur deficiency.

Statistical Analysis

Statistical analyses of several soil and plant variables were accomplished by a stepwise regression procedure devised for computer by Barr and Goodnight (1972). A set of dependent variables was chosen to be tested against each of the independent variables.

Two stepwise regression procedures were used in addition to an analysis of variance (hereafter referred to as AOV) involving the significance on the influence of soil type on the variables.

Analysis of variance among forage and grain yields from the Zn-NH_3 test plot was conducted.

Each soil and plant variable was abbreviated to simplify statistical analysis (Table VII).

TABLE VII

LIST OF ABBREVIATED VARIABLES
FOR COMPUTER ANALYSIS

Soil	0-8"	8-24"	24+"	0-24"	0-24+"
pH	SoilpH1				
NO_3(lbs./A)	SoilN1	SoilN2	SoilN3	SolN12	SolN123
P(lbs./A)	SoilP1	SoilP2	SoilP3	SolP12	SolP123
K(lbs./A)	SoilK1	SoilK2			
Ca(lbs./A)	SoilCa1				
Mg(lbs./A)	SoilMg1				
Fe(ppm)	SoilFe1				
Zn(ppm)	SoilZn1				
Mn(ppm)	SoilMn1				
Cu(ppm)	SoilCu1				
Soil type	ST				

TABLE VII continued

Plant(PLT)	1st Stage (STG)	2nd Stage (STG)
N (%)	PLTN1	PLTN2
P (%)	PLTP1	PLTP2
K (%)	PLTK1	PLTK2
Ca (%)	PLTCa1	PLTCa2
Mg (%)	PLTMg1	PLTMg2
Fe(ppm)	PLTFe1	PLTFe2
Zn(ppm)	PLTZn1	PLTZn2
Mn(ppm)	PLTMn1	PLTMn2
Cu(ppm)	PLTCu1	PLTCu2

CHAPTER IV

RESULTS AND DISCUSSION

Soil Test Results

Soil pH

The mean soil pH value (7.8) in Cimarron County is fairly high due to excessive levels of calcium. Table VIII shows that 90 percent of the soils sampled at the first depth (0-8") had a pH value greater than 7.3. The Richfield and Dalhart soils had lower pH values than the Portales or Mansker soils but not a measurable difference.

Soil Nitrogen

The soil nitrate values were divided into two divisions to make it simpler to interpret the results. The divisions and percentage of those soils tested are given in Table IX. Eighty-one percent of the soils sampled had been fertilized prior to the soil sample collection. The range of NO_3-N values ran from a minimum of 9.0 pounds per acre (hereafter referred to as lbs./A) to a maximum value of 230 lbs./A in the first depth. The Richfield soil contained higher amounts of NO_3-N than the other soils. The Richfield soils probably have been fertilized at higher

TABLE VIII

SOIL PH

Soil Class	Mean (0-8")	% Above 7.3 (0-8")
Dalhart	7.8	82
Mansker	7.8	100
Portales	8.0	100
Richfield	7.7	86
Overall	7.8	89

TABLE IX

SOIL NITRATE-NITROGEN LEVELS

NO_3	% Below 40 lbs./A			% Above 80 lbs./A		
	0-8"	8-24"	24+"	0-8"	8-24"	24+"
Dalhart	63	57	90	5	19	0
Mansker	30	60	80	40	20	10
Portales	40	53	87	20	20	0
Richfield	23	57	87	41	18	0
Overall	34	56	83	30	19	1

	0-8"	8-24"
Range	9-230 lbs./A	16-216 lbs./A
Mean	68 lbs./A	53 lbs./A

rates than the other soils. The Dalhart soil shows a smaller percentage of soils testing greater than 80 lbs./A in the (0-8") depth than the (8-24") depth. The overall NO_3-N test results show that only 30 percent of the soils tested contained greater than 80 lbs./A NO_3 in the upper eight inches of the soil profile. Several cooperators planned to later sidedress or put additional N through the irrigation system.

Soil Phosphorus

Forty-eight percent of the soils tested had been fertilized with a phosphate fertilizer prior to the soil sample collection.

The range of soil P was from 3 lbs./A to a maximum of 168 lbs./A with a mean value of 49 lbs./A in the top eight inches of the soil but only a mean value of 13 lbs./A in the (8-24") soil depth. The soil P ratings were divided into divisions as shown in Table X. In the Portales soil 67 percent of the samples contained less than 20 lbs./A of available soil P which is probably due to the higher soil pH and Ca resulting in less P availability because of the formation of insoluble calcium phosphate compounds. There is a possibility that the high $CaCO_3$ content of Portales soils neutralized the acidity of the Bray 1 extractant. Only 28 percent of the overall (0-8") samples and none of the (8-24") samples contained above 65 lbs./A which gives evidence of the need for additional amounts of fertilizer P.

TABLE X

SOIL PHOSPHORUS

	% Soil Samples Below 20 lbs./A			% Soil Samples Above 65 lbs./A		
	0-8"	8-24"	24+"	0-8"	8-24"	24+"
Dalhart	19	91	100	14	0	0
Mansker	10	100	90	0	0	0
Portales	67	94	100	0	0	0
Richfield	10	68	81	46	0	3
Overall	20	79	89	28	0	2

	0-8"	8-24"
Range	3-168 lbs./A	3-63 lbs./A
Mean	49 lbs./A	13 lbs./A

Soil Potassium

Soil K was shown to be adequate in all soils tested; i.e., 100 percent of all the soils tested were above 250 lbs./A, the maximum value considered to be adequate (Table XI). The Dalhart soil was shown to have only 55 percent of the soils to contain above 350 lbs./A soil K due to the low amounts of clay in the topsoil. The range of soil K values ran from 295 lbs./A to 1595 lbs./A in the (0-8") depth.

Soil Calcium and Magnesium

The range of soil test values in the (0-8") depth for Ca and Mg were 1550-9100 lbs./A and 170-2360 lbs./A respectively. The Dalhart soil contained less amounts of Ca and Mg as shown in Table XII.

A problem associated with Mg is that there is evidence of a ratio of exchangeable K to exchangeable Mg that is too wide which may cause an antagonizing reaction affecting nutrient uptake of Mg (Tisdale and Nelson, 1966).

Soil Iron

Iron has become a micronutrient of agronomic concern because of the evidence of its deficiency becoming more severe and widespread in the Great Plains. The soil test results shown in Table XIII indicates that 12 percent of the overall soils were from 2.1-4.5 ppm which is given as a marginal rating from OSU Extension Fact Sheet 2225.

TABLE XI

SOIL POTASSIUM

	% Above 250 lbs./A (0-8")	% Above 350 lbs./A (0-8")
Dalhart	100	55
Mansker	100	90
Portales	100	100
Richfield	100	100
Overall	100	90

	(0-8")
Range	295-1595 lbs./A
Mean	689 lbs./A

TABLE XII

SOIL CALCIUM AND MAGNESIUM

	% Above 3000 lbs./A Ca (0-8")	% Above 300 lbs./A Mg (0-8")
Dalhart	64	64
Mansker	90	100
Portales	100	100
Richfield	93	100
Overall	88	92
	Soil Ca (0-8")	Soil Mg (0-8")
Range	1550-9100 lbs./A	170-2360 lbs./A
Mean	5445 lbs./A	844 lbs./A

TABLE XIII

SOIL IRON

	% 2.1-4.5 ppm			% Above 4.5 ppm		
	0-8"	8-24"	24+"	0-8"	8-24"	24+"
Dalhart	9	5	5	91	95	95
Mansker	20	20	20	80	80	80
Portales	40	27	60	60	93	40
Richfield	5	3	12	95	97	88
Overall	12	8	18	88	92	82

	0-8"	8-24"
Range	3.0-16.8 ppm	2.4-20.2 ppm
Mean	7.0 ppm	7.5 ppm

Researchers (Lindsay and Norvell, 1969) placed soils that contained less than 4.5 ppm down to 2.5 ppm of Fe in a marginal category while those testing less than 2.5 ppm were placed in a deficient category. Two soils tested 2.4 ppm (samples 47 and 35). Both soils had a pH of 8.3 with a very low amount of soil P (less than 3 lbs./A) indicating the very high pH may be influencing the availability of both the P and Fe. One of the soils was a Richfield while the other was a Portales soil which showed very definite Fe deficiency symptoms on corn plants. Portales soils contained less amounts of Fe throughout the three depths.

Soil Zinc

Soil Zn levels obtained from the survey are given in Table XIV. Zinc levels ranged from 0.2 ppm to 7.6 ppm in the (0-8") sampling. Eighty-two percent of the Dalhart soils tested less than 0.5 ppm which is rated as a "low" value. The overall value shows that 90 percent of all soils tested contained less than 1.0 ppm. OSU Extension Fact Sheet 2225 gives values of 0.51-1.00 ppm Zn as a marginal rating. Few cooperators were apparently aware of the Zn problem since only about ten percent of the area had been fertilized with a zinc fertilizer.

Soil Manganese and Copper

Table XV shows that soil Mn levels are adequate for 100 percent of those soils tested. Soil Cu was adequate

TABLE XIV

SOIL ZINC

	% Below 0.50 ppm			% 0.51-1.0 ppm		
	0-8"	8-24"	24+"	0-8"	8-24"	24+"
Dalhart	82	86	90	9	10	10
Mansker	70	70	70	10	20	20
Portales	73	80	93	27	13	7
Richfield	54	42	60	36	28	17
Overall	64	58	72	26	22	14

	0-8"	8-24"
Range	0.20-7.60 ppm	0.12-9.98 ppm
Mean	0.62 ppm	0.70 ppm

TABLE XV

SOIL MANGANESE AND COPPER

	% Above 1.0 ppm Mn (0-8")	% Above 0.2 ppm Cu (0-8")
Dalhart	100	100
Mansker	100	100
Portales	100	100
Richfield	100	100
Overall	100	100
	Soil Mn (0-8")	Soil Cu (0-8")
Range	6.2-46.0 ppm	0.38-5.0 ppm
Mean	18.4 ppm	1.4 ppm

for all soils except on the location where an Fe deficiency was also present (area 47). Lindsay and Norvell (1973) stated the critical level for soil Cu as 0.2 ppm.

Soil Boron

Available B was tested in all the soil samples, but the values were not listed in the data because the plant samples were not tested for B. The range of available B tested between 0.04-0.99 ppm with a mean value of 0.29 ppm. Forty-five percent of all the samples tested below 0.25 ppm which is listed as a "low" value on the OSU Extension Fact Sheet 2225 indicating that there may be a boron deficiency problem in some of the soils of the survey area. Soils with higher pH values and higher levels of Ca reduce the availability of B (Fox, 1968).

Plant Analysis

Nutrient sufficiency ranges for the two stages of corn leaf samples were taken from Soil Testing and Plant Analysis (1973). The first stage values were taken from work conducted by Lockman (1969) (Table XVI) which were whole plant sample data rather than only a top mature leaf. Nutrient sufficiency levels used for the ear leaf at silking are given in Table XVIII.

Plant Nitrogen

The plant analysis results for the first stage plant N

TABLE XVI

SUFFICIENCY RANGES FOR THE FIRST SAMPLING OF CORN LEAVES

Element	Sufficiency Range			
	Very Low	Low	Sufficient	High
N (%)	-	<3.5	3.6-5.0	>5.0
P (%)	<0.28	0.29-0.40	0.41-0.8	>0.8
K (%)	-	<3.0	3.1-5.0	>5.0
Ca (%)	<0.7	0.8-0.9	1.0-1.6	>1.6
Mg (%)	-	<0.3	0.4-0.8	>0.8
Fe (ppm)	-	<50	51-300	>300
Zn (ppm)	<15	16-20	21-50	>50
Mn (ppm)	-	<50	51-160	>160
Cu (ppm)	-	<7	7-20	>20

From Soil Testing and Plant Analysis, American Society of Agronomy, Madison, Wisc.

TABLE XVIII

SUFFICIENCY RANGES FOR THE SECOND SAMPLING OF CORN LEAVES

Element	Sufficiency Range			
	Very Low	Low	Sufficient	High
N (%)	-	<2.76	2.77-3.50	>3.50
P (%)	<0.20	0.20-0.25	0.26-0.40	>0.40
K (%)	-	<1.71	1.72-2.50	>2.50
Ca (%)	-	<0.21	0.22-1.00	>1.00
Mg (%)	-	<0.21	0.22-0.60	>0.60
Fe (ppm)	-	<21	22-250	>250
Zn (ppm)	<15	16-20	21-70	>70
Mn (ppm)	-	<20	21-150	>150
Cu (ppm)	-	<6	7-20	>20

From *Soil Testing and Plant Analysis*, American Society of Agronomy, Madison, Wisc.

are given in Table XVII. The results shown indicate that 25 percent of the samples contain a "low" (less than 3.5 percent N) percent of N. Table XIX indicates that 43 percent of the second stage corn leaf samples fall in the "low" rating. This definitely points out that on these fields additional N is needed to maximize production.

Plant Phosphorus

The results of the plant P test indicates a very high percentage of samples testing in the "low" range (0.28 percent). The analysis from the silking stage (Table XIX) indicates an even higher percent (87 percent) of the samples testing in the "low" range (less than 0.25 percent P). The "low" division was further divided into two ranges: (1) those from 0.20-0.24 percent P and (2) those testing below 0.20 percent P. Thirty-nine percent of the total number of samples tested below 0.20 percent P indicating a very critical level of P in the corn ear leaf at the silking stage. The low plant P levels further verify the low soil P levels obtained from the soil analysis.

Plant Potassium

The plant K level of the first stage samples is very low (67 percent testing less than 3.0 percent K), but the second stage plant K level was sufficient in 85 percent of

TABLE XVII

PLANT ANALYSIS OF CORN LEAVES
EARLY SAMPLING

Element	% Very Low	% Low	% Sufficient	% High
Nitrogen	-	25	75	0
Phosphorus	63	33	4	0
Potassium	-	67	33	0
Calcium	26	45	27	2
Magnesium	-	22	78	0
Iron	-	0	23	77
Zinc	6	21	73	0
Manganese	-	2	83	15
Copper	-	0	64	36

TABLE XIX

PLANT ANALYSIS OF CORN LEAVES
SILKING STAGE

Element	% Very Low	% Low	% Sufficient	% High
Nitrogen	-	43	56	1
Phosphorus	39	48	13	0
Potassium	-	15	85	0
Calcium	-	0	100	0
Magnesium	-	18	82	0
Iron	-	0	92	8
Zinc	29	40	30	1
Manganese	-	0	92	8
Copper	-	0	39	61

the samples. The soil K levels were sufficient in all samples tested which indicates a possible problem of interpretation of the ranges of sufficiency of plant K. Research conducted by Agboola and Corey (1973) indicates that exchangeable Mg effects plant K through ion antagonism. The sufficiency ranges were of whole plant samples which may be the main reason for the values seemingly to be low in the first sampling stage.

Plant Calcium

Plant Ca tested low (less than 0.7 percent Ca) in 26 percent of the samples in the first stage, but in the second stage all samples tested were within the sufficient range (0.21-1.00 percent Ca). Because all the soils contained high levels of Ca, factors other than available soil Ca were responsible for low plant Ca levels in the early stages of growth. Possibly the main problem of interpretation may be incorrect calibration.

Plant Magnesium

Twenty-six percent of the first stage leaf samples tested "low" (less than 0.3 percent Mg) in plant Mg. In the second stage ear leaf sample 18 percent of the samples tested "low" (less than 0.21 percent Mg). Low plant Mg levels in the early growth stage may be a result of excessive Ca levels.

Plant Iron

Plant Fe tested sufficient in both the first and second sampling periods. Even though all the samples were within the sufficient range there were several areas where corn plants showed symptoms similar to an Fe deficiency. There is considerable evidence that plant analysis for total Fe cannot be relied upon to ascertain Fe status of plants.

Plant Zinc

Results obtained from the first stage shows that 27 percent of the plant leaf samples tested below 20 ppm Zn. Each of the areas testing "low" in plant Zn except for one showed a low level of soil Zn.

The second stage leaf analysis showed that 69 percent of the samples tested were less than 20 ppm, and 29 percent of those samples tested below 15 ppm which is given as the critical value for plant Zn at the silking stage as described by several authors. Low plant Zn values occurred on every soil group indicating that the low soil Zn values are widespread across the survey area. As was stated in the soil Zn results, ten percent of the area had been fertilized with zinc. There is a definite need for more use of zinc fertilizers to insure adequate Zn for high yielding corn plants.

Plant Manganese and Copper

Only two percent of the first stage plant samples tested below 50 ppm of plant Mn. The second stage plant analysis showed that both the plant Mn and Cu were sufficient according to the sufficiency levels reported earlier.

Irrigation Water Analysis

All of the irrigation water samples except for one were classified as excellent or good for irrigation purposes (Table XX) according to the USDA Handbook No. 60. Location 61 was classified as fair because of the high amount of Na in the sample.

The survey area contained two underground water formations from which the irrigation water samples were taken: (1) the Ogallala formation and (2) Cheyenne and Dakota formation. Both of these formations contained good quality water samples.

Several samples contained a high level of nitrates. The range of the tested nitrates was 6.2-96-8 ppm with a mean value of 17.1 ppm. Since the nitrate level of the irrigation water is fairly high, it will be very important in the total amount of N added to the soil. For example, water containing 45 ppm nitrates (NO_3) will add 28 pounds of N per acre foot of irrigation water.

TABLE XX

SUMMARY OF SURVEY AREA IRRIGATION H_2O SAMPLES

Element	Range
Ca	9-30 (epm)
Mg	11-30 (epm)
Na	7-36 (epm)
Cl	3-19 (epm)
SO_4	3-16 (epm)
CO_3	1-8 (epm)
HCO_3	8-33 (epm)
NO_3	6.2-96.8 (epm)
pH	7.6-8.6 (ppm)
%Na	17-61
Conductivity	330-640
Sodium Absorption Ratio	0.6-3.4

Field Plot

This experiment was divided into a foliar spray plot plus the test plot for the Zn-NH_3 complexes.

Results of the Zn-NH_3 harvest yield, as well as the soil test and plant analysis data, is given in the Appendix, Table XXII and Table XXIII.

The soil test analysis data did not indicate an Fe deficient level in the soil even though the corn plants showed evidence of an Fe deficiency symptom. The foliar spray plot showed that the plant deficiency symptom was an Fe deficiency by improving the chlorosis condition of the corn plants.

The plant analysis data resulting from the field plot did not show any significant increase in the level of plant Zn at either stage of growth. The analysis of variance (Table XXIV, Appendix) for both forage and grain yields did not show any significant difference between treatments (Zn-NH_3 additives).

Statistical Analysis

Stepwise Regression Procedure

Dependent Variable-Plant P (Second Stage)

The stepwise regression procedure selects the most significant independent variable which is chosen to be used to predict a dependent variable. This procedure was used to select the most significant independent variables to predict each dependent nutrient level.

Each dependent variable was predicted by two methods: (1) using stepwise regression disregarding each soil type and (2) using stepwise regression with each soil type data included. Each of the soil types that were sampled were used in the statistical analysis to evaluate the influence of soil type on predicting the nutrient value of each selected dependent variable.

The independent variables in the model include SoilpH1, SoilN1, SoilP1, SolP12, SolP123, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, and SoilCu1. Of these variables which were being correlated to plant P2, only SolP123 and SoilZn1 were deemed significant from the stepwise regression data at the 0.1 significance level when the soil type was not specified. The dependent variable plant P in the second stage was used as the example of each method used. Listed in Table XXI is the data that resulted for the variable PLTP2. The prediction equation for both methods is given along with the observed value. For example, at sample location number nine the observed value of PLTP2 was 0.24 percent P. The prediction equation gave a value of 0.20 percent P for the first listed method while the second method, which includes each soil type, gave a predicted value of 0.22 percent P. For the sample used as the example with soil type 1 (DA), the second method gives a better predicted PLTP2 value. At each sample location

TABLE XXI

REGRESSION DATA FOR DEPENDENT VARIABLE (PLTP2)

Data with Soil Type Disregarded

Source	B values	R^2	Prob>|T|	CV=17.08%
Intercept	0.17791			
SolP123	0.00038	0.26199	0.001	
SoilZn1	0.00870	0.28786	0.057	

Sample No.	Observed PLTP2	Predicted PLTP2	Residual PLTP2
9	0.24000	0.19925	0.04074

PLTP2= 0.17799 = 0.00039 (*SolP123) + 0.00870 (*SoilZn1)

PLTP2= 0.19925

Data with Soil Type Included

Source	B values	R^2	Prob>|T|	CV=16.37%
Intercept	0.18259			
ST 1	0.01624		0.1921	
ST 2	-0.05607		0.0134	
ST 4	0.00552		0.7037	
ST 5	-0.01023		0.7524	
ST 6	-0.00691		0.5787	
ST 7	-0.00656		0.5793	
ST 8	0.00776		0.7402	
ST 10	0.02115		0.5223	

TABLE XXI continued

Data with Soil Type Included

Source	B values	R^2	Prob>|T|	CV=16.37%
ST 11	-0.01029		0.2003	
ST 12	-0.03750		0.2498	
ST 13	0.06797		0.0065	
ST 14	0.00111		0.9258	
ST 15	-0.00798			
SolP123	0.00064	0.34971	0.0009	
SoilZn1	0.01604	0.41176	0.0022	
SoilP1	-0.00046	0.42946	0.1000	

Sample No.	Observed PLTP2	Predicted PLTP2	Residual PLTP2
9	0.24000	0.22302	0.01697

PLTP2= 0.18259 + (*ST 1) + 0.00064 (*SolP123) + 0.01604 (*SoilZn1) + (-0.00046) (*SoilP1)

PLTP2= 0.22302

Analysis of Variance (PLTP2)

Tests	Source	F value	Prob F
Numerator:	Soil Type	1.422	0.1695
Denominator:	Residual		

*Soil Test Values

Soil Type	SolP123	SoilP1	SoilZn1
1	48	25	0.31

there was a predicted value which varied from the observed value giving the residual. The overall results obtained by an AOV of soil type/residual indicated that the soil type data was not significant (F test equals 0.169) for obtaining each predicted value of plant phosphorus at the second stage (PLTP2).

The R^2 values were considered very small, but because of the large number of data points, the regression coefficient was still significant in most cases.

Soil Variables

SoilpH1

The dependent soil variable (pH at depth one) was statistically predicted by the independent soil variables listed in Table XXV (Appendix). SoilFe1 was the most significant single variable chosen (first variable) probably because soil Fe levels are inversely related to the soil pH value; i.e., the higher the pH value the lower the soil test Fe level.

The AOV with the soil types included in the data indicated that the soil type influence was significant when used to predict the soil pH value.

SoilN1

The dependent soil variable (SoilN1) was best predicted by the single independent variable SoilK1.

The data with the soil type included indicated that the R^2 values were very small, thus the significance of this variable would be deemed insignificant (Table XXVI, Appendix).

<u>SoilP1</u>

SolFe12 was the most significant single independent variable when the soil type was disregarded. With soil type included, SoilFe1 was the single variable which was picked to best predict SoilP1. SolZn12 was chosen with SoilFe1 to predict SoilP1. Soil Fe and soil Zn both were positive B values which indicates that for each increase in soil P, both soil Fe and soil Zn increases.

SolP12 was not listed in the data, but the results obtained were very much the same in that SoilFe1 and SolZn12 were the most significant variables chosen with soil type included (Table XXVII, Appendix).

<u>SoilK1</u>

SoilMn1 was chosen the most significant single independent variable from both sets of variables with and without soil types included (Table XXVIII, Appendix).

<u>SoilCa1</u>

SoilpH1 was deemed the most significant independent variable. Soil Ca is very influential in determining the soil pH which the results definitely indicated (Table XXIX, Appendix).

SoilMg1

The results from data with SoilMg1 showed that soil Cu and soil Ca were selected as the most significant but resulted in very low R^2 values (Table XXX, Appendix).

SoilFe1

Soil Fe was best predicted by SoIP12 as the single most significant variable while SoilpH1 was the second variable chosen. When the variable SoilP1 was predicted, SoilFe1 was deemed the most significant indicating a relationship between the two soil variables. Soil pH also was chosen because of the negative relationship between soil pH and available soil Fe.

The AOV for the soil type influence on SoilFe1 was deemed insignificant indicating no effect of each soil type on the soil Fe level (Table XXXI, Appendix).

SoilZn1

The R-square values of both the data with and without the soil types included are extremely small for the selected variables SoilMg1 and SoilFe1 (Table XXXII, Appendix).

SoilMn1

SoilK1 was chosen the most significant single variable when the soil types were disregarded. SoilpH1 was chosen the most significant single variable when the soil types were included. The availability of the micronutrient cations are usually greater under acid conditions. The results confirmed these by giving a negative B value when SoilpH1 was used as a dependent variable (Table XXXIII, Appendix).

SoilCu1

SoilFe1 was chosen the most significant variable in both data sets. Variable SoilFe1 and variable SoilCa1 were selected as the most significant (Table XXXIV, Appendix).

Plant Analysis

PLTN1

SolN12 was chosen as the most significant single variable predicting PLTN1. The R-square value was extremely small (R^2 equals 0.03) indicating that the soil N contributes only about three percent of the N which is taken up by the corn plant. The F test of the AOV reveals that there is not significant influence of soil type on PLTN1 as will be evident on the other selected plant variables (Table XXXV, Appendix).

PLTN2

The chosen variable for PLTN2 was SolN123. SolN123 was chosen, but was shown by the R-square value that it contributed only 11 percent of the prediction equation (Table XXXVI, Appendix).

PLTP1

SolP123 was the most significant single independent variable chosen, but as in PLTN1 and PLTN2, the R-square value is very small indicating that soil P does not contribute very significantly to the overall P taken up by the corn plant (Table XXXVII, Appendix).

PLTP2

This variable was discussed in detail as the dependent variable used as the example for predicting each variable through the use of stepwise regression analysis.

PLTK1

SoilpH1 was given as the most significant variable, but it contributed only four percent of the overall prediction (Table XXXVIII, Appendix).

PLTK2

The most significant single variable chosen was SoilMn1, but the variable was not indicated as being of any significance (Table XXXIX, Appendix).

PLTCa1

The PLTCa1 results showed that soil Fe was chosen as the most significant single variable with soil type disregarded. A possible reason for SoilFe1 to be chosen may be due to the availability of the soil Fe influenced by the total amount of soil Ca (Table XL, Appendix).

PLTCa2

SoilpH1 was the most significant soil variable chosen from data with soil type disregarded. Soil Ca definitely influences soil pH, which may be correlated to the uptake of plant Ca (Table XLI, Appendix).

PLTMg1

SoilFe1 was selected as the most significant single soil variable, but due to the extremely low R-square value it could not be deemed as significant data (Table XLII, Appendix).

PLTMg2

SoilFe1 was also chosen as the most significant variable for plant Mg, but it also showed a very small R-square value (Table XLIII, Appendix).

PLTFe1

SoilK1 and SoilpH1 were selected as the most significant single independent variable and second order variable, respectively (Table XLIV, Appendix).

PLTFe2

SoilK1 was also chosen for PLTFe2 as it was for PLTFe1. Plant Fe has been evaluated by others as a plant variable which is very difficult to correlate with other nutrients (Table XLV, Appendix).

PLTZn1

SoilP1 was selected as the most significant single variable. Even though the R-square value (0.097) was very low, there is a definite correlation (negative) between soil P and the uptake (availability) of soil Zn which is directly influential on the amount of plant Zn taken up (Table XLVI, Appendix).

PLTZn2

SoilP1 was selected as it was with PLTZn1 (Table XLVII, Appendix).

PLTMn1

The data revealed that SoilCa1 was chosen as the most significant single variable. The R-square value was larger than many other dependent variables, which is more of a significant value. The AOV indicated a F value which indicated that the soil type may be significant in predicting plant Mn in the first stage (Table XLVIII, Appendix).

PLTMn2

SoilN1 was selected as the most significant variable. SoilpH1 was chosen as the second most significant variable, which may have been chosen because of the influence on the availability of Mn as affected by soil pH (Table XLIX, Appendix).

PLTCu1

SoilCa1 was selected as the most significant variable, but with little explanable reason (Table L, Appendix).

PLTCu2

SoilK1 was the most significant single variable selected for PLTCu2 (Table LI, Appendix).

CHAPTER V

SUMMARY AND CONCLUSIONS

The soil fertility survey indicated that the average soil test values for NO_3-N, P, and Zn were not adequate to obtain maximum yields for the corn crop grown during 1975. Soil test levels of NO_3-N, P, and Zn were insufficient for maximum corn production as ascertained from plant analyses at the two plant growth stages. Results obtained from both growth stages indicated that N and Zn in the plant were not adequate. Plant P results also revealed that there was inadequate soil and fertilizer P available to the corn plant. The second sampling (silking stage) showed that only thirteen percent of the corn leaf samples contained sufficient amounts of P indicating an extreme need for additional amounts of fertilizer P to be applied to the soils in the Cimarron County survey area. Plant Zn values were also extremely low. At the second sampling, 29 percent of the leaf samples tested below 15 ppm Zn. Fifteen ppm Zn has been established as the critical value for Zn in corn leaf samples at the silking stage while the 16 to 20 ppm range is considered low.

Results obtained from the analysis of each of the plant stages indicated that plant analysis is very useful when used as a diagnostic tool for crop production. Low soil test levels of N, P, and Zn were confirmed with plant analysis of these nutrients.

Zinc-ammonia additives had no significant effect in improving the grain or forage yields of the corn crop planted on the plot location.

In the statistical analyses all of the dependent variables were significant when each soil type was included in the data except for soil Fe. Soil Fe was selected as the most significant single variable for the independent variables of SoilpH1, SoilP1, and SoilCu1. There was a negative and significant correlation between soil pH and the variable of SoilFe1. The soil pH was also highly correlated with exchangeable Ca. There was a positive correlation between soil Fe and soil P (0-24"), but sois Fe was negatively correlated with soil pH indicating the reduction in availability of soil Fe as the pH is increased. The soil P was highly correlated with soil Fe (0-24") and negatively correlated with soil Zn (0-8") but positively correlated with soil Zn (0-24"). There was a positive and significant correlation between soil Ca and soil pH.

There were highly significant correlations between N in both corn plant stages and the NO_3-N in the soil. Plant P at both stages was also positively correlated with the available P in the soil. Plant K at the first stage gave a negative and significant correlation with soil pH, but the second stage plant K correlated best with soil Mn. There were positive correlations between plant Fe at both stages and the independent soil variable K. Plant Zn at both stages was also negatively correlated with soil P; i.e., soil P influenced the availability of soil Zn which therefore was correlated with the uptake of Zn by the corn plant.

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APPENDIX

TABLE XXII

RESULTS FROM (ZN-NH_3 PLOT)

Soil Analysis

Sample(0-8")	pH	NO_3-N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B
RepI(Check)	8.0	42	43	510	5360	710	7.6	0.70	12.8	0.80	0.24
RepII(Check)	7.8	33	63	635	6350	680	8.0	0.50	11.6	0.76	0.19
RepIII(Check)	7.9	50	48	785	7340	810	8.6	0.70	15.2	0.90	0.19
RepIV(Check)	7.7	35	73	785	7660	1010	8.2	0.60	14.2	0.73	0.19

Plant Analysis-1st Sampling

Sample Formulation	%N	%P	%K	%Ca	%Mg	Fe ppm	Zn ppm	Mn ppm	Cu ppm
(Check)	3.65	0.264	2.72	0.76	0.39	435	47	188	21
3	3.69	0.267	2.67	0.72	0.42	418	47	197	25
7	3.72	0.247	2.47	0.73	0.44	385	43	197	26
9	3.16	0.267	2.32	0.74	0.43	363	44	191	26

TABLE XXII continued

Plant Analysis-2nd Sampling

Sample Formulation	%N	%P	%K	%Ca	%Mg	Fe ppm	Zn ppm	Mn ppm	Cu ppm
(Check)	2.99	0.23	1.26	0.65	0.31	138	33	163	20
3	3.00	0.18	1.37	0.65	0.33	153	36	163	17
7	3.04	0.19	1.30	0.65	0.33	158	33	163	18
9	3.06	0.22	1.26	0.60	0.30	133	29	143	18

TABLE XXIII

DATA FOR ZN-NH_3 PLOT

	0	3	7	9	Overall
Forage Treatment Mean	6.91	6.15	7.32	7.47	6.96
Grain Treatment Mean	142.62	113.65	138.38	131.11	131.44

TABLE XXIV

ANALYSIS OF VARIANCE FOR ZN-NH_3 PLOT

Forage Yield (Dry Wt.)

Source	df	SS	MS	F value	CV=12.28%
Block	3	0.178	0.059	0.081 ns	
Treatment	3	4.219	1.406	1.922 ns	
Error	9	6.585	0.732		
Total	15	10.982			

Grain Yield (Dry Wt.)

Source	df	SS	MS	F value	CV=17.98%
Block	3	963.028	321.009	0.574 ns	
Treatment	3	1959.294	653.098	1.169 ns	
Error	9	5030.017	558.891		
Total	15	7952.339			

TABLE XXV

REGRESSION DATA FOR SOIL PH (0-8")
(SOILPH1)

Selected independent variables: SoilN1, SoilN2, SoilP1, SoilP2, SolP123, SoilK1, SoilCa1, SoilCa2, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B values	R^2	Prob>|T|	CV=2.10%
Intercept	7.9243			
SoilFe1	-0.03988	0.36575	0.0002	
SoilMn1	-0.00628	0.50310	0.0170	
SoilCa1	0.00011		0.0001	
SoilN1	-0.00219		0.0001	
SoilK1	-0.00049		0.0001	

Data With Soil Type Included

				CV=2.22%

AOV: Soil Type/Residual

Mean	Prob>F
7.77	0.03

TABLE XXVI

REGRESSION DATA FOR SOILN (0-8")
(SOILN1)

Selected independent variables: SoilpH1, SoilP1, SolP12, SoilK2, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B values	R^2	Prob>|T|	CV=55.56%
Intercept	876.69901			
SoilK1	-0.04316	0.13981	0.0460	
SoilCa1	0.02059	0.19635	0.0001	
SoilpH1	-116.48671		0.0001	
SoilMg1	0.01487		0.0180	

Data With Soil Type Included

	CV=56.15%

AOV: Soil Type/Residual

Mean	Prob>F
67.59 lbs./A	0.03

TABLE XXVII

REGRESSION DATA FOR SOILP1

Selected independent variables: SoilpH1, SoilN1, SolN12, SolN123, SoilK1, SoilCa1, SoilMg1, SoilFe1, SolFe12, SoilZn1, SolZn12, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=43.09%
Intercept	-21.13108			
SolFe12	3.02811	0.40229	0.0001	
SoilK1	0.06502	0.57334	0.0001	
SoilCa1	-0.00456		0.0014	
SolZn12	7.56131		0.0007	
SoilZn1	-6.22603		0.0613	

Data With Soil Type Included

				CV=40.52%

AOV: Soil Type/Residual

Mean	Prob>F
48.98	0.0003

TABLE XXVIII

REGRESSION DATA FOR SOILK1

Selected independent variables: SoilpH1, SoilN1, SolN12, SolN123, SoilP1, SolP12, SolP123, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=19.34%
Intercept	2267.73362			
SoilMn1	8.68689	0.32625	0.0001	
SoilCa1	0.09244	0.53578	0.0001	
SoilP1	2.13110		0.0001	
SoilpH1	-302.47078		0.0001	
SoilMg1	0.08057		0.0005	
SolN123	-0.47154		0.0074	

Data With Soil Type Included

	CV=19.11%

AOV: Soil Type/Residual

Mean	Prob>F
689.57	0.0001

TABLE XXIX

REGRESSION DATA FOR SOILCA1

Selected independent variables: SoilpH1, SoilN1, SolN12, SolN123, SoilP1, SolP12, SolP123, SoilMg1, SoilFe1, SolFe12, SoilZn1, SolZn12, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=21.69%
Intercept	-20637.99626			
SoilpH1	3261.08733	0.27077	0.0001	
SoilN1	16.77121	0.53914	0.0001	
SoilCu1	735.29011		0.0001	
SolFe12	-95.922206		0.0015	

Data With Soil Type Included

	CV=19.72%

AOV: Soil Type/Residual

Mean	Prob>F
5445.24	0.0001

TABLE XXX

REGRESSION DATA FOR SOILMG1

Selected independent variables: SoilpH1, SoilN1, SolN12, SolN123, SoilP1, SolP12, SolP123, SoilCa1, SoilFe1, SolFe12, SoilZn1, SolZn12, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=29.14%
Intercept	2917.83379			
SoilCu1	135.83718	0.27655	0.0007	
SoilCa1	0.12071	0.39339	0.0001	
SoilP1	8.95205		0.0069	
SoilpH1	-371.13376		0.0023	
SolN123	-0.93167		0.0042	
SolP12	-5.48832		0.0389	

Data With Soil Type Included

	CV=26.07%

AOV: Soil Type/Residual

Mean	Prob>F
844.0	0.0001

TABLE XXXI

REGRESSION DATA FOR SOILFE1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoIP12, SoilK1, SoilCa1, SoilMg1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=20.79%
Intercept	37.42374			
SoIP12	0.03096	0.45965	0.0001	
SoilpH1	-3.89794	0.55126	0.0001	
SoilMn1	-0.06701		0.0050	
SoilCu1	0.88825		0.0001	
SoilK1	-0.00291		0.0005	

Data With Soil Type Included

	CV=21.07%

AOV: Soil Type/Residual

Mean	Prob>F
7.03	0.10

TABLE XXXII

REGRESSION DATA FOR SOILZN1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SolP12, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=119.07%
Intercept	-0.18875			
SoilMg1	0.00037	0.09184	0.0014	
SoilFe1	0.06762	0.13903	0.0188	

Data With Soil Type Included

	CV=103.45%

AOV: Soil Type/Residual

Mean	Prob>F
0.625	0.005

TABLE XXXIII

REGRESSION DATA FOR SOILMN1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SolP12, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=33.94%
Intercept	60.50508			
SoilK1	0.01979	0.32625	0.0001	
SoilpH1	-6.52142	0.45546	0.0251	
SoilCa1	-0.00088		0.0728	

Data With Soil Type Included

	CV=31.90%

AOV: Soil Type/Residual

Mean	Prob>F
18.39	0.0001

TABLE XXXIV

REGRESSION DATA FOR SOILCU1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SolP12, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=45.95%
Intercept	-1.73052			
SoilFe1	0.16297	0.35309	0.0001	
SoilCa1	0.00024	0.44402	0.0001	
SoilMn1	0.02606		0.0011	
SoilZn1	0.21422		0.0084	

Data With Soil Type Included

	CV=46.45%

AOV: Soil Type/Residual

Mean	Prob>F
1.38	0.0159

TABLE XXXV

REGRESSION DATA FOR PLTN1

Selected independent variables: SoilpH1, SoilN1, SolN12, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=13.24%
Intercept	3.56560			
SolN12	0.00101	0.0260	0.0962	

Data With Soil Type Included

				CV=12.96%

AOV: Soil Type/Residual

Mean	Prob>F
3.69	0.52

TABLE XXXVI

REGRESSION DATA FOR PLTN2

Selected independent variables: SoilpH1, SoilN1, SolN12, SolN123, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=14.06%
Intercept	2.52838			
SolN123	0.00149	0.11038	0.0009	

Data With Soil Type Included

				CV=13.45%

AOV: Soil Type/Residual

Mean	Prob>F
2.74	0.84

TABLE XXXVII

REGRESSION DATA FOR PLTP1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SolP12, SolP123, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=17.62%
Intercept	0.25624			
SolP123	0.00026	0.07318	0.0052	
SoilN1	-0.00021		0.0306	
SoilMg1	0.00001		0.0456	

Data With Soil Type Included

	CV=18.16%

AOV: Soil Type/Residual

Mean	Prob>F
0.27	0.95

TABLE XXXVIII

REGRESSION DATA FOR PLTK1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SolK12, SolK123, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=12.71%
Intercept	4.79879			
SoilpH1	-0.24799	0.04249	0.0327	

Data With Soil Type Included

				CV=12.65%

AOV: Soil Type/Residual

Mean	Prob>F
2.87	0.22

TABLE XXXIX

REGRESSION DATA FOR PLTK2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SolK12, SolK123, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=14.33%
Intercept	1.87359			
SoilMn1	0.00423	0.01663	0.1905	

Data With Soil Type Included

				CV=14.92%

AOV: Soil Type/Residual

Mean	Prob>F
1.95	0.99

TABLE XL

REGRESSION DATA FOR PLTCA1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=15.02%
Intercept	0.94661			
SoilFe1	-0.01609	0.03882	0.0413	

Data With Soil Type Included

				CV=25.46%

AOV: Soil Type/Residual

Mean	Prob>F
0.83	0.413

TABLE XLI

REGRESSION DATA FOR PLTCA2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=20.99%
Intercept	-0.46476			
SoilpH1	0.14249	0.09707	0.0016	

Data With Soil Type Included

				CV=21.26%

AOV: Soil Type/Residual

Mean	Prob>F
0.64	0.5055

TABLE XLII

REGRESSION DATA FOR PLTMG1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=23.64%
Intercept	0.41869			
SoilFe1	-0.00737	0.04542	0.0273	

Data With Soil Type Included

				CV=23.48%

AOV: Soil Type/Residual

Mean	Prob>F
0.37	0.2963

TABLE XLIII

REGRESSION DATA FOR PLTMG2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilMg1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=25.43%
Intercept	0.27988			
SoilFe1	-0.00589	0.05385	0.0181	
SoilMg1	0.00002		0.0848	

Data With Soil Type Included

	CV=25.50%

AOV: Soil Type/Residual

Mean	Prob>F
0.25	0.2412

TABLE XLIV

REGRESSION DATA FOR PLTFE1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=27.68%
Intercept	-838.35049			
SoilK1	0.23669	0.10685	0.0001	
SoilpH1	145.61457	0.15615	0.0036	
SoilCa1	-0.01474		0.0719	

Data With Soil Type Included

CV=28.36%

AOV: Soil Type/Residual

Mean	Prob>F
375.66	0.5777

TABLE XLV

REGRESSION DATA FOR PLTFE2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=33.47%
Intercept	132.07488			
SoilK1	0.06922	0.07922	0.0039	

Data With Soil Type Included

				CV=34.28%

AOV: Soil Type/Residual

Mean	Prob>F
179.81	0.6266

TABLE XLVI

REGRESSION DATA FOR PLTZN1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=36.84%
Intercept	31.02264			
SoilP1	-0.08854	0.09655	0.0016	

Data With Soil Type Included

				CV=34.06%

AOV: Soil Type/Residual

Mean	Prob>F
26.68	0.1672

TABLE XLVII

REGRESSION DATA FOR PLTZN2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=52.46%
Intercept	22.81765			
SoilP1	-0.08047	0.08001	0.0038	

Data With Soil Type Included

				CV=54.08%

AOV: Soil Type/Residual

Mean	Prob>F
18.88	0.8611

TABLE XLVIII

REGRESSION DATA FOR PLTMN1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=25.26%
Intercept	72.27971			
SoilCa1	0.00912	0.22387	0.0001	
SoilMg1	0.01377		0.0061	
SoilCu1	-6.97410		0.0709	

Data With Soil Type Included

CV=25.98%

AOV: Soil Type/Residual

Mean	Prob>F
124.72	0.0482

TABLE XLIX

REGRESSION DATA FOR PLTMN2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=33.96%
Intercept	-350.07313			
SoilN1	0.26408	0.13752	0.0003	
SoilpH1	50.09503		0.0001	
SoilK1	0.03103		0.0277	
SoilP1	0.19871		0.0567	

Data With Soil Type Included

	CV=34.37%

AOV: Soil Type/Residual

Mean	Prob>F
88.03	0.2092

TABLE L

REGRESSION DATA FOR PLTCU1

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=17.12%
Intercept	16.70155			
SoilCa1	0.00071	0.10059	0.0004	
SoilN1	-0.01303		0.0695	

Data With Soil Type Included

				CV=17.71%

AOV: Soil Type/Residual

Mean	Prob>F
19.70	0.5206

TABLE LI

REGRESSION DATA FOR PLTCU2

Selected independent variables: SoilpH1, SoilN1, SoilP1, SoilK1, SoilCa1, SoilMg1, SoilFe1, SoilZn1, SoilMn1, SoilCu1

Data With Soil Type Disregarded

Source	B value	R^2	Prob>|T|	CV=23.73%
Intercept	-11.37763			
SoilK1	0.00996	0.16082	0.0001	
SoilpH1	3.36107		0.0457	

Data With Soil Type Included

				CV=22.90%

AOV: Soil Type/Residual

Mean	Prob>F
21.60	0.0678

TABLE LII

SOIL ANALYSIS DATA

Sample No.	Lab No.	Soil Type	Depth	pH	NO_3	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
009	1786	01	1	7.2	023	025	0340	1750	0220	0.32	09.6	08.6	00.84	0.20
009	1787	01	2	7.4	046	013	0370	2500	0290	0.16	10.8	06.0	00.96	0.00
009	1788	01	3	7.4	046	010	0280	3100	0380	0.20	11.0	05.9	01.10	0.00
017	2269	01	1	7.6	038	038	0560	3190	0600	0.48	07.0	26.0	01.00	0.41
017	2270	01	2	8.1	027	023	0470	5750	0560	0.40	07.0	15.2	01.16	0.18
017	2271	01	3	8.2	010	003	0400	6950	0580	0.26	05.0	08.8	01.24	0.13
018	2272	01	1	7.3	015	033	0365	1750	0310	0.20	09.4	17.0	00.42	0.32
018	2273	01	2	7.8	027	005	0485	6470	0790	0.78	10.2	12.0	03.40	0.13
018	2274	01	3	8.1	020	003	0450	7550	0820	0.78	07.6	07.0	01.81	0.18
019	2275	01	1	8.0	012	035	0300	2500	0250	0.26	08.4	10.8	00.44	0.27
019	2276	01	2	8.1	027	003	0295	5930	0300	0.20	07.2	09.8	00.70	0.23
019	2277	01	3	8.3	020	003	0295	6690	0360	0.22	05.8	06.2	00.84	0.13
027	2299	01	1	8.1	044	038	0410	5430	0510	0.30	04.2	13.6	00.84	0.30
027	2300	01	2	8.2	027	003	0350	6230	0460	0.16	04.4	06.8	00.98	0.20
027	2301	01	3	8.5	020	003	0230	5900	0470	0.18	02.8	04.0	00.68	0.20
063	2404	01	1	8.1	024	038	0365	5010	0360	0.32	06.4	13.0	00.62	0.29
063	2405	01	2	8.1	097	003	0350	6200	0470	0.44	05.6	12.6	01.90	0.25
063	2406	01	3	8.3	006	003	0385	6410	0740	0.48	04.6	07.2	02.42	0.21
073	2434	01	1	8.1	012	021	0435	4100	0880	0.30	05.2	10.2	00.68	0.46
073	2435	01	2	8.2	016	003	0365	6260	0800	0.16	05.6	08.4	00.76	0.29
073	2436	01	3	8.2	010	003	0290	6140	0690	0.18	05.0	05.6	00.70	0.21
090	2488	01	1	7.1	065	079	0725	3050	0510	0.76	11.6	30.0	00.74	0.39
090	2489	01	2	7.6	190	016	0435	6050	0810	0.26	10.6	11.4	00.92	0.19
090	2490	01	3	8.2	038	003	0335	7150	1050	0.28	08.0	12.0	00.88	0.32
102	2524	01	1	8.0	011	018	0345	4460	0300	0.24	07.6	07.4	00.46	0.19
102	2525	01	2	8.1	038	010	0320	5920	0330	0.30	09.0	10.4	00.78	0.24
102	2526	01	3	8.0	014	003	0345	7250	0560	0.42	09.6	11.8	01.10	0.16
004	1771	02	1	8.0	C53	065	0485	5250	0640	0.42	08.2	08.3	01.40	0.55
004	1772	02	2	8.1	049	003	0530	6700	0810	1.02	10.2	06.4	06.60	0.25
004	1773	02	3	8.3	036	003	0340	5750	0750	0.32	08.6	05.1	01.94	0.25
053	2374	02	1	7.6	050	048	0540	4060	0790	7.60	10.4	11.0	01.78	0.36
053	2375	02	2	8.1	019	020	0405	6090	0780	0.60	08.2	13.4	01.90	0.13
053	2376	02	3	8.1	010	003	0390	5950	0840	0.34	06.2	08.4	01.52	0.18
087	2479	02	1	8.0	060	029	0450	6190	0660	0.42	06.6	12.2	00.66	0.24
087	2480	02	2	8.2	032	008	0280	6510	0760	0.18	06.6	09.8	00.70	0.16
087	2481	02	3	8.2	016	010	0270	5890	0750	0.18	05.4	08.2	60.64	0.35
006	1777	04	1	7.5	024	040	0300	1600	0210	0.46	09.4	07.3	00.78	0.25
006	1778	04	2	7.6	041	013	0315	6850	0260	0.24	10.2	04.8	00.88	0.15
006	1779	04	3	7.9	044	013	0235	5100	0280	0.28	09.6	04.6	00.86	0.15
007	1780	04	1	7.5	018	025	0325	1550	0200	0.32	08.6	06.2	00.64	0.35
007	1781	04	2	7.7	027	013	0315	2200	0250	0.22	10.2	05.0	00.80	0.30
007	1782	04	3	7.1	020	008	0250	2550	0310	0.18	09.6	06.0	01.18	0.10
070	2425	04	1	7.6	030	018	0310	2290	0220	0.34	07.4	10.8	00.50	0.29
070	2426	04	2	7.9	111	003	0245	2930	0180	0.22	06.6	08.0	00.52	0.21
070	2427	04	3	8.1	026	003	0195	5310	0240	0.20	06.8	06.0	00.46	0.16
101	2521	04	1	8.0	022	089	0540	4630	0420	0.68	07.2	09.0	00.60	0.32
101	2522	04	2	8.0	054	031	0400	6240	0410	0.32	07.4	10.8	00.80	0.16
101	2523	04	3	8.2	028	003	0280	6100	0470	0.22	06.6	08.0	00.78	0.16

TABLE LII continued

Sample No.	Lab No.	Soil Type	Depth	pH	NO_3	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
069	2422	07	1	8.0	060	003	0605	7700	0490	0.40	03.0	15.0	01.02	0.33
069	2423	07	2	8.1	032	003	0270	7380	0350	0.14	04.4	13.0	00.66	0.21
069	2424	07	3	8.3	010	003	0265	6140	0480	0.14	03.2	06.0	00.44	0.21
081	2461	07	1	8.0	085	003	0735	8010	0690	0.70	03.4	13.2	00.82	0.28
081	2462	07	2	8.2	051	003	0310	7690	0410	0.18	04.0	12.2	00.74	0.20
081	2463	07	3	8.3	032	003	0240	6700	0570	0.18	03.8	05.6	00.50	0.20
097	2509	07	1	7.9	120	047	0645	6650	0790	0.76	05.8	13.8	00.98	0.24
097	2510	07	2	8.0	127	003	0350	6240	0540	0.20	05.2	15.8	00.72	0.28
097	2511	07	3	8.4	010	003	0220	5350	0520	0.12	03.6	05.2	00.46	0.24
099	2515	07	1	8.1	032	003	0545	5900	0770	0.46	04.8	12.4	00.70	0.36
099	2516	07	2	8.0	127	003	0330	6580	0590	0.24	03.6	09.8	00.66	0.24
099	2517	07	3	8.3	070	003	0210	6090	0550	0.16	04.0	04.4	00.38	0.28
025	2293	08	1	8.0	064	040	0605	7200	0430	0.40	04.2	19.2	00.80	0.20
025	2294	08	2	8.1	065	003	0435	7940	0560	0.50	05.8	09.8	02.50	0.15
025	2295	08	3	8.3	038	003	0335	6680	0630	0.16	03.4	04.4	00.90	0.20
075	2440	08	1	7.9	055	026	0600	6100	0700	0.22	05.0	10.8	00.72	0.32
075	2441	08	2	8.3	035	003	0390	7040	0860	0.14	04.8	09.0	00.82	0.20
075	2442	08	3	8.2	018	003	0380	6700	1370	0.16	05.2	07.8	00.88	0.20
042	2341	10	1	7.9	150	085	0930	8310	0890	0.46	07.2	13.8	01.48	0.32
042	2342	10	2	8.2	051	003	0600	9030	0980	4.96	12.0	13.6	10.58	0.19
042	2343	10	3	8.1	032	003	0595	9090	0960	2.20	10.2	09.6	07.66	0.19
001	1762	11	1	7.6	230	058	0730	6800	1010	1.00	12.8	16.4	05.02	0.40
001	1763	11	2	7.5	200	038	0665	6600	1050	0.99	13.6	19.4	06.40	0.35
001	1764	11	3	7.9	065	025	0560	6950	1220	1.46	13.0	07.0	09.24	0.25
003	1768	11	1	7.4	110	123	0770	4050	0700	0.88	12.8	17.5	02.44	0.75
003	1769	11	2	7.8	043	035	0610	6400	1120	0.94	15.2	10.8	06.26	0.25
003	1770	11	3	8.0	032	035	0655	7250	1440	0.66	13.2	05.2	05.40	0.30
005	1774	11	1	7.8	080	068	0625	6000	0840	0.38	10.4	10.9	01.96	0.45
005	1775	11	2	8.2	043	015	0500	6850	0820	0.68	12.2	07.2	05.12	0.35
005	1776	11	3	8.1	022	003	0450	6600	0880	0.52	10.0	05.3	04.14	0.40
010	1789	11	1	7.9	076	085	0665	5800	0810	0.66	13.2	12.5	02.26	0.30
010	1790	11	2	7.9	049	028	0620	7100	1250	0.72	14.4	08.7	04.68	0.25
010	1791	11	3	8.4	036	083	0530	6000	1170	0.32	11.4	05.3	02.42	0.20
013	2257	11	1	7.5	032	068	1000	4280	1260	1.18	06.8	32.0	01.36	0.83
013	2258	11	2	8.2	032	008	0725	7580	1600	0.84	05.8	13.8	04.18	0.18
013	2259	11	3	8.2	020	003	0600	6640	1440	0.84	05.8	09.2	03.04	0.32
014	2260	11	1	7.7	050	045	0930	6010	1490	0.60	06.8	26.2	01.50	0.60
014	2261	11	2	8.0	027	010	0700	8200	1520	1.50	06.0	13.8	04.80	0.18
014	2262	11	3	8.3	022	003	0655	7630	1530	0.92	04.8	09.4	03.38	0.46
015	2263	11	1	7.1	052	080	0650	2500	0700	1.04	08.2	35.0	00.98	0.51
015	2264	11	2	8.1	027	013	0605	6950	1210	1.10	07.4	14.6	03.48	0.13
015	2265	11	3	8.2	020	015	0675	7580	1610	1.02	05.6	08.4	03.24	0.18
030	2308	11	1	7.4	037	090	1100	6210	1450	0.46	07.0	28.0	01.74	0.45
030	2309	11	2	8.2	057	023	0850	8000	2040	2.08	05.2	11.8	09.02	0.25
030	2310	11	3	8.4	030	003	0650	7130	1880	1.28	04.2	07.4	04.82	0.40
032	2314	11	1	7.9	120	033	0900	9100	1180	0.80	05.0	15.0	03.54	0.23
032	2315	11	2	8.3	051	003	0615	8200	1470	1.34	05.6	10.6	05.38	0.19
032	2316	11	3	8.3	034	003	0600	7100	1760	1.78	05.2	08.6	06.48	0.36
033	2317	11	1	7.9	056	053	1375	7220	1560	0.76	05.4	27.0	02.68	0.59
033	2318	11	2	8.3	032	003	0780	7650	2020	1.80	05.8	12.4	06.04	0.23
033	2319	11	3	8.6	020	003	0635	6370	2030	0.46	04.6	07.2	02.36	0.44
035	2320	11	1	8.1	090	003	0630	7540	0790	0.40	04.2	15.0	01.06	0.28
035	2321	11	2	8.3	054	003	0260	6700	0400	0.58	03.4	08.2	02.18	0.23
035	2322	11	3	8.3	046	003	0165	5900	0430	0.70	02.4	03.2	01.12	0.22
036	2323	11	1	8.3	031	030	0725	7700	1170	0.26	04.6	12.6	01.32	0.28
036	2324	11	2	8.3	030	003	0575	7810	1110	1.20	05.2	09.2	04.94	0.23

TABLE LII continued

Sample No.	Lab No.	Soil Type	Depth	pH	NO_3	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
103	2527	04	1	7.9	018	021	0350	3900	0590	0.48	09.0	10.4	00.66	0.19
103	2528	04	2	8.0	019	008	0315	6490	0680	0.28	08.8	09.6	00.80	0.08
103	2529	04	3	8.1	010	005	0350	6900	0740	0.20	08.0	08.0	01.02	0.08
104	2530	04	1	7.5	035	018	0350	2350	0490	0.34	07.6	10.0	00.62	0.28
104	2531	04	2	8.1	041	005	0345	5700	0600	0.22	09.8	10.4	00.86	0.08
104	2532	04	3	8.2	010	008	0310	6650	0700	0.18	09.2	09.2	00.82	0.04
066	2413	05	1	7.9	110	040	0800	7930	0580	0.42	05.2	32.0	01.04	0.99
066	2414	05	2	8.2	041	003	0430	8200	0320	0.52	06.0	16.0	02.30	0.41
066	2415	05	3	8.3	010	003	0300	7180	0360	0.92	05.0	07.8	03.74	0.21
012	2254	06	1	7.7	026	035	0815	5000	1130	1.44	05.4	24.0	01.62	0.51
012	2255	06	2	7.9	027	015	0640	7900	1340	1.40	07.8	13.8	03.58	0.23
012	2256	06	3	8.2	010	025	0635	7030	1740	1.06	06.0	09.6	03.74	0.37
020	2278	06	1	7.8	014	028	0470	4750	0360	0.46	09.0	15.8	00.82	0.13
020	2279	06	2	8.1	027	010	0370	6300	0450	0.16	07.4	09.6	00.94	0.09
020	2280	06	3	8.2	020	005	0380	6450	0490	0.26	06.6	08.0	01.16	0.13
024	2290	06	1	7.9	110	060	0755	3800	0650	3.00	05.0	18.0	01.08	0.30
024	2291	06	2	8.1	089	003	0545	8150	0550	0.28	06.2	11.6	01.22	0.20
024	2292	06	3	8.1	054	003	0345	6800	0410	0.18	04.2	05.6	00.94	0.20
041	2338	06	1	8.2	012	038	0315	2330	0400	0.26	06.6	11.8	00.44	0.32
041	2339	06	2	8.1	030	008	0325	6230	0490	0.46	06.4	10.2	01.50	0.23
041	2340	06	3	8.3	020	003	0275	5800	0480	0.14	04.8	05.8	00.62	0.19
055	2380	06	1	7.8	090	058	0675	6140	0930	0.82	08.0	19.4	01.84	0.31
055	2381	06	2	8.2	019	003	0540	6950	1060	0.62	06.2	09.4	02.64	0.22
055	2382	06	3	8.2	012	003	0490	6120	1200	0.76	06.0	08.2	02.88	0.22
074	2437	06	1	8.1	060	024	0510	6100	0890	0.24	04.0	11.0	00.80	0.35
074	2438	06	2	8.2	030	003	0375	6400	0860	0.12	04.4	08.4	00.78	0.32
074	2439	06	3	8.3	014	003	0400	6290	1100	0.16	04.2	07.4	00.78	0.28
077	2446	06	1	7.9	065	026	0490	5700	0650	0.42	04.0	10.2	01.52	0.32
077	2447	06	2	8.3	019	003	0290	6710	0720	0.18	04.2	08.8	00.86	0.20
077	2448	06	3	8.3	010	003	0365	6450	1080	0.14	05.0	07.8	00.90	0.20
105	2533	06	1	8.1	050	008	0650	6700	0980	0.38	05.8	13.4	01.10	0.19
105	2534	06	2	8.3	041	003	0390	7300	1100	0.20	08.0	11.6	01.22	0.12
105	2535	06	3	8.4	020	003	0500	6400	1690	0.22	08.6	07.2	01.38	0.12
124	2536	06	1	7.7	160	024	0660	7620	0490	0.50	05.0	22.0	01.02	0.16
124	2537	06	2	8.0	216	003	0445	7800	0480	0.28	05.8	18.8	01.08	0.08
124	2538	06	3	8.1	192	003	0330	6550	0610	0.24	05.2	09.0	00.92	0.19
002	1765	07	1	7.7	068	048	0565	3850	0810	0.50	12.2	11.6	02.18	0.55
002	1766	07	2	7.9	049	020	0555	7150	1230	1.20	14.4	05.0	07.98	0.35
002	1767	07	3	8.3	074	003	0485	6450	1190	0.70	11.0	04.7	04.84	0.50
021	2281	07	1	8.1	053	008	0600	8200	0670	0.34	05.0	18.2	01.32	0.30
021	2282	07	2	8.3	027	003	0550	7760	0860	0.18	05.4	09.0	01.42	0.25
021	2283	07	3	8.4	020	003	0510	6490	1050	0.18	05.0	07.2	01.48	0.25
022	2284	07	1	8.1	025	010	0670	7700	0890	0.30	04.6	17.8	01.18	0.25
022	2285	07	2	8.3	027	003	0280	6950	0450	0.20	04.8	08.2	01.06	0.20
022	2286	07	3	8.3	020	003	0220	6320	0450	0.16	03.2	04.8	00.52	0.15
028	2302	07	1	8.1	010	003	0690	8160	0840	0.88	05.2	11.6	04.02	0.15
028	2303	07	2	8.0	124	063	0850	7700	1000	0.36	05.2	18.4	01.40	0.35
028	2304	07	3	8.3	020	003	0520	7300	0800	0.22	05.0	07.0	01.76	0.20
047	2356	07	1	8.4	017	003	0480	5380	0610	0.46	03.6	13.8	00.48	0.31
047	2357	07	2	8.3	027	003	0320	6320	0380	0.18	02.4	11.4	00.76	0.22
047	2358	07	3	8.4	020	003	0190	5920	0410	0.08	03.0	04.2	00.20	0.22
049	2362	07	1	8.1	009	003	0475	5980	0920	0.28	04.4	14.6	01.24	0.27
049	2363	07	2	8.3	016	003	0450	6660	1040	0.58	05.0	09.8	03.04	0.27
049	2364	07	3	8.2	010	003	0385	5380	1400	0.40	04.8	05.5	01.86	0.22
064	2407	07	1	7.9	094	018	0940	8080	1560	0.64	07.0	28.0	02.70	0.29
064	2408	07	2	8.4	019	003	0680	7480	1620	0.70	06.8	09.4	03.92	0.62

TABLE LII continued

Sample No.	Lab No.	Soil Type	Depth	pH	NO_3	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
038	2329	11	1	8.0	048	050	0955	6140	1090	0.36	04.4	14.2	01.26	0.59
038	2330	11	2	8.4	027	003	0640	8690	1660	0.52	05.6	09.4	02.74	0.19
038	2331	11	3	8.4	020	003	0530	7320	1910	0.28	04.8	06.0	16.60	0.28
043	2344	11	1	7.2	063	155	1430	4460	1000	0.68	12.0	30.0	01.52	0.75
043	2345	11	2	7.8	035	040	0960	7720	1430	1.38	08.2	17.8	04.62	0.19
043	2346	11	3	8.3	020	063	0760	7330	1380	3.09	05.0	10.4	08.84	0.23
044	2347	11	1	7.5	020	168	1155	4050	1100	0.66	09.2	32.6	01.32	0.99
044	2348	11	2	7.9	032	053	0870	8440	1090	9.98	09.8	30.0	23.20	0.18
044	2349	11	3	8.2	020	003	0955	8650	1260	1.92	07.0	12.6	06.28	0.22
048	2359	11	1	8.1	012	040	0580	5680	0790	0.20	05.4	18.8	00.94	0.31
048	2360	11	2	7.9	027	003	0380	6290	0740	0.20	05.0	08.8	01.56	0.18
050	2365	11	1	8.2	012	003	0620	6780	0850	0.20	05.0	16.6	01.14	0.31
050	2366	11	2	8.1	019	003	0385	6430	0810	0.64	04.4	08.2	02.46	0.22
050	2367	11	3	8.4	010	003	0300	5250	1050	0.46	03.4	04.6	01.80	0.31
051	2368	11	1	7.7	170	040	0730	6750	1220	0.30	05.6	18.8	01.32	0.36
051	2369	11	2	8.1	190	003	0490	6990	1160	0.62	05.6	08.6	02.74	0.31
051	2370	11	3	8.2	026	003	0450	6330	1180	0.14	05.8	05.6	01.32	0.40
052	2371	11	1	7.5	037	055	0870	4950	1310	0.42	09.0	34.0	01.74	0.72
052	2372	11	2	8.0	022	020	0700	7360	1400	1.18	07.6	14.4	04.50	0.22
052	2373	11	3	8.2	010	045	0695	7300	1530	0.70	05.6	09.6	03.20	0.40
054	2377	11	1	7.8	065	045	0810	6590	1200	1.00	08.0	27.0	02.66	0.36
054	2378	11	2	8.1	024	003	0435	6410	0960	0.40	04.6	08.8	01.88	0.18
054	2379	11	3	8.4	014	003	0320	5540	0840	0.14	05.4	05.6	00.76	0.22
056	2383	11	1	7.8	032	121	1030	6970	0960	1.38	10.4	34.0	03.96	0.54
056	2384	11	2	7.9	022	048	0950	8400	1220	2.18	09.2	17.6	07.16	0.25
056	2385	11	3	8.2	010	003	0940	7730	1270	1.04	07.4	10.8	03.56	0.29
057	2386	11	1	7.4	096	118	1010	5700	1280	2.36	09.2	36.0	03.44	0.54
057	2387	11	2	8.0	095	035	0750	7700	1630	1.48	08.2	17.4	04.50	0.29
057	2388	11	3	8.2	078	003	0650	7560	1860	0.84	06.4	10.6	03.72	0.41
058	2389	11	1	7.7	055	081	1050	6110	1450	1.40	10.6	32.0	04.44	0.54
058	2390	11	2	8.0	062	018	0880	7950	1650	1.58	08.6	13.2	05.96	0.29
058	2391	11	3	8.3	046	030	0785	7180	1740	0.76	07.6	09.4	03.28	0.50
059	2392	11	1	7.6	070	058	0655	4780	0720	0.32	09.0	25.0	01.30	0.41
059	2393	11	2	8.0	127	023	0670	7200	1340	0.44	07.4	10.0	03.44	0.29
059	2394	11	3	8.2	064	003	0670	6780	1530	1.12	07.2	09.2	04.18	0.33
062	2401	11	1	7.7	160	071	0605	6350	0980	0.38	06.8	25.0	01.38	0.50
062	2402	11	2	8.1	062	003	0560	7310	0980	1.04	07.2	13.4	04.14	0.25
062	2403	11	3	8.2	014	003	0515	6850	0850	1.04	06.2	08.2	03.80	0.25
065	2410	11	1	7.6	100	058	1060	2600	0520	0.76	07.2	46.0	02.74	0.46
065	2411	11	2	8.1	024	025	0870	8960	1500	1.72	06.8	17.8	07.04	0.29
065	2412	11	3	8.3	005	045	0720	7770	1600	0.68	05.8	10.4	03.52	0.66
068	2419	11	1	8.0	037	042	1090	8050	0850	0.44	04.0	11.6	01.42	0.41
068	2420	11	2	8.2	016	003	0515	8400	1090	0.16	07.6	15.0	01.34	0.29
068	2421	11	3	8.2	010	003	0435	7100	1350	0.14	04.2	09.2	01.28	0.29
072	2431	11	1	8.0	100	021	0625	7500	1250	0.44	05.0	12.8	01.12	0.37
072	2432	11	2	8.1	062	003	0465	7150	1480	0.18	06.0	08.2	01.04	0.25
072	2433	11	3	8.4	024	003	0470	6550	1640	0.18	04.6	06.4	01.06	0.33
076	2443	11	1	7.9	043	068	0740	5220	0920	0.48	04.8	12.8	01.72	0.35
076	2444	11	2	8.2	038	003	0470	7390	1320	0.18	06.2	09.4	01.16	0.24
076	2445	11	3	8.3	044	003	0480	7010	1710	0.20	05.8	07.4	01.28	0.24
078	2452	11	1	7.2	009	066	0750	3200	0940	0.62	06.8	21.6	01.56	0.63
078	2453	11	2	8.2	035	018	0615	7810	1750	0.22	08.2	12.4	01.40	0.24
078	2454	11	3	8.2	020	013	0645	7230	1760	0.22	07.6	08.8	01.40	0.28
080	2458	11	1	7.1	180	008	0785	5330	1080	0.44	06.8	32.0	01.20	0.59
080	2459	11	2	8.1	124	005	0500	7720	1080	0.24	07.2	12.8	01.20	0.24

TABLE LII continued

Sample No.	Lab No.	Soil Type	Depth	pH	NO_3	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
083	2467	11	1	7.4	085	060	0620	2870	0740	0.92	06.2	12.2	01.60	0.43
083	2468	11	2	8.0	038	005	0570	7520	1500	0.24	09.4	14.4	01.28	0.20
083	2469	11	3	8.3	016	010	0560	7740	1580	0.28	07.2	08.4	01.04	0.28
084	2470	11	1	7.3	070	073	0860	3540	0910	0.82	10.2	24.0	01.10	0.55
084	2471	11	2	7.6	024	010	0560	4810	1130	0.30	11.4	22.0	01.12	0.35
084	2472	11	3	8.1	010	029	0575	6410	1180	0.24	09.0	12.0	01.12	0.20
085	2473	11	1	7.6	130	045	0685	6950	0710	0.52	07.0	18.6	01.02	0.28
085	2474	11	2	8.1	019	026	0485	8240	1110	0.20	08.8	12.8	01.12	0.16
085	2475	11	3	8.1	020	066	0580	7760	1110	0.24	07.0	10.6	01.06	0.24
086	2476	11	1	8.0	060	013	0420	5450	0790	0.32	05.8	11.0	00.66	0.28
086	2477	11	2	8.1	024	010	0290	6670	0850	0.20	06.6	09.4	00.74	0.16
086	2478	11	3	8.3	010	003	0280	7080	1000	0.18	06.8	07.2	00.74	0.20
089	2485	11	1	7.8	110	034	0810	7740	0870	0.68	05.8	14.2	00.96	0.24
089	2486	11	2	8.2	092	003	0380	7750	1030	0.22	05.6	09.0	00.86	0.28
089	2487	11	3	8.3	038	003	0410	7110	1060	0.10	05.2	06.8	00.74	0.39
091	2491	11	1	8.0	055	018	0530	6340	0920	0.32	06.4	09.4	00.78	0.39
091	2492	11	2	8.2	046	003	0325	6480	0950	0.16	07.0	07.8	00.80	0.28
091	2493	11	3	8.3	010	003	0300	5760	1020	0.18	05.0	06.2	00.66	0.19
092	2494	11	1	7.0	190	126	1595	5670	1370	0.60	10.8	32.0	01.70	0.71
092	2495	11	2	7.8	160	016	0710	8230	1940	0.34	08.2	24.0	01.60	0.24
092	2496	11	3	8.2	010	003	0595	7180	2180	0.24	06.0	11.6	01.28	0.39
093	2497	11	1	7.8	130	058	1320	7810	1670	0.40	06.4	16.0	01.56	0.28
093	2498	11	2	8.4	035	003	0665	7000	2200	0.26	08.0	11.0	01.46	0.28
093	2499	11	3	8.5	016	003	0615	6520	2360	0.26	07.8	06.8	01.26	0.47
094	2500	11	1	7.8	060	042	1030	8310	1420	0.42	05.6	13.9	01.40	0.24
094	2501	11	2	8.3	038	003	0530	7750	1710	0.22	06.6	10.4	01.30	0.24
094	2502	11	3	8.3	012	003	0480	6900	1850	0.20	05.0	06.4	01.12	0.36
095	2503	11	1	8.0	060	003	0815	7500	1050	0.38	05.6	12.0	01.28	0.28
095	2504	11	2	8.1	032	003	0420	8150	0580	0.18	07.6	10.0	01.34	0.16
095	2505	11	3	8.3	020	003	0365	7700	0680	0.20	06.8	07.8	01.28	0.12
096	2506	11	1	8.0	050	039	0835	8700	0780	0.42	06.0	12.4	01.38	0.19
096	2507	11	2	8.2	135	003	0410	8350	1120	0.22	06.2	12.6	01.22	0.19
096	2508	11	3	8.3	024	003	0380	6900	1320	0.26	05.8	07.0	01.08	0.28
098	2512	11	1	7.4	090	094	0790	5140	1320	0.46	10.4	18.0	01.34	0.39
098	2513	11	2	8.1	086	026	0640	6900	1560	0.18	10.0	14.6	01.34	0.24
098	2514	11	3	8.2	030	003	0620	6350	1750	0.24	06.8	09.4	01.18	0.32
100	2518	11	1	7.9	060	084	0590	5460	0890	1.14	06.4	11.6	00.96	0.32
100	2519	11	2	8.1	041	024	0445	6360	0890	0.56	10.4	11.2	01.36	0.16
100	2520	11	3	8.1	014	021	0525	6700	1370	0.26	12.8	11.4	01.28	0.16
039	2332	12	1	8.1	076	030	0800	7440	1510	0.36	04.6	14.8	01.56	0.36
039	2333	12	2	8.3	032	003	0560	7400	1680	0.54	05.6	07.2	02.38	0.32
039	2334	12	3	8.5	020	003	0520	6600	1730	0.28	04.8	06.0	01.76	0.44
060	2395	13	1	6.9	055	083	0555	1700	0460	0.52	11.8	30.0	00.78	0.42
060	2396	13	2	7.6	054	043	0505	5330	0750	0.86	13.2	04.6	03.34	0.21
060	2397	13	3	8.0	044	003	0665	7100	1280	1.46	08.6	12.2	05.80	0.25
061	2398	13	1	7.7	041	134	0550	3230	0700	0.62	09.6	27.0	01.24	0.62
061	2399	13	2	7.7	124	033	0605	6080	1030	1.00	09.2	19.4	04.44	0.33
061	2400	13	3	8.4	019	003	0680	7130	1540	1.30	07.2	09.6	05.24	0.33
011	1792	14	1	7.5	115	165	0850	6150	1920	0.52	16.8	15.4	02.74	0.25
011	1793	14	2	8.0	038	055	0770	8300	0980	1.62	20.2	10.0	10.70	0.05
011	1794	14	3	7.9	030	005	0660	7700	0920	0.80	13.8	06.2	06.24	0.00
016	2266	14	1	7.5	062	043	0580	4110	0860	0.38	07.2	26.0	01.06	0.32
016	2267	14	2	8.2	027	015	0450	6610	1080	0.32	05.0	09.0	01.42	0.23
016	2268	14	3	8.4	020	020	0480	5990	1170	0.16	04.8	06.8	01.14	0.27
023	2287	14	1	7.3	130	048	0885	4650	1200	0.36	06.2	36.0	01.54	0.75
023	2288	14	2	8.0	038	023	0725	7850	1610	0.66	05.8	11.6	04.04	0.20

TABLE LII continued

Sample No.	Lab No.	Soil Type	Depth	pH	NO_3	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
029	2305	14	1	7.8	190	050	0955	6100	0960	0.42	04.6	26.0	01.26	0.50
029	2306	14	2	8.1	035	018	0700	7590	1300	0.76	06.2	10.4	03.12	0.15
029	2307	14	3	8.5	020	003	0525	6190	1240	0.20	03.6	04.8	01.00	0.20
031	2311	14	1	8.2	022	063	0705	5540	0800	0.46	04.6	18.0	01.16	0.45
031	2312	14	2	7.9	051	020	0585	7620	0950	1.06	07.6	15.6	04.30	0.30
031	2313	14	3	8.2	046	003	0590	7550	1120	1.74	06.0	09.4	07.02	0.16
034	2449	14	1	7.7	050	076	0645	3100	1050	0.78	06.0	17.0	01.48	0.91
034	2450	14	2	7.9	038	021	0500	6230	1300	0.36	11.2	18.8	01.32	0.35
034	2451	14	3	8.3	016	058	0655	7530	1700	0.28	05.8	08.0	01.14	0.35
040	2335	14	1	7.9	050	045	0560	4600	0870	0.26	04.8	16.2	01.00	0.36
040	2336	14	2	8.2	032	008	0450	6990	0940	0.88	06.0	09.2	03.28	0.16
040	2337	14	3	8.2	020	003	0425	7120	1160	0.20	06.0	07.6	01.42	0.19
045	2350	14	1	7.8	023	063	0640	3450	0880	0.34	06.8	20.0	01.00	0.58
045	2351	14	2	8.0	027	020	0655	7130	1090	2.00	07.6	16.4	05.16	0.18
045	2352	14	3	8.4	020	003	0615	7150	1160	1.74	06.0	09.6	04.92	0.18
046	2353	14	1	8.0	013	083	0575	4410	0730	0.36	07.8	36.0	01.00	0.49
046	2354	14	2	8.0	027	040	0570	7150	0820	0.80	10.2	18.2	03.46	0.18
046	2355	14	3	8.3	020	003	0405	6530	0670	0.32	05.2	08.0	01.46	0.13
088	2482	14	1	7.6	160	068	0590	5480	0750	0.58	06.6	19.6	00.78	0.28
088	2483	14	2	8.1	100	008	0300	7020	0980	0.20	08.4	13.2	00.86	0.24
088	2484	14	3	8.3	010	003	0335	6910	1110	0.18	06.2	08.0	00.84	0.20
008	1783	15	1	7.6	021	023	0300	1600	0220	0.36	09.4	06.9	00.70	0.10
008	1784	15	2	7.5	035	010	0250	1650	0190	0.26	09.6	04.8	00.62	0.20
008	1785	15	3	8.0	024	008	0190	2050	0180	0.55	09.8	03.5	00.62	0.50
071	2428	15	1	8.0	046	003	0295	5830	0170	0.22	04.4	09.0	00.38	0.21
071	2429	15	2	8.1	108	003	0235	6510	0280	0.12	04.6	07.8	00.42	0.16
071	2430	15	3	8.0	036	003	0215	6600	0500	0.12	04.8	05.4	00.52	0.13
023	2289	14	3	8.2	022	005	0675	7200	1500	0.24	04.8	07.2	01.52	0.30
026	2296	14	1	7.4	092	093	0500	3050	0490	0.56	05.8	26.0	00.86	0.45
026	2297	14	2	8.2	027	005	0385	6420	0530	0.16	05.4	10.8	00.92	0.20
026	2298	14	3	8.2	020	003	0340	6230	0410	0.18	03.6	06.2	01.10	0.15
036	2325	11	3	8.1	020	003	0500	6620	1130	0.28	05.0	05.6	01.90	0.28
037	2326	11	1	7.9	210	035	0720	7790	1070	0.30	04.6	14.6	01.38	0.28
037	2327	11	2	8.1	059	003	0540	7740	1250	0.26	05.2	08.6	02.18	0.23
037	2328	11	3	8.4	020	003	0580	7160	1670	0.28	04.8	05.0	02.08	0.28
064	2409	07	3	8.6	005	003	0575	6040	1390	0.36	05.4	07.0	02.86	0.62
067	2416	07	1	8.0	075	005	0710	8330	0850	0.24	05.2	13.2	01.16	0.29
067	2417	07	2	8.0	019	003	0335	7550	0700	0.12	06.2	10.0	01.08	0.25
067	2418	07	3	8.3	010	003	0210	6100	0640	0.10	03.6	04.4	00.54	0.29
080	2460	11	3	8.4	034	010	0570	7620	1390	0.18	06.4	07.6	01.12	0.28
082	2464	11	1	7.7	150	021	0720	6940	0940	0.38	05.6	12.2	00.94	0.28
082	2465	11	2	8.2	035	003	0365	7750	1000	0.20	04.8	06.6	00.94	0.20
082	2466	11	3	8.4	014	003	0305	6800	0990	0.14	04.2	03.8	00.82	0.24

TABLE LII

PLANT ANALYSIS DATA

Sample No.	Lab No.	Soil Type	Stage	%N	%P	%K	%Ca	%Mg	Fe	Zn	Mn	Cu
009	2880	01	1	2.65	0.248	2.68	0.82	0.30	260	28	050	15
009	4018	01	2	2.92	0.240	1.88	0.63	0.24	150	32	060	17
017	2888	01	1	3.68	0.257	2.47	0.88	0.37	360	27	097	20
017	4026	01	2	2.20	0.200	1.45	0.58	0.25	160	29	060	18
018	2889	01	1	3.13	0.221	2.63	0.83	0.43	350	14	086	22
018	4027	01	2	2.30	0.160	1.32	0.65	0.30	100	09	030	20
019	2890	01	1	2.95	0.238	2.96	0.81	0.32	320	13	089	17
019	4028	01	2	2.32	0.190	1.89	0.76	0.23	140	13	051	24
027	2899	01	1	3.45	0.297	3.33	0.94	0.41	230	17	185	21
027	4037	01	2	2.45	0.220	2.43	0.81	0.30	130	18	141	26
063	2935	01	1	3.53	0.270	2.87	0.73	0.24	320	16	068	17
063	4070	01	2	2.50	0.200	1.89	0.84	0.26	240	16	059	19
073	2945	01	1	3.73	0.264	2.71	0.96	0.53	360	29	145	22
073	4080	01	2	2.90	0.220	2.16	0.73	0.28	170	14	078	18
090	2961	01	1	5.00	0.351	4.03	0.83	0.61	390	23	092	16
090	4129	01	2	3.10	0.270	2.16	0.70	0.24	100	16	070	15
102	2973	01	1	4.43	0.302	4.00	0.71	0.32	440	25	125	18
102	4131	01	2	3.40	0.270	2.00	0.85	0.28	160	12	110	21
004	2875	02	1	2.88	0.243	2.61	0.67	0.33	360	19	085	17
004	4013	02	2	2.35	0.160	1.60	0.53	0.23	180	14	060	15
053	2925	02	1	3.70	0.270	2.40	0.80	0.34	440	18	088	17
053	4062	02	2	2.60	0.270	1.98	0.68	0.22	220	20	083	29
087	2958	02	1	4.43	0.302	2.77	1.04	0.49	310	49	164	24
087	4126	02	2	1.60	0.140	2.16	0.60	0.23	060	16	040	09
006	2877	04	1	3.50	0.275	2.73	0.77	0.30	290	16	056	16
006	4015	04	2	2.95	0.240	1.88	0.55	0.23	180	21	050	16
007	2878	04	1	3.45	0.243	3.10	0.88	0.38	260	24	047	17
007	4016	04	2	3.60	0.240	1.68	0.69	0.23	180	25	050	20
070	2942	04	1	3.55	0.248	2.36	0.88	0.28	230	40	075	19
070	4077	04	2	3.05	0.220	2.07	0.73	0.24	170	24	056	19
101	2972	04	1	4.43	0.329	2.74	0.83	0.31	450	43	115	20
101	4099	04	2	2.85	0.260	2.16	0.79	0.21	160	19	060	12
103	2974	04	1	3.00	0.318	3.56	0.55	0.27	310	32	109	23
103	4132	04	2	2.00	0.160	1.92	0.60	0.23	150	14	040	11
104	2975	04	1	3.93	0.256	2.77	0.78	0.31	340	39	104	21
104	4100	04	2	2.60	0.160	2.43	0.74	0.33	170	18	040	13
066	2938	05	1	3.70	0.203	2.78	0.66	0.23	340	22	101	16
066	4073	05	2	2.75	0.190	1.89	0.63	0.15	160	19	062	24
012	2883	06	1	3.88	0.275	3.15	0.75	0.33	660	45	097	25
012	4021	06	2	2.25	0.190	1.60	0.46	0.21	110	22	050	17
020	2891	06	1	3.30	0.243	3.08	0.68	0.50	460	16	104	22
020	4029	06	2	2.25	0.150	2.07	0.75	0.25	140	12	040	23
024	2895	06	1	3.83	0.405	2.59	0.96	0.48	410	16	195	18
024	4033	06	2	3.10	0.240	1.89	0.93	0.37	180	19	152	27
041	2913	06	1	3.40	0.230	2.40	1.08	0.51	350	15	136	20
041	4051	06	2	2.52	0.190	1.98	0.83	0.35	180	14	110	26
055	2927	06	1	4.08	0.275	2.87	0.76	0.35	540	24	137	22
055	4064	06	2	2.95	0.230	2.07	0.61	0.24	200	17	084	23

TABLE LIII continued

Sample No.	Lab No.	Soil Type	Stage	%N	%P	%K	%Ca	%Mg	Fe	Zn	Mn	Cu
074	2946	06	1	4.15	0.248	2.77	0.85	0.46	380	22	156	22
074	4081	06	2	2.70	0.220	2.07	0.59	0.25	210	18	080	24
077	2949	06	1	4.45	0.275	3.15	0.83	0.50	260	30	150	20
077	4123	06	2	2.30	0.190	1.50	0.65	0.30	100	07	080	11
105	2976	06	1	3.85	0.216	2.49	0.72	0.38	450	27	101	22
105	4101	06	2	3.15	0.190	1.80	0.75	0.53	160	17	080	18
124	2896	06	1	3.75	0.324	2.85	0.98	0.30	250	20	153	16
124	4034	06	2	3.10	0.220	1.98	0.86	0.18	170	19	165	27
002	2873	07	1	3.80	0.351	2.73	0.68	0.26	350	20	111	17
002	4011	07	2	2.95	0.240	1.80	0.70	0.25	190	20	070	21
021	2892	07	1	3.75	0.508	2.47	0.93	0.28	360	23	122	18
021	4030	07	2	2.50	0.190	1.98	0.64	0.19	150	18	053	24
022	2893	07	1	3.60	0.243	2.49	0.71	0.26	320	26	101	17
022	4031	07	2	2.70	0.190	2.16	0.81	0.26	140	30	113	21
028	2900	07	1	4.05	0.311	3.10	1.20	0.48	260	28	164	19
028	4038	07	2	2.62	0.220	1.80	0.70	0.31	150	24	073	21
047	2919	07	1	3.58	0.265	2.85	0.83	0.46	390	32	161	21
047	4057	07	2	3.05	0.220	1.80	0.72	0.39	160	28	163	25
049	2921	07	1	2.45	0.265	2.98	0.93	0.44	530	17	193	28
049	4059	07	2	1.40	0.090	1.89	0.61	0.28	190	17	083	17
064	2936	07	1	3.93	0.243	2.00	0.49	0.31	510	31	107	30
064	4071	07	2	2.90	0.190	1.80	0.60	0.29	200	18	052	20
067	2939	07	1	4.00	0.238	2.59	0.83	0.35	370	38	095	21
067	4074	07	2	2.65	0.160	1.71	0.76	0.26	120	20	043	21
069	2941	07	1	3.88	0.237	2.49	1.04	0.38	370	35	081	18
069	4076	07	2	2.88	0.220	1.80	0.60	0.21	190	20	039	20
081	2952	07	1	3.88	0.194	2.96	0.98	0.43	410	62	198	22
081	4085	07	2	3.25	0.190	1.80	0.40	0.13	150	51	147	29
097	2968	07	1	4.23	0.297	2.71	0.88	0.41	660	51	206	22
097	4095	07	2	3.10	0.230	1.80	0.90	0.32	220	30	148	20
099	2970	07	1	3.75	0.264	2.52	0.72	0.33	540	51	191	22
099	4097	07	2	2.80	0.190	2.25	0.74	0.24	180	23	150	21
025	2897	08	1	3.60	0.257	2.57	0.80	0.33	320	26	101	18
025	4035	08	2	2.80	0.220	2.07	0.78	0.37	190	18	096	22
075	2947	08	1	3.78	0.270	2.65	0.98	0.45	410	23	126	23
075	4082	08	2	3.35	0.190	1.53	0.55	0.21	280	15	082	32
042	2914	10	1	2.43	0.265	2.50	1.01	0.40	300	17	159	22
042	4052	10	2	2.95	0.230	1.98	0.59	0.31	200	16	105	33
001	2872	11	1	3.83	0.270	2.52	0.86	0.37	430	18	146	18
001	4010	11	2	3.30	0.240	1.92	0.55	0.16	140	15	170	22
003	2874	11	1	3.75	0.292	2.63	0.66	0.28	350	29	085	19
003	4012	11	2	3.25	0.270	1.84	0.64	0.24	150	24	090	23
005	2876	11	1	3.63	0.297	2.54	0.63	0.26	320	17	128	23
005	4014	11	2	2.80	0.200	1.80	0.51	0.21	130	18	090	18
010	2881	11	1	3.23	0.324	3.08	0.80	0.32	370	18	118	17
010	4019	11	2	2.62	0.230	2.12	0.55	0.22	180	15	110	20
013	2884	11	1	3.55	0.270	2.39	0.59	0.34	444	36	098	19
013	4022	11	2	2.10	0.160	1.88	0.37	0.21	110	14	040	17
014	2885	11	1	3.58	0.284	3.08	0.73	0.41	270	42	162	20
014	4023	11	2	2.70	0.190	2.16	0.47	0.25	130	28	080	15
015	2886	11	1	3.90	0.329	3.08	1.01	0.40	320	29	127	20
015	4024	11	2	2.40	0.110	2.20	0.37	0.23	160	20	050	16
030	2902	11	1	3.50	0.283	2.96	0.55	0.30	510	35	151	19
030	4040	11	2	2.75	0.220	2.16	0.67	0.33	530	16	130	32
032	2904	11	1	3.15	0.248	3.24	0.91	0.45	360	14	142	20
032	4042	11	2	2.72	0.200	2.16	0.66	0.31	180	13	132	27

TABLE LIII continued

Sample No.	Lab No.	Soil Type	Stage	%N	%P	%K	%Ca	%Mg	Fe	Zn	Mn	Cu
036	2908	11	1	3.33	0.162	2.56	1.28	0.55	500	32	141	22
036	4046	11	2	2.42	0.140	2.52	0.68	0.26	190	18	096	23
037	2909	11	1	2.45	0.203	2.64	1.05	0.53	230	14	131	19
037	4047	11	2	2.90	0.160	2.43	1.09	0.36	200	19	123	30
038	2910	11	1	3.60	0.265	2.78	0.69	0.31	420	21	122	19
038	4048	11	2	3.00	0.220	1.71	0.62	0.26	220	20	113	29
043	2915	11	1	3.30	0.265	3.45	0.95	0.29	480	14	191	21
043	4053	11	2	2.70	0.240	2.25	0.67	0.19	180	12	139	28
044	2916	11	1	3.70	0.351	3.68	1.81	0.45	220	14	134	17
044	4054	11	2	2.95	0.240	1.98	0.83	0.33	200	11	087	27
048	2920	11	1	3.45	0.405	2.36	0.85	0.41	320	20	153	20
048	4058	11	2	1.85	0.160	2.07	0.76	0.27	190	11	105	24
050	2922	11	1	2.63	0.324	2.59	0.94	0.39	630	25	134	15
050	4060	11	2	1.95	0.180	2.25	0.64	0.29	180	16	092	16
051	2923	11	1	3.68	0.248	2.93	0.63	0.27	370	31	141	20
051	4061	11	2	2.85	0.220	2.07	0.61	0.19	150	18	105	27
052	2924	11	1	3.35	0.405	2.92	0.99	0.48	350	25	078	15
052	4120	11	2	2.20	0.230	1.45	0.59	0.26	100	09	050	12
054	2926	11	1	3.78	0.211	2.36	0.55	0.29	320	15	073	14
054	4063	11	2	2.95	0.240	2.23	0.53	0.23	180	19	062	25
056	2928	11	1	4.08	0.351	3.15	0.84	0.33	370	15	150	23
056	4065	11	2	2.95	0.270	1.89	0.70	0.23	300	15	100	25
057	2929	11	1	4.35	0.184	2.35	0.79	0.34	570	23	095	13
057	4066	11	2	2.65	0.230	2.25	0.69	0.43	230	11	157	30
058	2930	11	1	3.95	0.270	3.34	0.68	0.33	480	19	102	21
058	4067	11	2	3.25	0.270	2.25	0.62	0.24	220	19	075	24
059	2931	11	1	4.00	0.211	2.64	0.70	0.35	470	24	075	18
059	4068	11	2	3.25	0.220	2.25	0.59	0.26	270	20	084	26
062	2934	11	1	4.00	0.324	3.08	0.95	0.45	340	23	135	21
062	4122	11	2	1.90	0.160	1.32	0.57	0.24	150	06	090	12
065	2937	11	1	4.08	0.284	2.73	0.75	0.30	500	20	131	19
065	4072	11	2	3.10	0.260	2.07	0.64	0.20	150	17	071	25
068	2940	11	1	3.63	0.257	2.89	0.84	0.36	320	21	177	22
068	4075	11	2	2.78	0.160	1.62	0.47	0.16	160	29	112	29
072	2944	11	1	4.00	0.243	2.58	0.95	0.36	420	31	134	22
072	4079	11	2	2.85	0.220	2.25	0.48	0.16	180	98	068	22
076	2948	11	1	3.33	0.256	2.84	0.65	0.30	350	22	089	20
076	4083	11	2	3.15	0.220	1.80	0.62	0.29	180	11	079	24
078	2950	11	1	4.48	0.283	2.74	0.89	0.53	210	29	153	18
078	4124	11	2	2.40	0.270	2.12	0.63	0.28	050	13	070	12
080	2951	11	1	3.70	0.162	2.80	0.60	0.31	260	47	115	21
080	4084	11	2	2.95	0.160	2.07	0.45	0.17	180	40	100	21
082	2953	11	1	3.93	0.216	3.43	1.23	0.25	190	37	147	19
082	4086	11	2	2.95	0.220	1.71	0.42	0.12	250	10	045	20
083	2954	11	1	3.73	0.229	2.55	0.63	0.38	370	22	075	14
083	4087	11	2	3.15	0.220	1.62	0.39	0.20	280	18	051	20
084	2955	11	1	3.85	0.264	3.09	0.75	0.43	310	29	088	16
084	4088	11	2	2.85	0.240	1.98	0.49	0.21	370	18	047	21
085	1956	11	1	4.90	0.324	3.34	1.16	0.46	170	34	238	22
085	4089	11	2	3.10	0.300	2.16	0.80	0.30	190	17	163	25
086	2957	11	1	3.88	0.189	2.90	0.79	0.41	230	30	102	18
086	4125	11	2	1.95	0.110	0.83	0.31	0.10	050	10	020	06
089	2960	11	1	4.60	0.302	3.69	1.70	0.65	120	43	171	18
089	4128	11	2	2.65	0.200	1.96	0.68	0.34	090	26	080	13
091	2962	11	1	4.18	0.270	3.15	0.76	0.46	510	33	129	39
091	4130	11	2	3.25	0.220	1.92	0.85	0.30	140	28	110	20

TABLE LIII continued

Sample No.	Lab No.	Soil Type	Stage	%N	%P	%K	%Ca	%Mg	Fe	Zn	Mn	Cu
094	2965	11	1	4.08	0.264	3.06	0.87	0.33	450	27	192	29
094	4092	11	2	2.85	0.190	1.71	0.78	0.29	200	15	102	25
095	2966	11	1	2.50	0.210	3.09	0.67	0.32	300	47	108	20
095	4093	11	2	2.85	0.140	1.62	0.49	0.18	160	29	044	21
096	2967	11	1	4.50	0.297	3.47	0.91	0.28	360	44	173	23
096	4094	11	2	2.80	0.190	2.07	0.87	0.24	150	17	104	22
098	2969	11	1	4.18	0.291	3.28	0.55	0.24	440	25	130	20
098	4096	11	2	3.00	0.230	1.80	0.50	0.18	210	12	093	21
100	2971	11	1	3.83	0.270	2.52	0.62	0.26	370	59	099	19
100	4098	11	2	3.00	0.270	2.16	0.63	0.24	210	18	080	16
039	2911	12	1	3.60	0.248	2.80	0.58	0.29	440	23	140	23
039	4049	12	2	2.38	0.160	2.07	0.63	0.32	180	12	124	29
060	2932	13	1	4.00	0.324	3.59	0.84	0.25	330	19	084	19
060	4069	13	2	3.10	0.350	1.98	0.58	0.15	250	13	052	29
061	2933	13	1	2.30	0.329	3.20	0.68	0.29	340	22	112	16
061	4121	13	2	2.30	0.260	2.12	0.58	0.22	260	10	100	15
011	2882	14	1	3.63	0.270	2.70	0.67	0.32	400	16	121	17
011	4020	14	2	2.38	0.220	1.40	0.35	0.19	180	14	080	18
016	2887	14	1	3.85	0.270	3.17	0.63	0.35	410	25	091	18
016	4025	14	2	2.70	0.220	2.00	0.35	0.21	120	21	050	17
023	2894	14	1	3.50	0.257	2.54	0.72	0.38	370	23	120	15
023	4032	14	2	2.92	0.240	1.98	0.71	0.38	200	24	101	24
026	2898	14	1	3.45	0.270	2.63	0.76	0.32	250	17	106	16
026	4036	14	2	1.95	0.220	2.43	0.75	0.25	120	17	091	20
029	2901	14	1	3.35	0.270	3.40	0.76	0.33	470	18	118	21
029	4039	14	2	3.10	0.240	2.25	0.72	0.31	180	23	154	35
031	2903	14	1	3.93	0.302	3.01	0.86	0.39	410	27	130	22
031	4041	14	2	3.10	0.240	2.16	0.59	0.25	170	22	101	30
034	2906	14	1	3.68	0.297	3.20	0.66	0.30	370	19	115	18
034	4044	14	2	3.00	0.270	2.07	0.47	0.21	250	18	095	26
040	2912	14	1	3.60	0.270	2.85	0.71	0.28	280	14	110	23
040	4050	14	2	2.30	0.160	1.98	0.82	0.33	200	11	093	25
045	2917	14	1	3.58	0.302	2.61	0.76	0.40	380	26	130	19
045	4055	14	2	3.25	0.270	1.98	0.63	0.32	230	15	101	25
046	2918	14	1	3.68	0.216	2.68	1.03	0.45	470	26	160	20
046	4056	14	2	2.85	0.190	1.80	0.77	0.25	170	21	123	22
088	2959	14	1	3.95	0.297	3.28	0.91	0.56	160	33	149	18
088	4127	14	2	2.70	0.190	1.46	0.61	0.31	130	18	060	13
008	2879	15	1	3.35	0.297	3.33	0.61	0.27	190	22	048	13
008	4017	15	2	3.10	0.220	2.08	0.51	0.22	100	15	040	15
071	2943	15	1	3.53	0.248	2.46	1.19	0.34	290	27	130	17
071	4078	15	2	3.05	0.190	1.80	0.86	0.23	230	14	094	24
033	2905	11	1	3.48	0.270	2.90	0.63	0.28	630	25	134	18
033	4043	11	2	2.80	0.240	2.07	0.53	0.22	210	18	119	23
035	2907	11	1	3.50	0.235	2.85	1.20	0.44	720	31	146	23
035	4045	11	2	2.70	0.160	2.70	0.71	0.27	170	23	128	25
092	2963	11	1	3.78	0.275	2.93	0.81	0.29	620	26	142	20
092	4090	11	2	3.25	0.220	1.80	0.47	0.15	210	10	117	27
093	2964	11	1	3.75	0.256	2.52	0.75	0.31	370	21	121	18
093	4091	11	2	2.65	0.220	2.07	0.68	0.27	310	08	153	26

VITA

Lloyd Ray Harrison

Candidate for the Degree of

Master of Science

Thesis: RELATIONSHIP BETWEEN SOIL TESTS, PLANT ANALYSES, AND CORN PRODUCTION ON KEY SOILS IN CIMARRON COUNTY, OKLAHOMA

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