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Investigating soil property and quality changes from samples submitted to the LSU AgCenter Soil Testing Laboratory

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INVESTIGATING SOIL PROPERTY AND QUALITY CHANGES FROM SAMPLES
SUBMITTED TO THE LSU AGCENTER SOIL TESTING LABORATORY

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the Degree of
Master of Science

in

The School of Human Resource Education
and Workforce Development

by
Mark A. Williams
B.S., Louisiana State University, 1985
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ABSTRACT

The primary purpose of the study is to investigate the trends in soil nutrient levels from soil samples submitted to the LSU AgCenter soil testing and plant analysis laboratory during 2008 to 2012. This study indicates the trend for soil pH, soil phosphorus and soil potassium for corn, cotton, rice, grain sorghum, soybeans, and sugarcane. These six crops were analyzed in this study because of the economic significance to the Louisiana agricultural industry. The trend in soil nutrients studied were generally within the recommended levels for sustainability and environmental stewardship. This study describes the trends for soil pH, soil phosphorus and soil potassium for Louisiana soils during the years 2008 – 2012. The value of this paper lies in calling attention to broad nutrient needs and challenges faced by the crop producers. Finally, the study findings demonstrate the importance of monitoring soil nutrient trends and environmental stewardship.

CHAPTER 1: INTRODUCTION

Rationale

During the past decade, considerable emphasis has been placed on nutrient management and water quality. Soil testing is a tool that allows producers to plan their nutrient and soil amendment (lime) inputs based on soil nutrient levels. The soil test results provide valuable information of the actual amount of soil nutrients and the pH level of the soil.

For soils to be productive, they must be rich in nutrients necessary for basic plant nutrition (Doran, 1996). Soil tests indicate the relative capacity of soil to provide nutrients to plants. Therefore, the soil test summary can be viewed as an indicator of the nutrient supplying capacity of soils in Louisiana. The summary of soil test data from 2008-2012 provides a review of the nutrient status of soil samples over the years. The value of statewide soil test summaries lies in calling attention to broad nutrient needs and challenges of the soils in Louisiana and changes that have occurred over time (Fitts, 1956).

Two major uses of soil test summaries are (i) to evaluate fertilizer and lime recommendations, and (ii) to encourage the proper use of fertilizer and lime (Donahue, 1987). Various types of soil test summaries can be prepared to convey the information on soil nutrient levels. Single-year comparisons will be made to evaluate the need for fertilizer and lime. Multi-year comparisons will be studied to evaluate how needs are changing. Summaries will be made on a parish/county, regional, and statewide basis.

Soil testing is a tool used to measure the soil's ability to supply nutrients for optimum plant growth (Gartley, 1994). One of the most important results of testing is the soil pH. This test determines the amount of lime or sulfur needed to adjust the soil pH to the proper range for the plant or crop to be grown (Fitts, 1956).

Soil is dynamic and is constantly undergoing change. The quantity and availability of plant nutrient elements in the soil change because of removal by the growing or harvested crop, leaching, erosion, or the addition of fertilizer, manure or compost (Brady, 1974). The soil test is a snapshot of the current fertility status and provides information to maintain the growth potential of the soil.

Many crops can tolerate a wide range of soil pH when all other growing conditions are good. Some plants however, require a narrow range of soil pH for proper growth. The only way to determine if a soil is acid, neutral, or alkaline is with a soil test. Most plants including flowers, ornamental shrubs, turf grass and vegetables grow best in slightly acid soil with a pH range of 6.1 to 6.9 (Doran, 1996). The pH value of soil is one of a number of environmental conditions that affects the quality of plant growth. The soil pH value directly affects nutrient availability (Jensen, 2013). Plants thrive best in different soil pH ranges. Azaleas, rhododendrons, blueberries and conifers thrive best in acid soils (pH 5.0 to 5.5). Vegetables, grasses and most ornamentals do best in slightly acidic soils (pH 5.8 to 6.5). Soil pH values above or below these ranges may result in less vigorous growth and nutrient deficiencies (Kluepfel, 1999). The availability of most soil nutrients is greatest at or near the soil pH of 6.5. When the soil pH rises above this level the trace elements such as iron, manganese, copper, and zinc become less available.

When it comes to growing agriculture crops, managing soil fertility is important economically as well as environmentally. If a producer under-applies nutrients the yield and profitability will suffer. Over-application of nutrients is money wasted. In addition, over-applied phosphorus may result in increased transport through runoff into surface water, where it can contribute to environmental problems (Dinkins, 2007).

Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. Excess fertilizers, pesticides, and insecticides from agricultural land can contribute significantly to nonpoint source pollution (EPA, 2005).

The agricultural extension agents and crop advisors use the information contained in the soil test results as a guide to adjust fertilizer recommendations based on climate and soil properties at a specific location. Crop advisers and agricultural extension agents generally know regional differences in nutrient needs, so they may be the best source for specific recommendations (Dinkins, 2007).

Problem Statement

The primary purpose of the study is to investigate the trends in soil nutrient levels from soil samples submitted to the LSU AgCenter soil testing and plant analysis laboratory during 2008 to 2012.

Research Objectives

1. The first objective of this study was to investigate soil pH levels for samples submitted to LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.
2. The second objective of this study was to investigate if the concentration of soil P has changed over time for the samples submitted to the LSU AgCenter soil testing laboratory

during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

3. The third objective of this study was to investigate soil concentrations of potassium, for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

Significance of the Study

The significance of this study was to investigate the current and past concentrations of soil nutrients found in soil samples submitted to LSU AgCenter soil testing laboratory during the period from 2008-2012. The average Louisiana crop producer has many inputs into the production of a crop for each season. One of the most expensive inputs is soil amendments and fertilizer. The following crops, corn, cotton, rice, soybeans, sorghum, and sugarcane were chosen for this study due to their economic significance to Louisiana agriculture.

The results of this study will help inform producers, extension agents, and crop consultants about the trends in the concentrations of soil nutrients as an indicator of nutrient removal harvested crops. This study should also encourage nutrient management and sustainability among crop producers. The study will also provide extension agents a better understanding of crop nutrient requirements and usage through each growing season. The soil summary information demonstrates to the agriculture extension agents the regional differences in soil nutrient levels, as effective educational tool when making fertilizer recommendation for a crop producer.

Limitations

In this study, the researcher chose to focus on six major row crops produced in Louisiana, because of their high demand for various soil nutrients and their economic significance, even

though forestry is the number agriculture crop in Louisiana. Another limiting factor of only using soil samples submitted to LSU AgCenter soil testing laboratory, is because of the variability in acreage sampled from year to year the researcher could only look at soil trends. Perhaps expanding the study to include soil test results for the same crops grown in other states with similar soil characteristics would be beneficial.

CHAPTER 2: REVIEW OF LITERATURE

Soil quality integrates physical, chemical and biological components and processes and the interactions between them (Dexter, 2004; Karlen et al., 2001). Fundamentally, soil consists of sand, silt, and clay particles. Sand represents the largest particle size of 2 mm, whereas clay represents the smallest of the particles down to microscopic size of less than 0.002 mm. The combination of sand, silt and clay with mineral material and organic matter form the soil texture. These particles combine together to form aggregates. Texture and organic matter content of a soil control the degree of aggregation that is possible.

Physical, chemical and biological processes help form aggregates. Physical and chemical processes are more important in the formation of smaller aggregates. Freezing and thawing, wetting and drying, roots pushing through the soil and burrowing earthworms physically push particles closer together. At the molecular level, electrochemical charges bond clay particles together so that organic matter can then bind with the clay particles (Magdoff, 2009).

Biological processes are very important in the formation of soil aggregates. Humus and compounds produced by the soil organisms help bind soil particles together. Fine roots and fungal strands surround aggregates and help stabilize them. The plant residue provides food for the fungi and bacteria that help form and stabilize soil aggregates. All of these processes explain why plant residue, manure, and other forms of organic matter improve soil structure (Doran, 1994).

Aggregate stability is the strength of soil aggregates to withstand chemical and physical forces, such as tillage or rain. Healthy soil will have varied aggregate size and will have high aggregate stability. Soils with poor aggregate stability are susceptible to formation of surface crust when rain hits the aggregates and detach soil particles. Fine clay particles then clog the

spaces between aggregates and form a crust on the soil. The addition of organic matter and other biological activity help stabilize aggregates and prevent erosion and the formation of crusts.

Soil structure is the arrangement and stability of aggregates and pore spaces in soil. The pore size and shapes affect the ability of a soil to transmit water and air. This influences root and plant development. Soils with good structural development are more porous and less dense than poorly structured soils (Magdoff, 2009).

The density of the soil is a measure of the proportion of the solids and voids in a volume of soil. Soil bulk density is dependent upon the soil texture, with sandy soils having a higher density than fine textured soils. Degradation in soil structure due to depletion of organic matter or other factors can increase bulk density over the long term. Compaction from wheel traffic or grazing can increase soil bulk density (Brady, 1974).

Soil Testing

A routine soil test is a valuable management practice for all farming operations, whether the producer is growing vegetables, row crops or pasture for livestock. The purpose of soil testing is to provide an accurate assessment of the soil's fertility status that can be used to make fertilizer and lime recommendations. The results of a soil test are an important measure of the soil's ability to supply nutrient elements needed for optimum plant growth (Jensen, 2013).

The routine soil test measures soil pH, phosphorus, potassium, calcium, magnesium, sodium, sulfur, copper, and zinc. The most important information on the soil test results and key indicator of soil health is the soil pH. Soil pH measures the acidity or alkalinity level of the soil. The pH of a soil has a significant effect on the availability of the different plant nutrients to the plant. Soil pH affects whether a given nutrient is more or less available to the plant. Plants absorb most nutrients from the soil through their roots. If plants do not have access to the

micronutrients, they need because the soil pH is high, their growth will be suppressed and nutrient deficiency symptoms such as chlorosis (yellowing) may appear (Brady, 1974).

When soils are acidic (have a low pH), some nutrients are available in excess and plants take up more than they need, with often with toxic results. If the soil tests results, indicate high acidity or alkalinity you can adjust the pH of the soil to the optimal range with a variety of amendments (Brady, 1974).

Soil testing takes the guesswork out of maintaining the soil in optimum condition for plant growth and development. Different plants have different soil pH and nutrient requirements. Soil testing is inexpensive when compared to the investment in seed, plants, amendments, time and labor needed to produce a crop. In comparison, the cost per acre average for fertilizer is about two hundred dollars and the cost of soil sampling is about ten dollars per sample.

Maintaining soil fertility and reducing the application of unnecessary nutrients is not the only benefit of regular soil testing. Using routine soil tests to monitor nutrient levels contributes to the sustainability of the land and is the foundation of environmental stewardship. This is as equally important in developing a nutrient management plan when combined with production information such as cropping history and yield maps.

A nutrient management plan should consider the impact of nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, NPS comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground

sources of drinking water. Excess fertilizers, pesticides, and insecticides from agricultural land can contribute significantly to nonpoint source pollution (EPA, 2005).

LSU Soil Testing and Plant Analysis Laboratory STPAL

The LSU Soil Testing Lab was established in 1944. In 2001, the Laboratory was combined with the Plant Analysis Laboratory to become the Soil Testing and Plant Analysis Laboratory (STPAL). This lab is a leader in providing the citizens of Louisiana with soil, plant tissue, and water analysis information. The lab is also central to the research community's quest to provide fertilizer and liming recommendations to optimize crop yields and profit margins. STPAL offers a wide variety of soil, plant tissue and water tests and fertilizer recommendations to the public. Our clients include farmers, home consumers, agricultural consultants, horticulturists, extension specialists, extension agents, and researchers across Louisiana. The lab is guided by an advisory committee consisting of AgCenter research/extension faculty members and agricultural consultants. The protocols that are used conform to the North American Proficiency Test (NAPT) program (Miller, 2001).

STPAL Mission is committed to provide prompt and exacting service on soil, plant, and water chemical analyses used for fertilization and environmental management decisions by the public and the research community. Clientele recommendations are based on the latest Louisiana-specific soil fertility research to optimize crop performance with the least amount of fertilizer inputs.

Soil Fertility

Doran and Parkin (1994) defined soil quality as “the capacity of a soil to function, within ecosystem and land use boundaries, to sustain productivity, maintain environmental quality, and promote plant and animal health”.(p3) What is an essential element? An essential mineral

element is one that is required for normal plant growth and reproduction. With the exception of carbon (C) and oxygen (O), which are supplied from the atmosphere, the essential elements are obtained from the soil. The amount of each element required by the plant varies; however, all essential elements are equally important in terms of plant physiological processes and plant growth (Doran, 1994).

There are four categories of essential elements for plants based on their origin or relevance to plant needs for proper development. Non-mineral essential elements are derived from the air and water. Primary essential elements are most often applied in commercial fertilizers or in manures. Secondary elements are normally applied as soil amendments or are components of fertilizers that carry primary nutrients. Non-mineral, primary and secondary elements are also referred to as macronutrients since they are required in relatively large amounts in most crops (Tugel, 2000).

Micronutrients are required in very small, or trace, amounts by plants. Although micronutrients are required by plants in very small quantities, they are equally essential to plant growth. Carbon, hydrogen and oxygen are derived from air or water. Primary macronutrients include nitrogen, phosphorus and potassium, which mostly come from the soil. Secondary macronutrients mostly found in the soil are calcium, magnesium and sulfur. Other essential elements required by plants but only in trace amounts are considered, as micronutrients are iron, manganese, boron, zinc, copper, molybdenum, chlorine, cobalt and nickel (Tugel, 2000).

Soil pH

Soil pH is the most important soil characteristic to consider when it comes to plant growth. Soil pH is the measure of the acidity or alkalinity of the soil. The relevance of soil pH

is that it influences the chemical and biological reactions that take place in the soil, including the availability and uptake of essential plant nutrients (Doran J. W., 1994).

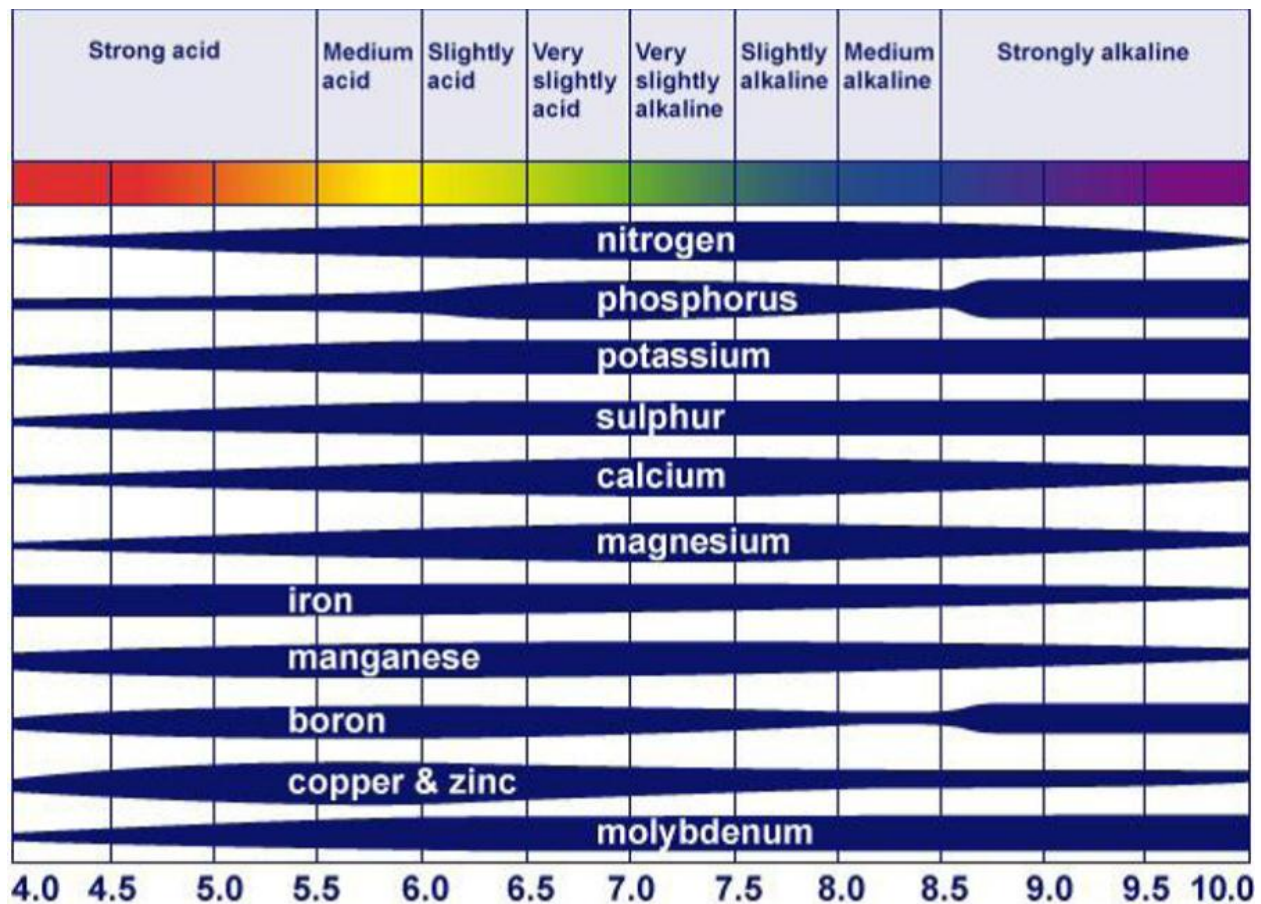


Figure 1 Nutrient availability as affected by soil pH; the wider the band, the greater the availability. (Adapted from Truog, USDA Yearbook of Agriculture 1943-1047)

Soils in Louisiana

Soils are named and classified based on physical and chemical properties in their horizons (layers). "Soil Taxonomy" uses color, texture, structure, and other properties of the surface two meters to key the soil into a classification system to help people use soil information. This system also provides a common language for scientists (SSS, 1999).

The soil in Louisiana is as diverse as the culture of the people that inhabit the land. Most soils found in Louisiana originate from sediments left behind from the rivers that snake across

Louisiana. This sediment is termed alluvium and is rich in nutrients due the high amount of organic matter it contains. Each soil type is unique depending on its developmental history. Soil is continually forming and undergoing change. Gases and water move into and out of soil. Organic matter found in or added to the soil is transformed among many different forms. Living organisms, including microbes, roots, and insects change the physical and chemical environment of the soil (Weindorf, Understanding Louisiana Soils, 2008).

Louisiana is divided into six major soil areas coastal plain, flatwoods, coastal prairie, loess hills, recent alluvium, and coastal marsh (Lytle 1968) & (Lytle & Sturgis 1962). The state soil of Louisiana is the Ruston soil series, covering 733,714 acres. Ruston soils are very deep, well drained, and moderately permeable soils; however, they are strongly acid and have low fertility (Weindorf, An update of the field guide to Louisiana soil classification, 2008).

General Crops Grown in Louisiana

According to the 2012 LSU Agriculture Center Agriculture Summary, the major crops grown in Louisiana include cotton, corn, grain sorghum, oats, forestry products, rice, sugarcane, and soybeans. Some of the minor but significant crops grown in the state include fruit crops, hay sold, home vegetable gardens, nursery crops, peanuts, pecans, sod/turf production, sweet potatoes, and wheat. The gross farm value of all plant enterprises was \$4.095 billion in 2012. After all commodities were harvested, processed and packaged, the value added brought an additional \$3.114 billion in 2012. Total value of plant or crop enterprises to the Louisiana economy was \$7.209 billion for this year 2012.

Many Louisiana communities depend on agriculture for local jobs and economic well-being. Forestry is the number one agriculture crop in Louisiana and is ranked third in the nation

for rice production. The soil beneath our feet provides the food we eat, cleans the water we drink, and supports the diverse biological habitats around us.

Current acreage of the major agronomic crops grown in Louisiana are represented in the Table 1.

Table 1 Economic value of selected Louisiana crops. (AgCenter, 2013)

Crop	Acreage	Gross Farm Value
Corn	533,395	\$600,550,789
Cotton	225,095	\$231,853,805
Rice	391,036	\$371,419,683
Soybeans	1,120,527	\$586,073,097
Sorghum	115,045	\$74,892,106
Sugarcane	427,044	\$586,073,097

Functions of Essential Elements in Plants

Carbon (C), hydrogen (H) and oxygen (O) are readily available in the environment and are directly involved in photosynthesis, which accounts for most plant growth. Nitrogen (N) is a component of protein and enzymes found in chlorophyll, nucleic acids, and amino acids, which control almost all biological processes. Phosphorus (P) is important for plant development including the development of the root system, normal seed development and uniform crop maturation. Phosphorus (P) is essential component in photosynthesis, respiration and cell division. Potassium (K) is responsible for regulation of water usage in plants, disease resistance, and stem strength. (Doran J. W., 1994)

Secondary macronutrients consist of calcium (Ca), magnesium (Mg), and sulfur (S) which are required for specific plant functions. Calcium is essential for cell elongation and division. It is specifically required for root and leaf development, plant function and cell membranes, and formation of cell wall compounds. Magnesium is a primary component of

chlorophyll and is therefore actively involved in photosynthesis. It is a structural component of ribosomes, which are required for protein synthesis and is involved in phosphate metabolism, respiration, and the activation of several enzyme systems. Sulfur is required for the synthesis of the sulfur-containing amino acids, which are essential for protein formation. Sulfur is also involved with the development of enzymes and vitamins as well as the promotion of nodulation for nitrogen fixation by legumes (Doran J. W., 1994).

The micronutrients essential to plant growth include boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), and chloride (Cl), which are needed only in trace amounts by the plant (Brady, 1974).

Lack of Summary Analysis

In reviewing information for this study, it was found that very few states produce soil test result summaries based on soil submitted to the university soil-testing laboratory. On a national basis there is a soil test summary conducted every five to six years comparing test results that include university and private run laboratories (Fixen, 2013). Typically a soil summary is produced every four to five years and in some cases just every 10 years.

The last soil test summary compiled from soil test data conducted at the LSU AgCenter soil testing and plant analysis laboratory was in 2001 and are currently discontinued. The main reason the summary was discontinued is the high cost of printing and distributing the summary as well as the time it takes to compile the data. The soil is one of the most critical inputs into plant and animal production, but receives the least amount of attention (Magdoff, 2009). Within research and extension programs there is very little funding available to provide compilation and distribution of soil summaries.

Need for Soil Summary

Routine soil testing provides soil fertility information for a specific location, but summarizing the samples received at the LSU Soil Testing and Plant analysis Laboratory is necessary for estimating nutrients needs, and tracking changes in soil pH and nutrient levels per parish/county, region, and statewide. These summaries show trends in soil fertility and nutrient management which is valuable tool for producers and extension agents. Summary of soil test data is useful not only identifying broad trends in fertility, but also for evaluating fertilizer, lime and manure management practices (Donohue, 1987). The summaries also help in identifying areas of unique, localized fertility conditions requiring special management and for identifying soil areas having high environmental risk to water quality (Doran, 1994).

Summaries contain valuable information depicting trends in soil nutrients that can be early indicators of changes in soil properties for a specific field, farm, parish/county or region (Donohue, 1987). The soil properties include concentrations of nutrients and nonessential trace elements and soil pH. Monitoring soil properties is an important part of maintaining a nutrient management plan and reducing the occurrence of environmental risk (Dinkins, 2007).

Benefit to Producers and Agricultural Agents

Summarization of the collected soil test data is useful in monitoring trends in soil fertility; nutrient availability and identifying environmental risk due to nutrient build up. Soil test summaries are valuable because they show the current status as well as the long-term changes in soil properties for a field, farm, parish/county, region and state. Soil test summaries serve as a guide to determine the short and long-term impacts of soil management practices and identify emerging soil management problems (Doran, 1994).

The soil test summaries are of benefit to the agriculture agents that are responsible for making soil management recommendations to stay informed of changing soil properties and make necessary adjustments to their recommendations (Jensen, 2013). This information is vital part in the education of producers in the role of best management practices and encouraging environmental stewardship.

The largest benefit to the producer is the reduction in the over application of fertilizer and unnecessary crop nutrients. The economic savings realized by the producer reinforces the importance of nutrient management through routine soil testing.

Another area of benefit is to the community gardens and community supported agriculture, by working with the county agent and soil analysis reports in maintaining and monitoring soil nutrients thus reducing the application of unnecessary nutrients.

CHAPTER 3: METHODOLOGY

Purpose

The primary purpose of the study was to investigate the trends in soil nutrient levels from soil samples submitted to the LSU AgCenter soil testing and plant analysis laboratory during 2008 to 2012.

Research Objectives

The first objective of this study was to investigate soil pH levels for samples submitted to LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

The second objective of this study was to investigate if the concentration of soil P has changed over time for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

The third objective of this study was to investigate soil concentrations of potassium, for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

The soil fertility study consisted of over 59,711 agronomic crop soil samples analyzed by the LSU AgCenter Soil Testing and Plant Laboratory for the period of 2008-2012. The percentage of samples falling under low, medium, high, and very high levels for pH, P and K were calculated by year, and cropping option. The statewide trend in pH, P and K over the past five years was studied. Soil fertility data and statewide trends are presented in table format.

Soil test results are reported as parts per million (ppm). The results are interpreted by test category and adjusted by soil: very low (VL), low (L), optimum (Opt), high (H), and very high

(VH). The optimum category is the most profitable category to maintain over time. The low and very low categories indicate deficient soil test levels, while high and very high indicate a higher test level than required for crop production. The very high soil test category indicates that the nutrient concentration exceeds crop needs, and further additions of that nutrient very seldom produce a profitable yield response.

Soil Test Procedures and Rating:

pH: 1:1 (Water)

- Very Low: <5.0
- Low: 5.0-5.4
- Medium: 5.5-5.9
- Optimum: 6.0-6.5
- High: 7.0 -7.5
- Very High: >7.5

P: Mehlich 3 ppm

- Very Low: <10
- Low: 10-20
- Medium: 20-35
- High: 35-60
- Very High: >60

K: Mehlich 3 ppm

The potassium level in soil varies by crop and soil texture. The following Table 2 represents the parts per million levels for test categories very low, low, medium, and high of soil K for corn and grain sorghum on alluvial non-irrigated soil.

The data in Table 3 represents the parts per million levels for test categories very low, low, medium, and high of soil K for corn and grain sorghum on upland non-irrigated soil.

Table 2 Corn and Sorghum Soil K ppm Alluvial Non-Irrigated

Soil Texture	Very Low	Low	Medium	High
Clay	141	211	317	334
Clay loam	123	176	264	282
Fine Sandy Loam	53	88	123	141
Sandy Loam	35	53	79	123
Silty Clay	141	211	317	334
Silty Clay Loam	123	176	264	282
Silty Loam	70	106	141	158
Very Fine Sandy Loam	53	88	123	141

Table 3 Corn and Sorghum Soil K ppm Upland Non-Irrigated

Soil Texture	Very Low	Low	Medium	High
Clay	88	141	176	194
Clay loam	88	141	176	194
Fine Sandy Loam	44	70	106	123
Sandy Loam	35	53	88	106
Silty Clay	88	141	176	194
Silty Clay Loam	88	141	176	194
Silty Loam	62	97	141	158
Very Fine Sandy Loam	44	70	106	123

The data in Table 4 represents the parts per million levels for test categories very low, low, medium, and high of soil K for cotton on alluvial non-irrigated soil.

The data in Table 5 represents the parts per million levels for test categories very low, low, medium, and high of soil K for cotton on upland non-irrigated soil.

Table 4 Cotton Soil K ppm Alluvial Non-Irrigated

Soil Texture	Very Low	Low	Medium	High
Clay	141	211	317	334
Clay loam	123	176	264	282
Fine Sandy Loam	53	88	123	141
Sandy Loam	35	53	79	123
Silty Clay	141	211	317	334
Silty Clay Loam	123	176	264	282
Silty Loam	70	106	141	158
Very Fine Sandy Loam	53	88	123	141

Table 5 Cotton Soil K ppm Upland Non-Irrigated

Soil Texture	Very Low	Low	Medium	High
Clay	88	141	176	194
Clay loam	88	141	176	194
Fine Sandy Loam	44	70	106	123
Sandy Loam	35	53	88	106
Silty Clay	88	141	176	194
Silty Clay Loam	88	141	176	194
Silty Loam	62	97	141	158
Very Fine Sandy Loam	44	70	106	123

The data in Table 6 represents the parts per million levels for test categories very low, low, medium, and high of soil K for rice on alluvial soil.

The data in Table 7 represents the parts per million levels for test categories very low, low, medium, and high of soil K for rice on upland soil.

Table 6 Rice Soil K ppm Alluvial

Soil Texture	Very Low	Low	Medium	High
Clay	88	141	176	211
Clay loam	70	106	141	158
Fine Sandy Loam	35	62	88	106
Loam	44	70	106	123
Silty Clay	88	141	176	211
Silty Clay Loam	70	106	141	158
Silty Loam	44	70	106	123
Very Fine Sandy Loam	35	62	88	106

Table 7 Rice Soil K ppm Upland

Soil Texture	Very Low	Low	Medium	High
Clay	88	141	176	194
Clay loam	44	79	114	132
Fine Sandy Loam	35	62	88	106
Loam	44	70	106	123
Silty Clay	88	141	176	194
Silty Clay Loam	44	79	114	132
Silty Loam	44	70	106	123
Very Fine Sandy Loam	35	62	88	106

The data in Table 8 represents the parts per million levels for test categories very low, low, medium, and high of soil K for soybeans on alluvial non-irrigated soil.

The data in Table 9 represents the parts per million levels for test categories very low, low, medium, and high of soil K for soybeans on upland non-irrigated soil.

Table 8 Soybeans Soil K ppm Alluvial Non-Irrigated Soil

Soil Texture	Very Low	Low	Medium	High
Clay	141	211	317	334
Clay loam	123	176	264	282
Fine Sandy Loam	53	88	123	141
Sandy Loam	35	53	79	123
Silty Clay	141	211	317	334
Silty Clay Loam	123	176	264	282
Silty Loam	70	106	141	158
Very Fine Sandy Loam	53	88	123	141

Table 9 Soybeans Soil K ppm Upland

Soil Texture	Very Low	Low	Medium	High
Clay	88	141	176	194
Clay loam	88	141	176	194
Fine Sandy Loam	44	70	106	123
Sandy Loam	35	53	88	106
Silty Clay	88	141	176	194
Silty Clay Loam	88	141	176	194
Silty Loam	62	97	141	158
Very Fine Sandy Loam	44	70	106	123

The data in Table 10 represents the parts per million levels for test categories very low, low, medium, and high of soil K for sugarcane on alluvial soil.

Table 10 Sugarcane Soil K ppm Alluvial

Soil Texture	Very Low	Low	Medium	High
Clay	141	211	317	334
Clay loam	123	176	264	282
Fine Sandy Loam	53	88	123	141
Sandy Loam	53	88	123	141
Silty Clay	141	211	317	334
Silty Clay Loam	123	176	264	282
Silty Loam	70	106	141	158
Very Fine Sandy Loam	53	88	123	141

Data Collection

The data was collected from the LSU AgCenter soil testing laboratory archives in the form a Microsoft access file. The data were sorted and transferred to Microsoft excel then formatted to be loaded into SAS for analysis.

Data Analysis

The following represented the statistical analysis performed, by objective.

Objective 1 was to investigate soil pH levels for samples submitted to LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane. Frequencies and means were used to summarize the data for this objective.

Objective 2 was to investigate if the concentration of soil phosphorus has changed over time for the samples submitted to the LSU AgCenter soil testing laboratory during the years

2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

Frequencies and means were used to summarize the data for this objective.

Objective 3 was to investigate soil concentrations of soil potassium, for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane. Frequencies and means were used to summarize the data for this objective.

CHAPTER 4: RESULTS

The primary purpose of the study was to investigate the trends in soil nutrient levels from soil samples submitted to the LSU AgCenter soil testing and plant analysis laboratory during 2008 to 2012. The number of samples analyzed totaled 59,711 using SAS for the following crops, corn, cotton, rice, grain sorghum, soybeans and sugarcane.

Objective One

Objective one of this study was to investigate soil pH levels for samples submitted to LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

The data presented in Table 11 represents the soil pH listed by crop and the mean value of the soil pH for each year from 2008 through 2012.

Table 11 Mean Soil pH by Crop by Year

Crop	2008	2009	2010	2011	2012
Corn	6.08 n=650, SD =0.74	6.29 n=479, SD =0.94	6.08 n=476, SD=.81	6.27 n=961, SD=.99	6.56 n=992, SD=1.01
Cotton	6.19 n=452, SD =0.73	6.46 n=179, SD=.98	5.96 n=472, SD=.84	6.06 n=1024, SD=1.03	6.64 n=466, SD=1.02
Rice	5.88 n=90, SD =0.92	5.96 n=235, SD=1.03	5.73 n=253, SD=.94	6.33 n=246, SD=1.0	6.11 n=274, SD=.80
Grain Sorghum	5.89 n=144, SD =0.96	6.48 n=171, SD=.96	5.79 n=150, SD=.92	6.39 n=415, SD=.94	6.57 n=482, SD=1.07
Soybeans	5.89 n=701, SD =0.81	6.03 n=717, SD=.98	6.26 n=999, SD=1.05	6.28 n=1369, SD=1.0	6.39 n=1639, SD=1.01
Sugarcane	6.23 n=312, SD =0.74	6.11 n=243, SD=.72	6.80 n=440, SD=1.0	6.57 n=507, SD=.98	6.37 n=616, SD=.99
Totals	6.05 n=2349,SD =.79	6.17 n=2024,SD =.97	6.19 n=2790,SD =1.0	6.27 n=4522,SD =1.0	6.45 n=4469,SD =1.0

Objective Two

Objective two of this study was to investigate if the concentration of soil P has changed over time for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

The data presented in Table 12 represents the soil P listed by crop and the mean value of the soil P for each year from 2008 through 2012.

Table 12 Mean Soil P by Crop by Year

Crop	2008	2009	2010	2011	2012
Corn	44.12 n=650, SD =328.23	38.74 n=479, SD =59.78	43.61 n=476, SD=154.09	44.94 n=961, SD=194.64	41.51 n=992, SD=48.09
Cotton	28.60 n=452, SD =24.37	32.57 n=179, SD=17.28	33.42 n=472, SD=19.04	38.13 n=1024, SD=54.96	37.90 n=466, SD=21.26
Rice	22.87 n=90, SD =50.63	22.35 n=235, SD=28.52	117.80 n=253, SD=1156.74	25.42 n=246, SD=35.57	27.52 n=274, SD=64.31
Grain Sorghum	93.18 n=144, SD =759.37	30.11 n=171, SD=31.28	24.74 n=150, SD=18.24	30.84 n=415, SD=17.73	30.99 n=482, SD=22.22
Soybeans	41.32 n=701, SD =344.96	33.65 n=717, SD=40.68	32.69 n=999, SD=26.48	35.99 n=1369, SD=61.40	37.75 n=1639, SD=55.78
Sugarcane	46.87 n=312, SD =146.10	50.40 n=243, SD=110.75	34.10 n=440, SD=17.69	24.92 n=507, SD=20.55	33.36 n=616, SD=62.50
Totals	42.85 n=2349,SD =330.63	35.17 n=2024,SD =56.16	42.19 n=2790,SD =354.91	36.09 n=4522,SD =100.27	36.64 n=4469,SD =50.60

Objective Three

Objective three of this study was to investigate soil concentrations of potassium, for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

The data presented in Table 13 represents the soil K listed by crop and the mean value of the soil K for each year from 2008 through 2012.

Table 13 Mean Soil K by Crop by Year

Crop	2008	2009	2010	2011	2012
Corn	157.45 n=650, SD =99.86	163.99 n=479, SD =136.60	205 n=476, SD=650.68	295.77 n=961, SD=2224.24	184.44 n=992, SD=154.95
Cotton	179.39 n=452, SD =96.91	169.76 n=179, SD=104.26	142.82 n=472, SD=94.75	249.19 n=1024, SD=2152.24	178.26 n=466, SD=87.28
Rice	137.98 n=90, SD =91.50	199.11 n=235, SD=169.32	234.78 n=253, SD=819.08	168.69 n=246, SD=142.64	213.85 n=274, SD=145.86
Grain Sorghum	170.40 n=144, SD =120.05	180.70 n=171, SD=129.65	175.87 n=150, SD=130.95	222.60 n=415, SD=114.74	190.71 n=482, SD=122.54
Soybeans	146.12 n=701, SD =107.21	154.19 n=717, SD=107.94	137.55 n=999, SD=100.26	247.17 n=1369, SD=1863.50	180.82 n=1639, SD=131.33
Sugarcane	177.72 n=312, SD =155.99	166.99 n=243, SD=123.13	144.37 n=440, SD=73.81	166.43 n=507, SD=127.03	155.41 n=616, SD=70.90
Totals	161.03 n=2349,SD =112.26	166.88 n=2024,SD =127.39	161.99 n=2790,SD =375.18	242.38 n=4522,SD =1776.28	180.95 n=4469,SD =127.36

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Purpose of the Study

The primary purpose of the study was to investigate the trends in soil nutrient levels from soil samples submitted to the LSU AgCenter soil testing and plant analysis laboratory during 2008 to 2012.

Summary and Conclusion

Objective One

Investigate soil pH levels for samples submitted to LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

Corn Summary and Conclusion

The soil pH levels for corn increased over the observed five-year period from 6.08 to 6.58. The number samples analyzed in 2008 were 650 and a noted increase to 992 samples in 2012.

The soil pH for corn demonstrated an increase during the five-year period possibly attributed the yearly increase in acreage planted, that was not previously planted in corn. The optimum soil pH level for corn is 5.5 to 6.5. The increase in acreage planted in corn was driven by two factors, a higher commodity price for corn grain and the demand for corn for ethanol production to energy needs for biofuel.

Cotton Summary and Conclusion

The soil pH levels for cotton showed variability in levels during the five-year period studied. The optimum soil pH for cotton is 5.8-6.5. In 2008 cotton soil pH level was 6.19 which decreased to 5.96 in 2010 and increased to 6.64 in 2012. The number of samples analyzed for

cotton also varied year to year during the five-year period with 2009 having the lowest number of samples of 179 and 2011 having the highest at 1024 samples analyzed.

The soil pH level for cotton fluctuated during the five-year period partly due to the 2011 and 2012 growing seasons for cotton were exceptional. This coupled with higher commodity prices for cotton pushed an increase in cotton production in the last two years.

Rice Summary and Conclusion

The soil pH levels for rice increased slightly over the five-year period. In 2008, the soil pH for rice was 5.88 and increased to 6.11 in 2012, but noted a slight decrease in 2010 to 5.73. The number of samples analyzed for rice was similar during the study period except for the first year with only 90 analyzed. Soil pH levels for rice should be maintained below 6.0 to avoid zinc deficiency.

The soil pH levels for rice maintained the least variability of all crops analyzed in this study. Rice soil pH levels are more closely monitored due the intense cultivation practices required for growing rice and to avoid zinc deficiency.

Grain Sorghum Summary and Conclusion

The soil pH levels for grain sorghum varied from year to year during the five-year period. Changing from 5.89 in 2008 to 6.48 in 2009 and likewise in 2010 at 5.79 to 6.39 in 2011 and ending in 2012 at 6.57. The optimum soil pH for sorghum is 5.8-6.5. The number of samples analyzed during the five-year period remained similar except for an increase in sample numbers in 2011 and 2012 with 415 and 482 respectively.

The soil pH levels for grain sorghum demonstrated variability during the five-year study, but noted a sharp increase in 2011 and 2012. The increase soil pH in the acreage planted in was

driven by two factors, first a higher commodity prices for grain sorghum and second the use of grain sorghum for ethanol production to energy needs for biofuel.

Soybeans Summary and Conclusion

The soil pH levels for soybeans demonstrated a steady increase during the five-year period increasing from 5.89 in 2008 to 6.39 in 2012. The number of samples analyzed for soybeans increased as well during the five-year period going from 701 in 2008 to 1639 in 2012.

The soil pH level of soybeans increased steadily during the study period as well the number of samples analyzed. The commodity price for soybeans increased over the course of the study to all time record high prices, which fueled the increase in acreage planted with soybeans. Most of the acreage planted in soybeans in 2011 and 2012 was not previously planted with soybeans.

Sugarcane Summary and Conclusion

The soil pH levels for sugarcane did not vary as much as the other crops during the five-year period. The soil pH level in 2008 was 6.23, but did increase to 6.80 in 2010, then decreased to 6.57 in 2011 and 6.37 in 2012. The number of samples analyzed for sugarcane during the five-year period doubled going from 313 in 2008 to 617 in 2012.

The soil pH level for sugarcane remained more stable than the other crops analyzed in this study. Sugarcane acreage remains constant from year to year, as this crop is predominately grown in the coastal and alluvial soil areas of the state.

Objective Two

Objective two of this study was to investigate if the concentration of soil P has changed over time for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

Corn Summary and Conclusion

The soil phosphorus levels for corn during the five-year period were categorized in the high range for phosphorus. This indicates that the levels of phosphorus used by the crop were replaced post-harvest. The samples ranged in values from around 1 ppm to 9139 ppm. The number samples analyzed in 2008 were 650 and a noted increase to 992 samples in 2012.

The soil P for corn appeared stable in the high range during the five-year period. The researcher did note the extreme variation in the values found in the study for soil phosphorus. Several factors may contribute to this including, soil texture and over application of phosphorus.

Cotton Summary and Conclusion

The soil phosphorus levels for cotton during the five-year period ranged from optimum to high ratings. The number of samples analyzed for cotton also varied year to year during the five-year period with 2009 having the lowest number of samples of 179 and 2011 having the highest at 1024 samples analyzed.

The cotton acreage did not vary as much as some of the other crops in the study, but cotton production did increase. The increase in production also increased in the demand for soil phosphorus. The range of soil P levels fluctuated between 2.5 ppm to 1576 ppm. This resulted in some over application of phosphorus.

Rice Summary and Conclusion

The soil phosphorus levels for rice during the five-year period remained in the medium range with the exception of 2010, which was extremely high at 117.80. The number of samples analyzed for rice was similar during the study period except for the first year with only 90 analyzed.

The soil phosphorus levels for rice during the five-year period averaged in the medium category for soil P with a noted extremely high average in 2010. The sample results for 2010 varied from .14 to 18287, which indicates some possibility that soil samples may have been collected shortly after an application of fertilizer or the area sampled may have had a different crop grown prior to rice production.

Grain Sorghum Summary and Conclusion

The soil P levels for grain sorghum averaged in the medium range during the five-year period with the exception of 2008, which was extremely high at 93.18. The number of samples analyzed during the five-year period remained similar except for an increase in sample numbers in 2011 and 2012 with 415 and 482 respectively.

The soil P levels for grain sorghum averaged in the medium range for phosphorus during the five-year period. The low number of samples submitted for 2008 as compared to the 2011, and 2012 seasons can account for the higher than normal average for 2008. The values do indicate that there is wider margin between the low and high reading for soil phosphorus.

Soybeans Summary and Conclusion

The soil P levels for soybeans during the five-year period studied were steady in the medium to high range with average values of 33.65 to 41.32. The number of samples analyzed for soybeans increased during the five-year period from 701 in 2008 to 1639 in 2012.

The soil P levels for soybeans during the five-year period indicate nutrient stability in phosphorus levels. This stability in soil P indicates that soybean producers maintain critical levels for phosphorus.

Sugarcane Summary and Conclusion

The soil P levels for sugarcane during the five-year period studied varied slightly from 46.87 in 2008 to 33.36 in 2012. The highest value for soil P was 50.40 in 2009. The number of samples analyzed for sugarcane during the five-year period doubled going from 313 in 2008 to 617 in 2012.

The soil P levels for sugarcane during the five-year period studied indicated only small variations due primarily to cultivation practice of sugarcane where as fertilizer is applied in the spring and fall of the year.

Objective Three

Objective three of this study was to investigate soil concentrations of potassium, for the samples submitted to the LSU AgCenter soil testing laboratory during the years 2008-2012 for the following crops, corn, cotton, rice, soybeans, sorghum and sugarcane.

Corn Summary and Conclusion

The soil K levels for corn during the five-year period studied range from 157.65 in 2008 to 295.87 in 2011. The number samples analyzed in 2008 were 650 and a noted increase to 992 samples in 2012.

The soil K levels for corn during the five-year period studied ranged from medium to high levels, as potassium is a more stable soil nutrient. The corn harvested for grain returns potassium back to the soil from the plant material scattered during harvest. The number of samples analyzed indicates an increase in the number of acres in corn production in the last two years of the study period.

Cotton Summary and Conclusion

The soil K levels for cotton during the five-year period studied range from 179.39 in 2008 to 249.19 in 2011. The number of samples analyzed for cotton also varied year to year during the five-year period with 2009 having the lowest number of samples of 179 and 2011 having the highest at 1024 samples analyzed.

The cotton acreage did not vary as much as some of the other crops in the study, but cotton production did increase. The soil K levels studied ranged from high to very high depending on soil texture and alluvial or upland soil. The number of samples for cotton submitted to the soil laboratory increased significantly in 2011 partly due to the increase in the higher cost of fertilizer required for cotton production.

Rice Summary and Conclusion

The soil K levels for rice during the five-year period remained in the high range with the exception of 2010, which was extremely high at 234.78. The number of samples analyzed for rice was similar during the study period except for the first year with only 90 analyzed.

The soil potassium levels for rice during the five-year period averaged in the high category for soil K with a noted extremely high average in 2010. The sample results for 2010 varied from 27.91 to 6989.48, which indicate some possibility that soil samples may have been collected shortly after an application of fertilizer or the area sampled may have had a different crop grown prior to rice production.

Grain Sorghum Summary and Conclusion

The soil K levels for grain sorghum averaged within a narrow range of 170.40 to 190.71 during the five-year period with the exception of 2011, which was extremely high at 222.60.

The number of samples analyzed during the five-year period remained similar except for an increase in sample numbers in 2011 and 2012 with 415 and 482 respectively.

The potassium soil levels for grain sorghum remained stable during the five-year period studied. It was noted a rise in soil K in 2011 to 222.60, but is typically used by the next planted crop. The sample numbers indicate an increase in acreage planted in grain sorghum in 2011 and 2012.

Soybeans Summary and Conclusion

The soil K levels for soybeans during the five-year period studied were within a narrow range of 170.40 to 190.71.

The number of samples analyzed for soybeans increased during the five-year period from 701 in 2008 to 1639 in 2012.

The soil K levels for soybeans during the five-year period indicate nutrient stability in potassium levels. This stability in soil K indicates that soybean producers maintain critical levels for potassium.

Sugarcane Summary and Conclusion

The soil K levels for sugarcane during the five-year period studied varied slightly from 177.72 in 2008 to 155.41 in 2012. The lowest value for soil K was 144.37 in 2010. The number of samples analyzed for sugarcane during the five-year period doubled going from 313 in 2008 to 617 in 2012.

The soil K level for sugarcane remained more stable than the other crops analyzed in this study. Sugarcane acreage remains constant from year to year, as this crop is predominately grown in the coastal and alluvial soil areas of the state.

Recommendations

The value of this study is in the monitoring of the trends in soil nutrients with respect to sustainability and environmental stewardship. Soil summaries serve as a guide to the extension agents and crop advisors making soil amendment recommendations that are based on soil test results. The development of future soil summaries on a statewide level every five years would be essential in monitoring broad nutrient needs and challenges. The information gained from these summaries would serve to develop educational materials and action programs that reinforce the use of best management practices in agriculture production.

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