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DETERMINATION OF NUTRIENT CONCENTRATION LEVELS IN SOIL SAMPLES TAKEN FROM SLASHED AND BURNED FIELDS ON SAN SALVADOR ISLAND, BAHAMAS

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ABSTRACT

The slash and burn technique has been used in the Bahamas to increase nutrient levels in nutrient-poor soil. The Cornell Method for "Chemical Soil Tests" developed by Thomas Greweling and Michael Peech is a useful way to determine these concentrations and to measure the effectiveness of the slash and burn technique. The specific nutrient levels being tested for at Elmira College are phosphorus, ammonia, nitrate, and potassium. Each year, approximately three sets of soil samples are taken from two slashed-and-burned fields. Ten samples taken between February 1997 and May 1998 were analyzed. Each sample was studied and compared to samples from previous years to determine an overall trend of nutrient concentration expressed in grams of nutrient per kilogram of soil. With our latest test results, trends have become more apparent due to modifications in our testing procedures. In addition to these tests, we have broadened our research to include a total organic analysis of our samples.

INTRODUCTION

The soil of the Bahamas is characterized as very thin, nutrient-poor material comprised mainly of sand, clay, and ash with a maximum depth of no more than two inches. In the pre-Columbian days of Bahamian civilization, the Arawak Indians practiced slash and burn or "shifting cultivation." The most successful crops grown in the days of the Arawaks were starches and other sugar-rich products, such as manioc, yucca, sweet potatoes, peanuts, lima beans, and squash (Eneas, 1998). Presently, the most successful crops are corn, lima beans, pigeon peas, and native okra. The typical Arawak plot, or *conuco*, was located on a fairly smooth, gently sloped piece of land for drainage purposes. After a site was chosen, the large trees were stripped, cut, and burned, while the stumps and smaller trees were left, presumably for support of the cultivated crops as well as the soil. A special hand tool, called a *dibble*, was used to prepare the ash-covered plots for planting. As the approaching rains of the wet season were the only source of water for the plots, planting was done at the end of each dry season. The only other source of nutrients aside from the nutrient-rich ash was manure, which the Arawaks employed at each planting (Eneas, 1998).

During the time of the Arawaks, a single plot was reported by Eneas to have lasted for fifteen to twenty years, with alternating fallow periods of thirty years during which the plots were restocked with nutrients and decayed plant matter. Today the plots being used in our research only last about three years at the most, after which time the plots are abandoned by the native cultivators for new plots. This extremely abbreviated time frame for utility is most likely a direct result of the severe erosion and degradation of the island soil due to overuse and weather. All in all, the slash and burn technique for soil fertilization was and still is an economical and fairly efficient method given the socioeconomic conditions of remote, island life.

MATERIALS AND METHODS

Samples are collected at three different intervals each year. The fields under study range in activity from recently cut and burned to not in use at all. This wide range of activity is useful however given the fact that the expected results should show a wide range of nutrient levels throughout the time period in question.

Ten samples were taken over the fifteen-month period under analysis from two agricultural plots with an average area of 0.140 acres each. Table 1 lists the sample source, date collected, and the burn status of each field at the time of collection. The samples were taken directly from the thin soil surface and contain a mixture of sand, ash, rock, and dead plant matter. They were stored in zip lock plastic bags for transfer to the lab in Elmira.

The soil mixture was then filtered through a Sargent 30 mesh sieve to remove larger components, leaving a fine-textured, small-granule sample. Following the Cornell method for extraction, 10 grams of each sample were weighed and placed in 50 ml of an acetic acid extracting solution with a small amount of activated decolorizing carbon. The method does not specify the amount of carbon to be used, but is specific in its requirement that the resulting extract be a "clear, colorless solution." Due to complications in achieving a uniformly clear and colorless solution for each sample, a great deal of time was devoted to the determination of a minimal but precise amount of decolorizing carbon that would be sufficient in removing all color from the samples without significantly altering their compositions. The final amount that was decided upon and used throughout the remainder of our experiment was 1g of decolorizing carbon for every 10g of soil extracted. The solutions were prepared and mixed for 30 minutes on an automatic mixer and then filtered by gravity through Q2 filter paper into 50ml Erlenmeyer flasks (Greweling and Peech, 1965). This procedure yielded a series of clear, colorless solutions.

The solutions were then tested for concentrations of phosphorus, ammonia, nitrate, and potassium using reagents and standards prepared according the Cornell method. The phosphorus test was performed using the ammonium molybdate reagent, the ammonia analysis employed the Nessler reagent, the nitrate test used brucine, and potassium test standards and samples were analyzed by flame photometry rather than the less accurate turbidity test using sodium cobalnitrite which

Table 1. Table of sample collection dates, collection sites, and the burn status of the field at the time each sample was collected over the fifteen-month period.

Sample #	Date Collected	Location	Burn Status
1	2/19/97	Lower Field	Unknown
2	2/19/97	Upper Field	Cut & Dry, Not Burned
3	5/6/97	Upper Field	Freshly Burned
4	5/6/97	Lower Field	Not in Use
5	6/15/97	Upper Field	Freshly Burned
6	6/15/97	Lower Field	Not in Use
7	2/20/98	Upper Field	Not in Use
8	2/20/98	Lower Field	Not in Use
9	5/11/98	Upper Field	Not in Use
10	5/11/98	Lower Field	Not in Use

was used previously (Perkin-Elmer, 1982). Due to the presence of an as-yet-to-be-determined salt precipitate that formed upon mixing the prepared reagents with each of our samples, the protocol was altered from that in the Cornell method to include a centrifuge step after mixing but before UV spectroscopy. The tubes were centrifuged at 3300rpm for three minutes forming a soft white pellet of salt at the bottom of the tube. The supernatant was decanted off into a clean dry test tube and was then ready for UV spectroscopy. No mention of such a problem has been found in the current and limited literature on the subject of tropical soils, and more research needs to be done concerning the presence of salts in such soils.

In addition to these standard tests, a total organic analysis has been added to the project this year. The hope was that the variation in percent organic matter would match those of the nutrients over the course of the burn cycle. Two grams of each sample were placed in a small crucible without a lid and brought up to 375°C in increments of 75° every 15 minutes. Upon reaching 375°C, the samples were kept at that temperature for an hour and then were brought up to 550°C, at which time they were left overnight for 20 hours. The next day, the samples were cooled and weighed (Carter, 1993).

RESULTS

Analytical results were expressed in:

<u>Grams of nutrient</u>
Kilograms of soil.

Sample results were plotted as date collected versus g nutrient/kg soil. The concentration cycle for phosphorus is shown in Figure 1, for ammonia in Figure 2, for nitrate in Figure 3, and for potassium in Figure 4. Each nutrient graph displayed a sharp peak in nutrient concentration for soil samples taken from one to three months immediately succeeding a burn. This was true in every case for the upper field, which had been recently burned, but only for nitrate in the lower field which had not been recently burned. The other nutrient graphs for the lower field showed minimal to no elevation in nutrient concentration. Immediately following each peak in nutrient concentration in the upper field, the levels began to drop significantly, although most markedly in ammonia and potassium. In the lower field there were also marked decreases in those nutrients that were elevated, especially in nitrate and potassium. In almost all cases in both fields, a noticeable characteristic was the return of the nutrient concentrations at the end of the fifteen- month period to within a very close proximity to their original concentrations.

The total organic analysis results, summarized in Figure 6, also indicated a cycle, with each field having starting and ending values within a 1-5% range of each other. The highest peak for both fields occurred immediately after the fields had been slashed, but before the actual burn. The lowest percent organic matter for both fields occurred approximately one month after the burn.

DISCUSSION

As is indicated by the graphs of nutrient concentration for the upper field, the cycle of slashing and burning has fairly predictable effects on both the nutrient concentration and the percent organic matter for the treated soil. The percent organic matter peaks occur at the time of the slash and burn cycle when the most organic matter would presumably be present on or in the soil. Furthermore, the troughs in percent organic matter occurring immediately after the burn are to be expected, as the burn would presumably consume most of the organic matter.

In comparing data obtained after protocol modifications to data obtained before modifications, it is evident that those alterations significantly improved the accuracy of the results. It is more difficult to compare the data presented here to that obtained in past years' experiments due to the change in units used to express nutrient concentrations for the fields. Ideally, a long-term trend should be established for the same fields, but since each field is abandoned after about three years of use, this is not a realistic goal. In lieu of that goal, it is more feasible to attempt to establish general trends in nutrient concentrations for all fields used in a ten-year (or longer) period.

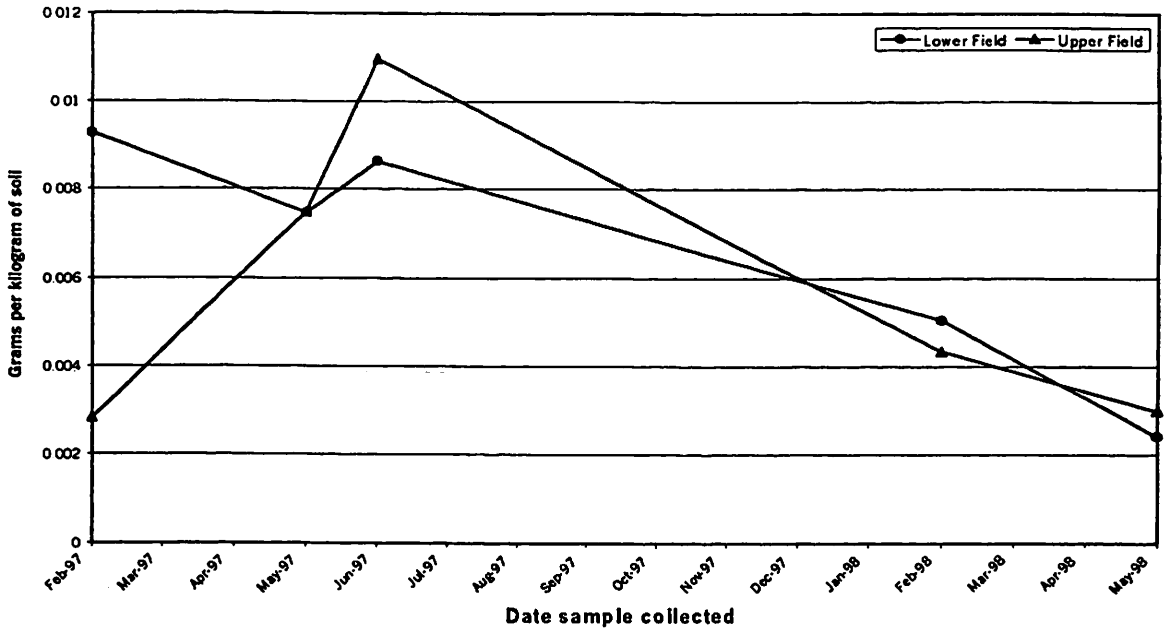

Figure 1. Change in Phosphorus Levels for Two Fields Over a 15 Month Period

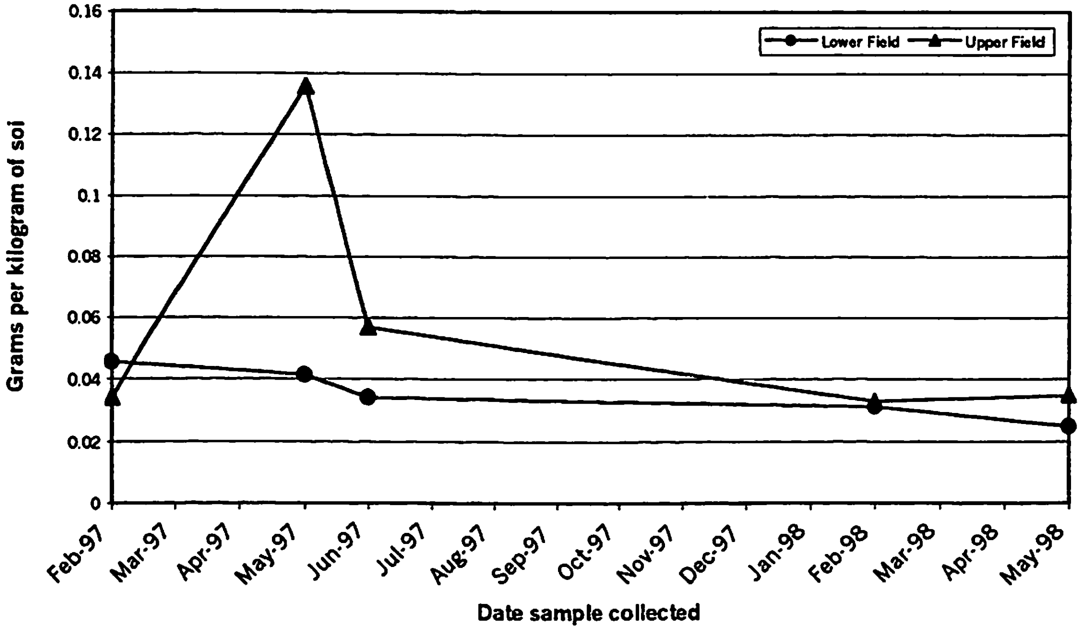

Figure 2. Change in Ammonia Levels for Two Fields Over a 15 Month Period

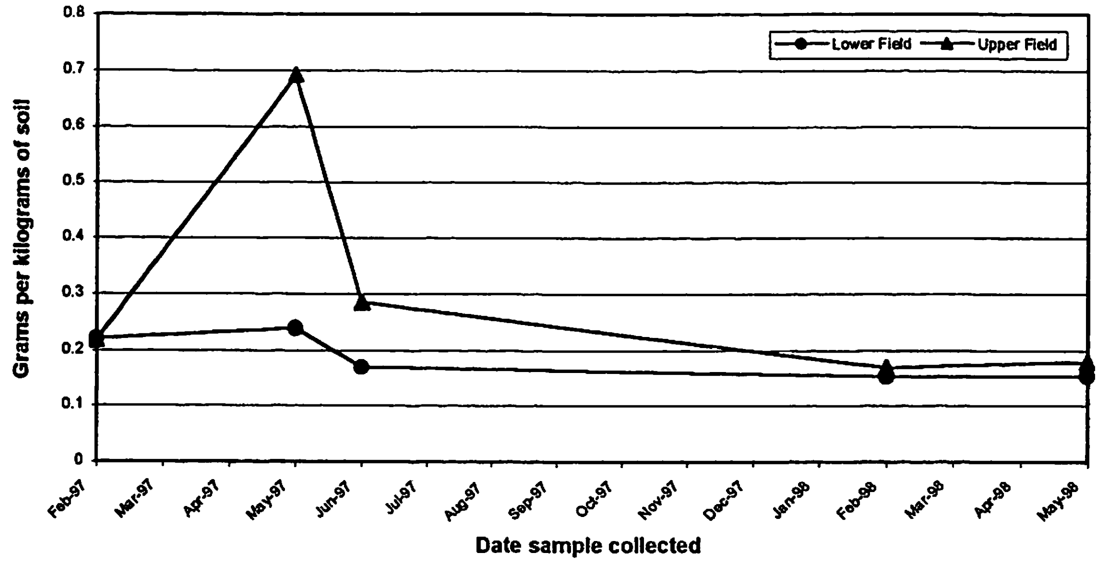

Figure 3. Change in Potassium Levels for Two Fields Over a 15 Month Period.

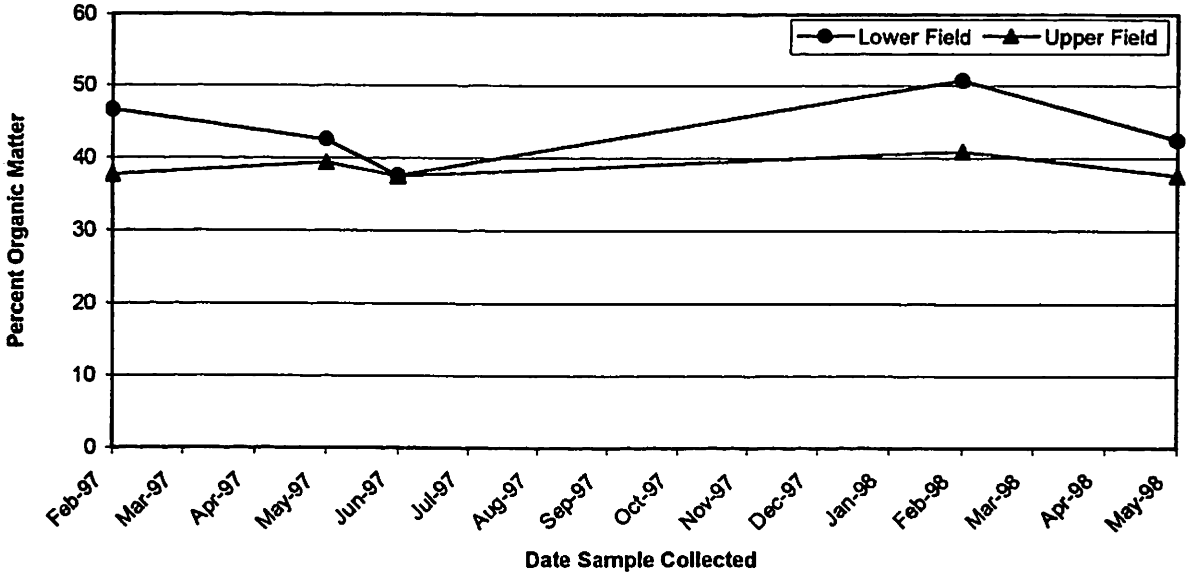

Figure 4. Change in Percent Organic Matter in Two Fields Over a 15 Month Period.

In an attempt to broaden the understanding of the cycling of these nutrients and other essential elements in slashed and burned tropical soils, other tests will be added. These include, but are not limited to, flame photometric analysis of major elements and ions, as well as more specific location-dependent analyses of nutrient concentrations in order to determine if water drainage and run-off are affecting the concentrations of fields located on an incline.

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