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Original Research Paper

Soil Chemical Properties as Influenced by *Albizia lebbeck Benth* (Rattle Tree) under Agri-Silvicultural System (Alley Cropping) with *Solanum tuberosum Linn.* (Potato).

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This study was conducted (on alfisol) in the Jos Plateau-Nigeria, to assess the effect of *Albizia lebbeck Benth* (its green manure and tree rows) on soil chemical properties under alley cropping (an agro-forestry system) with Irish potato (*Solanum tuberosum* L.). The experiment was a randomized complete block design (RCBD) comprising five treatments and three replicates. Pre and post experimental soil sample analysis on soil pH, % organic carbon, %Nitrogen, available phosphorus, exchangeable cations (Ca, Mg, K, Na), exchangeable acidity and effective cation exchange capacity (ECEC) were done. Tending operations and data collection on apparent growth and yield parameters throughout the five cropping seasons were carried out. Results indicated that the soils in the study area which developed from the biotite granite of the Jos Plateau were very low in organic matter and % Nitrogen and the values decreased from pre planting to after planting due to absorption by the plants/crop removal (no significant differences among treatments and blocks). But the treatments (*A. lebbeck* green manure and its tree rows) significantly influenced the available Pat 0 – 10 cm (P=0.05) and K at 0 – 10 cm (P=0.05) and 10 – 25 cm (P=0.01) soil depths. Block effects were observed at significant level on the $_{P}$H (H_2O) at 10 – 25 cm (at P=0.01) and 25 – 40 cm depths (P=0.05) and on Mg at 0 – 10 cm depth (P=0.01). The available P decreased generally from the surface soil (down wards) to the subsoil in the study site owing to absorption by the plants/crop removal and leaching. The values of exchangeable acidity and effective cation exchange capacity increased generally from surface soil to the sub-soil probably due to leaching or infiltration of the exchangeable cations. Thus, the apparent growth parameters (plant height, leaf count and collar girth) except stem count were highly influenced by the different levels of *Albizia lebbeck* green manure application and its tree rows (sequel to N_2- fixation) at P $\leq$0.1 which subsequently brought about different values in yield (tuber count (P $\leq$0.5) and tuber weight (P $\leq$ 0.01) of the crop (Irish potato) in all the 5 treatments and throughout the 5 cropping seasons.

Keywords: Soil chemical properties, *Albizia lebbeck,* influence, agrisilviculture, potato.

INTRODUCTION

The need to improve the nutrient status of impoverished soils in the tropics in a bid to increasing and sustaining agricultural production cannot be over emphasized. Nitrogen as an element is abundantly available in the atmosphere (about 79%) but very deficient in most soils. Several tons of chemical (nitrogenous) fertilizers are purchased yearly to remedy soil nitrogen deficiencies.

Besides its being exorbitant, its (chemical fertilizer) application could adversely affect the ozone layer thereby causing an increase in skin cancer and rates of mutation in organisms due to harmful radiation (Alexander, 1982). Integration of non-nitrogen and nitrogen fixing trees into agroforestry systems has been identified as one of the ways of increasing the organic matter and nitrogen content in most savanna soils.

These are the soils which Alasiri (1997) described as being low in nutrients and of poor structure due to continuous cultivation. In soil fertility improvement and land reclamation, nitrogen fixing trees can play significant roles, particularly under alley cropping system which has been known to

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enhance both nutrient and structural characteristics of soils (Osunde, 1995).

Most tropical soils are highly weathered and leached, some of which are typical Ultisols that are usually characterized by low levels of organic matter and nitrogen content of about 0.3 – 0.6% and 0.03 – 0.05% respectively (D'Hoore, 1964). In the past, organic matter build-up was achieved under bush fallow system or shifting cultivation or land rotation, as a means of fertility maintenance (Greenland and Nye, 1959). But owing to rapidly increasing population, these systems are no more practicable due to pressure on land by other sectors of the economy (Yayock *et. al.,* 1988). The vital role played by organic matter in the soil cannot be over-emphasized as Nye (1961) had earlier described it as a vital component of soil exchange complex. This can be increased through ample supply of organic residues such as litter and compost. These inputs can be achieved under alley cropping with trees that are characterized by profuse litter deposition and nitrogen fixing capacity.

Also, Adepetu *et. al.* (1979) reported a 58% drop in the organic matter content of the low soil series in a virgin forest site at Ile-Ife, South Western Nigeria during a seven-year continuous cropping. Among the major constraints to sustainable soil management and cropping on the Jos Plateau are high cost and inadequate supply of inorganic fertilizer at the right time while some of the available ones are even adulterated. It is pertinent to mention here that farmyard manure was initially used to remedy the ugly situation of low nutrient status. This is limited to small area of land since the demand by large scale farmers or the numerous small scale farmers cannot be met owing to major constraints such as unavailability/scarcity or insufficient quantities of animal wastes, transportation and labor costs (Yayock *et al.,* 1988).

Arising from this situation is the need for an alternative and inexpensive technique of soil/input management. Under agroforestry system, trees can help in the improvement of soil fertility through physical remediation that can sustain higher water holding capacity coupled with good permeability. Greater erosion resistance, litter deposition, better micro-climate and improved rate of mineralization are also feasible. Effective timing of nutrient release through decisions on when to prune the hedge or tree rows in agroforestry farm for mulching or as green manure is easily determined (Young, 1985; Adebagbo, 1997).

Thus, a suitable nitrogen-fixing tree such as *Albizia lebbeck* could be used by incorporating it into agroforestry system. Its prunings in form of green manure add nitrogen to the soil since large quantities of nitrogen are normally harvested along with the prunings. Saginga and Mulongoy (1995) reported that more than 3000 kg N ha^{-1} y^{r-1} was realized when *Gliricidia* /*Leucaena* hedge rows were pruned and their nitrogen in the range of 40 – 70 $kgNha^{-1}$ per season was released to crops. Also, the soil nutrient status would be augmented through organic matter decomposition, mineralization and subsequent transfer of nutrients from tree rows of this species (*Albizia lebbeck)*to the companion crops in the alleys.

Crops can thrive and produce well in alleys of *Albizia lebbeck* if efficiently employed, more so when Dommergues (1987) described it as being capable of fixing high amount of nitrogen because most soils in the tropics habour the *Bradyrhizobium* strains of nitrogen fixing bacteria needed for nodulation which is present in this species (*Albizia lebbeck).*

The objective of this study is to assess/quantify the effects of *Albizia lebbeck* green manure and its tree rows on soil chemical properties under alley cropping with potato in the study area.

MATERIALS AND METHOD

The Study Area

The study was carried out in the Teaching and Research Farm of the Department of Agricultural Extension and Management, Federal College of Forestry, Bauchi Road, Jos, Plateau State, Nigeria in the north – eastern part of the Jos city. The Jos Plateau is located in the Northern Guinea Savanna but owing to its distinctive features, it has been mapped out separately from the rest of the Northern Guinea Savanna Zone (Keay, 1959). The Jos Plateau lies between latitude 8^0 50^1N and 10^0 10^1N and longitude 8^0 22^1E and 9^0 30^1E (Udo, 1978).

The average elevation is about 1250 meters above sea level while its height above the surrounding plains is about 600 m and the highest point is about 1777 meters above mean sea level which is about 20 km eastwards from Shere Hill. Also, a number of relatively low plains are found at the boundaries of the Jos Plateau, at the north-east, it is surrounded by the Bauchi plains, Jama'- Kaduna plains to the north-west and the Benue lowlands to the South. The Jos Plateau is about 8,600 km^2, its north to south length is about 105 km and 81 km from east to west and almost occupies the center of the Nigeria's physical space (Keay, 1951; Keay, 1959; Hill, 1978; Davis, 1973; Morgan, 1979; Eziashi, 1995).

Pre-Experimental (Pre- Planting) Soil Analysis

In order to assess the initial nutrient status of the experimental site and use the result of the laboratory analysis as a basis for the block design, soil nutrient analysis was carried out. Prior to blocking of the experimental site into three parts to represent the three blocks, three portions or locations were randomly selected (as major locations/portions). This was followed by random selection of four sub-locations from each major location. Subsequently, from each sub-location, soil samples were collected at three depths: 0-10, 10-25, and 25-40 (cm).

Composite samples from each major location were used for analysis (that is, the three major locations were assigned Arabic numerals 1, 2, and 3, their corresponding sub-locations were 1a, 1b, 1c, 1d; 2a, 2b, 2c, 2d; 3a, 3b, 3c, 3d). Each sub-location was at 3 soil depths represented in Roman numerals i, ii, and iii. To make composite samples, combinations of ai + bi + ci + di; aii + bii + cii + dii and aiii + biii + ciii + diii were produced).Thus, a total number of 9 samples (3 from each of the major locations) were analyzed and taken as pre-experimental site nutrient status.

Furthermore, each sample was meticulously put in polythene bags separately, labeled and taken to the laboratory, removed from the polythene bags, air dried, ground, sieved with 2 mm sieve, smooth and coarse samples weighed separately, the percentage of the coarse portion determined and smooth portion subjected to laboratory analysis. Also, a soil profile was dug at a suitable place in the experiment site. This paved way to have the knowledge of the different horizons in the soil profile, ensured proper identification and classification of the different soil types (for example, Entisols, Inceptisols, Alfisols and Ultisols).

It is pertinent to mention here that the same soil sample analytical procedures were employed before (pre) and after (post) the experiment. Determination of the particle size distribution of the soil samples was done by using the hydrometer method (Day, 1965) and separated into sand, silt and clay and expressed in percentages, while the pH (1:2:5) in water and KCl was determined electronically by using a functional pH meter. Flame photometer was employed in the determination of the exchangeable cations (bases) such as Na and K while estimation of the Ca, Mg was done by means of atomic absorption spectrometer (AAS). Effective cation exchange capacity (ECEC) was determined by summation method, following the extraction of exchangeable acidity with the aid of IN KCL. Coleman (in Kamprath, 1984) suggested that the determination of CEC through the summation of exchangeable bases plus KCL exchangeable acidity serves as a more realistic method of evaluating the actual amount of bases experienced by plants. The percentage organic carbon content was determined with the aid of potassium dichromate method of Walkey and Black (1974), available phosphorus by Bray and Kurtz (1945) method and total nitrogen by Kjeldal method (Jackson, 1962). The results obtained are presented in Table 1 - 10.

The experimental design employed was randomized complete block design (RCBD) consisting of five (5) treatments and three (3) replicates. A table of random numbers was employed in assigning treatments to each block. The five treatments used are as follows:

T_o: Potato planted on flat bed without tree rows and green manure of *A. lebbeck*.
T_1: Potato planted in the alleys of *A. lebbeck* without green manure.
T_2: Potato planted with green manure of *A. lebbeck* at 5 ton ha^{-1} without its tree rows.
T_3: Potato planted in alleys of *A. lebbeck* tree rows with its green manure at 5 ton ha^{-1}
T_4: Potato planted in alleys of *A. lebbeck* tree rows with its green manure at 10 ton ha^{-1}

Each plot/replicate in a block was 3m x 2m, the green manure was single application two weeks before planting the pre - sprouted potato tubers (bertita variety). *A. Lubbock* tree seedlings had earlier been raised from seeds prior to planting (seedlings were 6 months old before transplanting (0.60m and 2.0m within and between rows respectively). All necessary tending operations were carried out. Analysis of variance (ANOVA) was employed in analyzing the data collected on the soil samples, apparent growth parameters (plant height, number of leaves, stem count, collar girth) and yield parameters (tuber count and tuber weight) in order to find out if there were significant differences among treatments and blocks owing to the possible influence of the green manure of *A. lebbeck* and its tree rows.

Post – Experimental Soil Sample Collection and Analysis

Immediately after final harvest at the 5th planting season, soil samples were collected for laboratory analysis by employing the same method of analysis earlier described (in pre-experimental soil sample analysis). Samples from the five treatments (T_0, T_1, T_2, T_3 and T_4) were analyzed(that is, three replicates per treatment). A comparison between the results from composite samples of pre and post (final) experiment soil nutrient analysis was made using the analysis of variance technique (ANOVA).

Thus, improvement or effect on the nutrient status of the soil due to the nitrogen fixing activities of *Albizia lebbeck* tree rows and incorporated green manure (of this tree species) was evaluated. In order to ensure uniform results, all the soil samples were analyzed by the same analyst and with the same sets of chemicals (reagents) at the Soil Science Department of Faculty of Agriculture, Ahmadu Bello University, Zaria and Institute of Agricultural Research, ABU, Zaria, Nigeria.

RESULTS AND DISCUSSION

Chemical properties of the soil samples (before and after planting)

The significant difference in block effect with regard to P^H (H_2O) at 10 – 25 cm and 25 – 40 cm soil depths ($P \leq 0.01$ and $P \leq 0.05$ respectively) was observed and this could be attributed to addition of organic matter in the form of green manure from *Albizia lebbeck.* Since the pH (H_20) was initially low (4.5) before planting which made the soil very strongly acid (Troug, 1948; Olowolafe, 2003) but rose to a range of 5.1 to 5.4 in T_2-T_4 which indicates the influence of the green manure application (Tables 1 & 11, Figure 1).

Kunishi (1982) had earlier observed that organic matter raises the soil pH, helps in ameliorating phytotoxicity in acid soils, decreases soluble manganese and exchangeable aluminium (Al) and increases calcium and available phosphorus. Olowolafe (2003) had also reported that the addition of more organic matter could lead to the release of more basic cations that resulted in the improvement of base saturation and soil pH. Lack significant difference at 0-10 cm depth was probably as a result of crop/plant absorption or leaching.

The soil structure also could have been improved probably owing to the application of the organic manure in T_2, T_3 and T_4 which could have probably improved infiltration and porosity of the soil. Thus, the green manure applied and N_2 – fixation activities of the tree rows of *A. lebbeck* might have contributed in reducing the acidity of the soil, which brought about better yield of potato in T_1-T_4 over that of T_0. This agrees with Kunishi (1982) who observed that the pH range of 5.5-8.5 is within the pH range of tolerance for crop production and that soil acidity does result to low agricultural productivity.

The organic matter (OM) in T_0 – T_4 (after planting) was lower than the value before planting (Tp) due to crop removal and leaching and those of T_2 – T_4 are higher than T_0 and T_1 probably because of the addition of green manure. The OM of the T_P and T_0 – T_4 are generally low (Tables 2 & 11, Figure 2) below 2% (0.79 – 1.94 %) which could be attributed to the fact that the soils are of granite origin (Olowolafe, 2003) and is characteristic of tropical soils (Landon, 1991). This low level of OM was as a result of the high temperature experienced in larger period of the year, which brings about high decomposition, mineralization rates and subsequent disappearance of organic matter which is detrimental to the practice of sustainable agriculture in the tropics (Mulongoy and Merckx, 1993; Olowolafe, 2003).

Lack of significant effect of blocks and treatments at all depths on the total nitrogen (TN) could be due to the generally low level of TN in the site (Tables 3 & 11, Fig. 3). This is a characteristic feature of tropical soils/environment with high temperature that results to fast loss of nitrogen owing volatilization, crop removal, erosion and leaching (Landon, 1991; Olowolafe, 2003). Only the effect of block and treatment at 0–10 cm depth on available phosphorus (available Phosphorus) was significant probably because of reasonable differences in the values before planting and those of the treatments.

For instance, the values in T_P, T_1, T_2 and T_4 are relatively higher (16.40 – 23.45 ppm) as opposed to T_0 and T_3 (which are 6.45 and 15.52 ppm, respectively), thus, a significant difference among the blocks and treatments was observed (Tables 4 & 11, Figure 4).

Table 1: pH (H_20) of the Pre / Post Experimental Soil Samples at Three Soil Depths

		0-10cm			10-25 cm		25-40cm		
T	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**
T_p	4.8	4.4	4.3	4.5	4.2	4.1	4.8	4.0	4.1
T_0	4.8	5.2	5.7	4.3	4.7	5.7	4.0	5.7	5.7
T_1	4.5	4.0	5.0	4.0	4.6	5.8	4.7	5.8	5.5
T_2	4.3	5.8	5.4	4.2	5.6	5.6	4.0	5.6	4.8
T_3	4.6	5.1	5.6	4.6	5.8	5.8	4.5	5.8	5.8
T_4	4.0	5.0	5.1	4.2	5.6	5.5	4.3	5.3	4.8

Table 2: Organic Matter Content of Pre / Post Experimental Soil Samples

		0-10cm			10-25 cm		25-40cm		
T	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**
T_p	1.79	1.65	2.41	1.45	0.59	1.45	0.83	0.96	0.59
T_0	1.10	1.32	1.24	0.93	1.03	1.15	1.14	0.86	0.86
T_1	0.93	1.38	1.57	1.03	1.15	1.57	1.03	0.91	0.20
T_2	1.20	1.48	1.45	1.03	1.48	1.24	1.03	1.33	1.07
T_3	1.31	1.89	1.15	1.10	1.89	1.69	1.31	1.24	0.91
T_4	1.82	1.24	1.98	1.38	1.26	1.48	0.96	0.95	1.19

Table 3: Total Nitrogen Content of the Pre / Post Experimental Soil Samples

		0-10cm			10-25cm		25-40cm		
T	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**
T_p	0.12	0.09	0.09	0.11	0.05	0.05	0.12	0.05	0.05
T_0	0.05	0.07	0.05	0.05	0.05	0.05	0.07	0.05	0.05
T_1	0.04	0.07	0.07	0.04	0.09	0.07	0.04	0.07	0.09
T_2	0.05	0.07	0.07	0.05	0.09	0.09	0.76	0.09	0.07
T_3	0.07	0.09	0.07	0.05	0.09	0.09	0.05	0.07	0.09
T_4	0.09	0.05	0.84	0.09	0.05	0.09	0.05	0.07	0.69

Table 4: Available Phosphorus (P) Content of Pre / Post Experimental Soil Samples

0-10cm			10-25cm			25-40cm			
T	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**
T_p	26.53	14.07	29.75	6.37	0.77	4.22	3.40	2.52	3.20
T_0	15.68	9.87	21.00	7.00	5.75	20.00	2.59	6.60	4.20
T_1	12.53	20.23	16.45	38.50	8.47	7.70	1.54	6.80	3.36
T_2	21.70	14.35	37.80	8.96	12.95	19.46	4.20	3.36	5.74
T_3	12.67	2.73	3.95	5.25	2.63	14.00	7.20	5.11	2.75
T_4	16.80	12.95	26.95	5.11	5.88	20.16	2.45	3.15	15.05

Table 5: Calcium (Ca) Content of Pre / Post Experimental soil Samples

0-10 cm				10- 25cm		25-40cm			
T	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**
T_p	3.80	3.00	5.40	3.60	2.80	5.40	2.80	5.20	2.80
T_0	2.40	3.20	2.20	2.40	2.00	2.80	4.00	2.60	2.00
T_1	2.40	2.00	1.80	3.60	3.20	2.40	2.20	2.80	3.20
T_2	2.60	3.00	3.40	2.00	1.82	1.60	1.20	2.40	3.00
T_3	2.40	2.80	2.80	2.40	3.40	2.80	1.60	3.40	2.60
T_4	2.40	2.80	4.00	3.80	3.00	3.00	1.80	2.20	1.80

Table 6: Magnesium (Mg) Content of Pre / Post Experimental Soil Samples

0-10cm			0-25cm			25-40cm			
T	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**
T_p	0.62	0.25	1.48	0.26	0.58	1.58	0.62	0.26	0.68
T_0	0.62	0.58	0.62	0.32	0.26	0.80	1.83	0.42	1.33
T_1	0.57	0.36	0.95	1.85	1.36	0.27	0.78	0.76	0.43
T_2	0.68	0.42	1.06	0.58	0.22	0.23	0.47	1.73	1.08
T_3	0.73	1.13	1.22	0.40	1.32	0.72	0.46	1.90	0.85
T_4	0.48	0.72	1.58	1.55	0.58	0.83	0.28	0.37	0.22

Table 7: Potassium (K) Content of the Pre / Post Experimental Soil Samples

0-10cm				10-25cm			25-40cm		
T	1a	1b	1c	2a	2b	2c	3a	3b	3c
T_p	0.27	0.21	0.19	0.17	0.16	0.12	0.22	0.22	0.10
T_0	0.13	0.20	0.17	0.12	0.15	0.14	0.14	0.17	0.17
T_1	0.12	0.10	0.10	0.11	0.11	0.12	0.12	0.16	0.13
T_2	0.18	0.12	0.12	0.20	0.19	0.12	0.17	0.14	1.10
T_3	0.22	0.26	0.13	0.17	0.23	0.18	0.18	0.18	0.13
T_4	0.18	0.14	0.19	0.16	0.20	0.16	0.11	0.13	0.16

Table 8: Sodium (Na) Content of the Pre / Post Experimental Soil Samples

0-10cm				10-25cm			25-40cm		
T	1a	1b	1c	2a	2b	2c	3a	3b	3c
T_p	0.17	0.17	0.19	0.17	0.23	0.20	0.19	0.39	0.23
T_0	0.17	0.17	0.12	0.17	0.18	0.15	0.23	0.14	0.17
T_1	0.23	0.17	0.16	0.26	0.18	0.17	0.30	0.20	0.13
T_2	0.37	0.18	0.15	0.45	0.19	0.14	0.23	0.14	0.12
T_3	0.23	0.20	0.15	0.27	0.18	0.14	0.15	0.17	0.16
T_4	0.18	0.29	0.14	0.23	0.18	0.13	0.19	0.12	0.13

Table 9: Exchangeable acidity of the Pre / Post Experimental Soil Samples

0-10cm				10-25cm			25-40cm		
T	1a	1b	1c	2a	2b	2c	3a	3b	3c
T_p	1.00	1.00	0.60	1.40	1.80	0.40	1.60	1.40	2.60
T_0	0.40	1.00	0.80	0.80	1.40	1.20	1.40	1.60	1.20
T_1	0.23	0.80	0.60	0.60	0.80	0.80	0.60	1.60	1.20
T_2	0.80	0.80	0.80	1.40	0.60	1.20	1.60	1.60	0.80
T_3	0.60	0.80	0.80	0.80	1.60	2.00	1.80	1.20	1.60
T_4	0.60	0.80	0.40	1.60	0.80	0.80	1.40	1.20	0.80

Table 10: ECEC of the Pre / Post Experimental Soil Samples

0-10cm				10-25cm			25-40cm		
T	1a	1b	1c	2a	2b	2c	3a	3b	3c
T_p	5.83	4.63	7.86	5.60	5.57	8.70	5.43	7.47	6.41
T_0	3.72	5.15	3.91	3.81	4.00	5.09	7.60	4.93	4.85
T_1	3.92	3.43	3.61	7.02	5.65	3.76	4.00	5.52	5.09
T_2	4.63	4.52	5.53	4.63	3.00	5.53	3.67	5.01	3.11
T_3	4.18	5.20	5.10	4.04	6.73	5.84	4.19	6.85	5.34
T_4	3.80	4.75	6.31	7.34	4.76	4.92	7.78	4.05	5.10

As earlier stated by Olowolafe (2003), soils that were derived from granites contain relatively high available phosphorus and there is high P-fixation in acid tropical soils (Courley, 1987). This could be the reason why available P values are high in Tp (23.45 pp at 0-10 cm depth, increased to 24.62 pp in T2, but decreased to a range of 3,7 -18.90pp in T0, T1, T3 and T4). Those treatments with fairly low values could be as a result of lower fixation rate and higher rate of absorption by plants (*A. lebbeck* and potato) in the treatments.

Pertaining to the exchangeable cations, there was no significant effect of treatments on Ca levels. This could be attributed to the nature of the parent material, fairly uniform levels of Ca in Tp and the respective treatments (T_0 – T_4), different rates of Ca intake by plants and the dominant nature of Ca at the exchange site (Tables 5 & 11). The low levels of Ca (Table 5) in some of the treatments could also be due to leaching as a result of the high rainfall pattern which is about 1371 mm per annum (Alford *et al.,* 1979; Eziashi, 1995) on the Plateau and the generally low pH values of the soils from the site (granite) which favours the formation of kaolinite. Kaolinite is the main slicate clay mineral in the major soil types on the Plateau (Inceptisols, Alfisols and Ultisols) which is a contributory factor to the low Ca and Mg (Olowolafe, 2003). Magnesium (Mg) is one of the exchangeable cations that dominates the exchange site (the site) (Tables 6 & 11).

The significant effect of blocks on Mg content at 0 – 10 cm depth could be attributed to the influence of fertility gradient (in respect of block) at the experimental site. Generally, soils derived from granites are low or very low in exchangeable Ca and Mg (Olowolafe, 2003). Similarly, the significant effect of the treatments on K levels at 0 – 10 cm and 10 – 25 cm could be as a result of the application of green manure, which might have influenced the K content in the soil samples from the treatments (Tables 7 & 11, Fig. 5). The generally low K levels, which could be as a result of leaching and the low K content of the soil parent material as earlier reported by Olowolafe and Dung (2000). The non-significant effect of the treatments on Na observed at all soil depths could be attributed to the low level of variations among the mean values of the treatment which ranged from 0.15 – 0.26 cmol (+) kg^{-1} which is not enough to bring about significant differences (Tables8& 11).

However, the low level of sodium (Na) at the exchange site might not be unconnected with the nature of the parent material, leaching, intake by plants and treatments applied.

Table 11: Etract from the ANOVA Table showing block and treatment effects on soil chemical properties in the experimental site

SCP	Soil Depth (cm)	MS Block/Replicate	MS Treatment	MSE	F Ratio: Block	F Ratio: Treatment
$P^H(H_2O)$	0 – 10	0.71	0.35	0.21	0.073 NS	0.230 NS
$P^H(H_2O)$	10 – 25	1.97	0.45	0.24	0.007**	0.180 NS
$P^H(H_2O)$	25 – 40	1.165	0.48	0.28	0.020*	0.214 NS
O. M.	0 – 10	0.07	0.14	0.05	0.462 NS	0.924 NS
O. M.	10 – 25	0.07	0.06	0.05	0.465 NS	0.396 NS
O. M.	25 – 40	0.007	0.030	0.020	0.116 NS	0.511 NS
% N	0 – 10	0.032	0.033	0.033	0.415 NS	0.466 NS
% N	10 – 25	0.0001	0.0003	0.0007	0.856 NS	0.778 NS
% N	25 – 40	0.0250	0.0398	0.0530	0.641 NS	0.604 NS
P	0 – 10	158.66	129.140	32.26	0.043*	0.0414*
P	10 – 25	106.21	73.358	81.596	0.315 NS	0.505 NS
P	25 – 40	6.961	5.0141	12.203	0.583 NS	0.831 NS
Ca	0 – 10	0.5956	1.342	0.4356	0.299 NS	0.612 NS
Ca	10 – 25	0.1585	1.606	0.531	0.748 NS	0.064 NS
Ca	25 – 40	1.069	1.012	0.773	0.295 NS	0.335 NS
Mg	0 – 10	0.879	0.041	0.0853	0.002**	0.704 NS
Mg	10 – 25	0.0200	0.288	0.342	0.945 NS	0.550 NS
Mg	25 – 40	0.0013	0.034	0.251	0.995 NS	0.314 NS
K	0 – 10	0.002	0.005	0.002	0.366 NS	0.045*
K	10 – 25	0.002	0.003	0.0006	0.094 NS	0.021*
K	25 – 40	10.009	10.461	10.810	0.428 NS	0.481 NS
Na	0 – 10	0.008	0.002	0.0032	0.127 NS	0.656 NS
Na	10 – 25	0.017	0.003	0.0043	0.060 NS	0.629 NS
Na	25 – 40	0.005	0.006	0.004	0.319 NS	0.265 NS
EA	0 – 10	0.112	0.0441	0.0343	0.081 NS	0.342 NS
EA	10 – 25	0.016	0.169	0.274	0.945 NS	0.691 NS
EA	25 – 40	0.007	0.229	0.220	0.970 NS	0.445 NS
ECEC	0 – 10	I.738	2.023	0.763	0.153 NS	0.089 NS
ECEC	10 – 25	0.735	2.283	2.254	0.729 NS	0.459 NS
ECEC	25 – 40	0.6680	2.233	1.972	0.717 NS	0.404 NS

Note: SCP = soil chemical properties, **ANOVA** = analysis of variance, **MS** = mean square, **MSE** = mean square error, **EA** = exchangeable acidity, **ECEC** = effective cation exchange capacity, * = significant at 5% probability level, ** = significant at 1% probability level, **NS** = not significant.

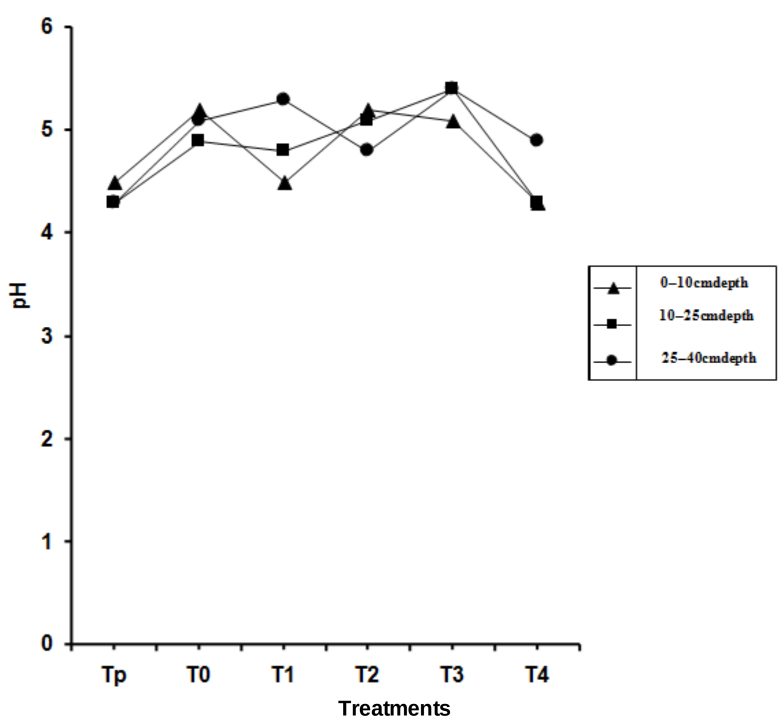

Fig. 1: Effects of Treatments on Soil P^H (H_2O) at Three Soil Depths (Tp= Pre-Experimental Value)

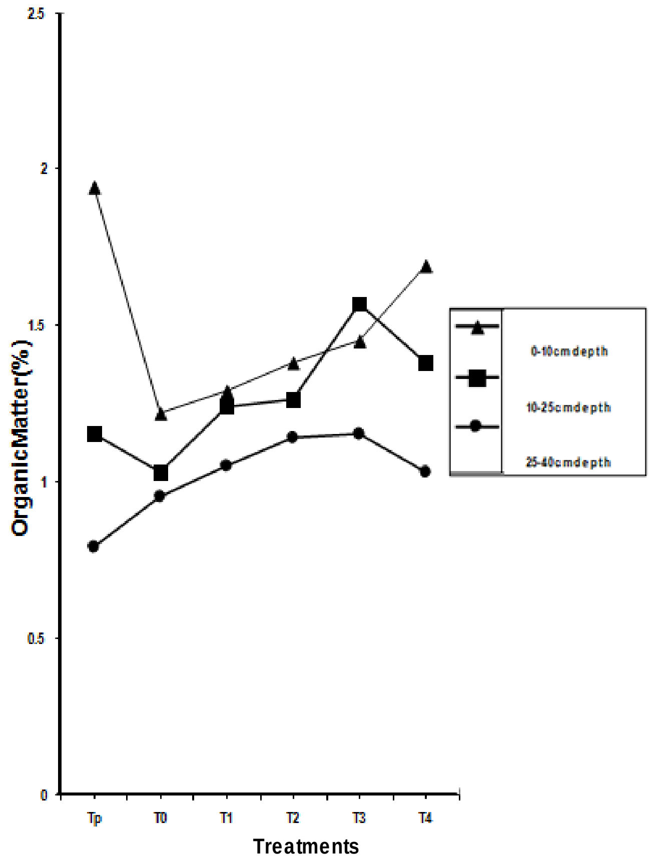

Fig. 2: Effects of Treatments on Organic Matter at ThreeSoil Depths (Tp= Pre-Experimental Value)

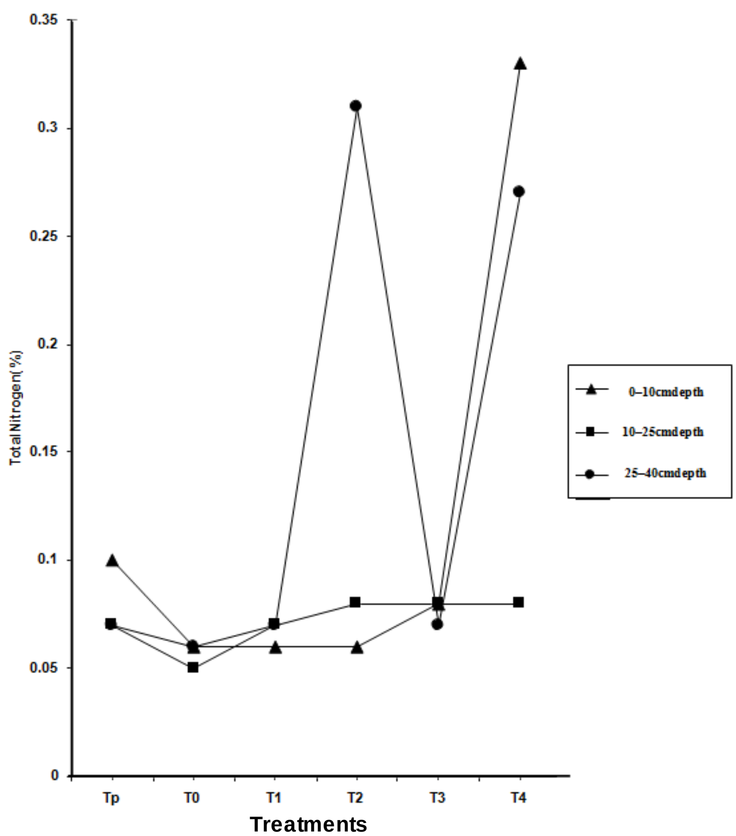

Fig. 3: Effects of Treatments on Total Nitrogen at Three Soil Depths (Tp = Pre-ExperimentalValue)

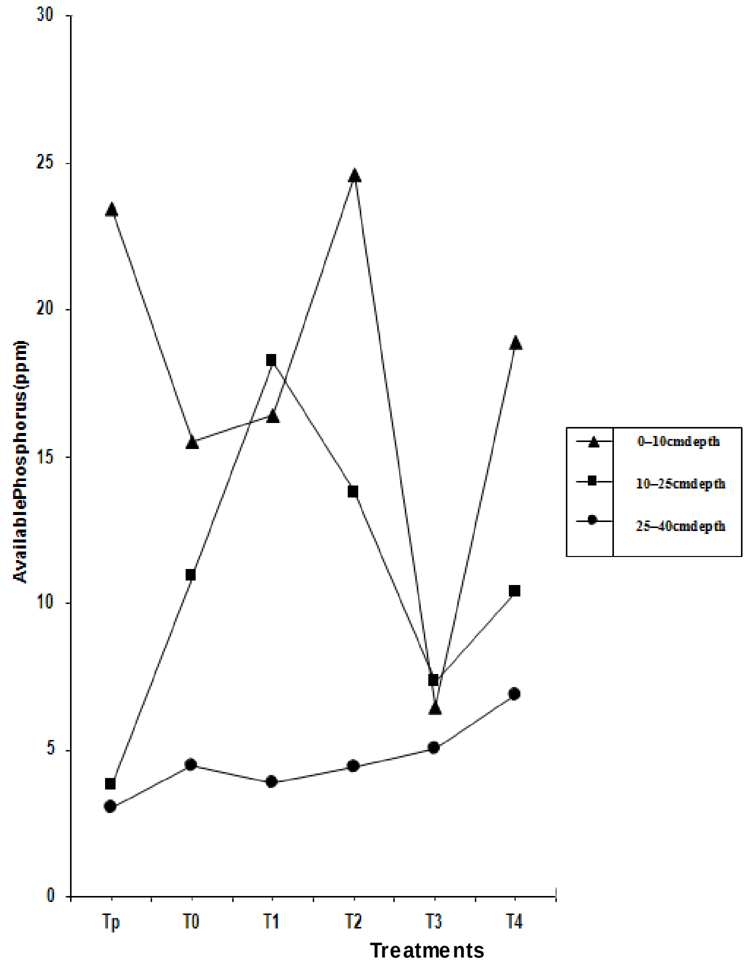

Fig. 4: Effects of Treatments on Available Phosphorus at Three Soil Depths (Tp= Pre-Experimental Value)

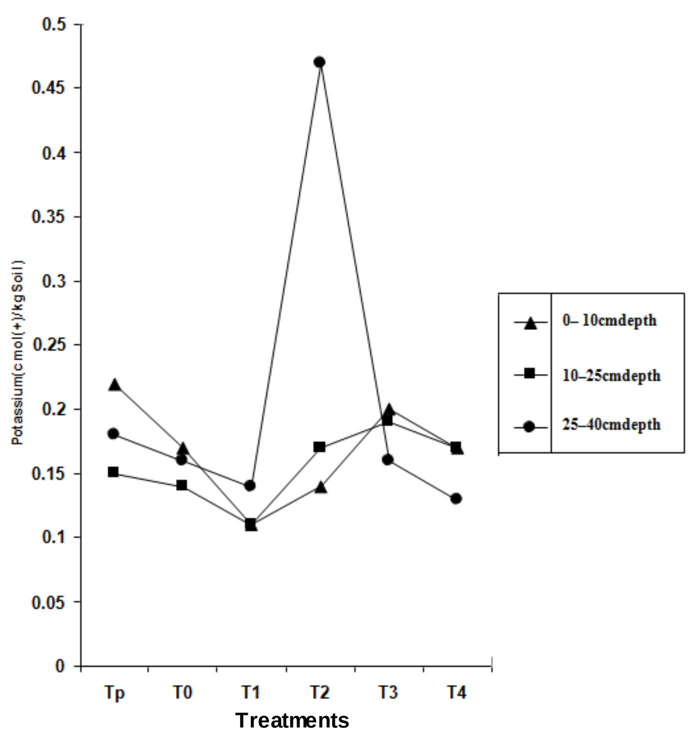

Fig. 5: Effects of Treatments on Potassium Content at ThreeSoil Depths (Tp= Pre-Experimental Value)

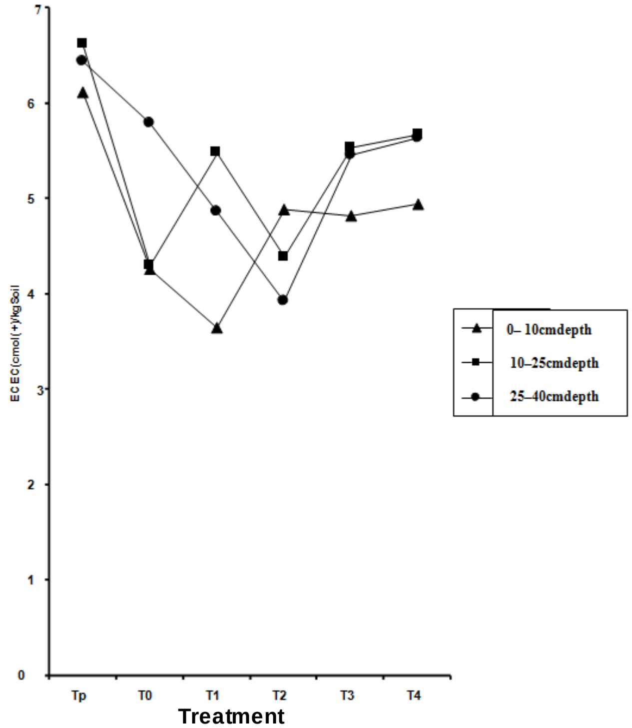

Fig. 6: Effects of Treatments on ECEC at Three Soil Depths (Tp = Pre-Experimental Value)

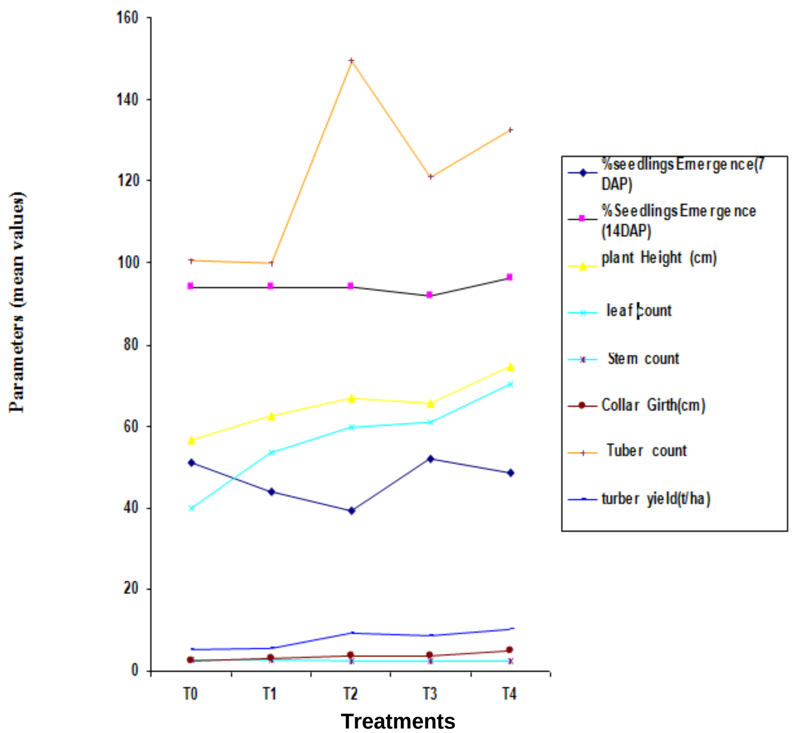

Fig. 7: Treatment Effects on Growth and Yield Parameters of Irish Potato Crop

The generally low exchangeable acidity is as a result of the low pH and organic matter of the soil. This phenomenon had earlier been observed by Nyle and Ray (1996) in respect of soils with low pH and organic matter. The generally low levels of the exchangeable cations in the study site (which has been under continuous cultivation is traceable to nutrient removal by crops and grazing (by the cattle in the College). This further indicates that the amount of nutrients (cations) removed from the soil exceeds what was added to the soil through manuring or nitrogen fixation activities of the *Albizia lebbeck* trees, hence, the increasing value of exchangeable bases and accompanying decline in soil pH in the experimental site (Olowolafe, 2007).

The differences among the mean values of exchangeable acidity could be attributed to possible effect of clay content in the soils. The values of subsoil are higher than that of the surface soil which could be due to leaching or higher infiltration rates of the exchangeable cations at the exchange site. For instance, the values of the exchangeable acidity before planting (0.87 to 1.87) decreased profoundly (to 0.54 – 0.80) in the surface soil (0 – 10cm depth) but to a little extent in the deeper strata (10 – 40 cm) with mean values of 0.73 to 1.53 cmol (+) kg^{-1} soil (Tables 9 & 11). This is due to leaching of nutrients or their uptake by the crop (potato) and *A. lebbeck,* as more H^+ and Al^+ replaced the exchange site and thereby making the soil more acidic. This phenomenon had earlier been reported by Fomba (1998), Adeleye *et. al.* (2010) and Dhakal (2010) on the effects of organic manures/leaf mulching on crop growth and yield. Also, low organic matter contents normally adversely affect exchangeable acidity since soil organic matter plays a vital role in the supply of plant nutrients and enhancement of exchangeable acidity. The low organic carbon in the site is traceable to the influence of high temperature, which is a prominent feature of tropical environment which leads to fast rates of decomposition, mineralization and subsequent disappearance of soil organic matter (Nye and Ray, 1996; Olowolafe and Dung, 2000).

The observed decrease in the effective cation exchange capacity (ECEC) from a range of 6.12 to 6.62 downwards the soil strata (0 – 40 cm depth) before planting to a range of 3.65 to 5.79 down the strata (0 – 40 cm depth) after planting could be due to absorption by plants, crop removal and leaching. Also, the values of the ECEC reduced because of the reduction in the values of exchangeable cations and exchangeable acidity since ECEC is the summation (addition) of the exchangeable cations and exchangeable acidity (Tables 10 & 11, Fig.6). Therefore, the increase in exchangeable acidity and ECEC from the surface soil to the deeper strata of the soil (subsoil) in the study site could be as a result of leaching or infiltration of the exchangeable cations or their absorption by the potato crops for growth and yield. This agrees with the earlier observation made by Olowolafe and Dung (2000) in respect of soils derived from the biotite-granite on the Jos Plateau (Nigeria) with regard to their nutrient status and management for sustainable agriculture.

Apart from factors such as leaching, infiltration, absorption by crops and grazing, erosion could also be a contributory factor for the decline in exchangeable acidity and ECEC in the surface soil. This agrees with the reports by Lal (1981) and Olowolafe (2007) who observed that considerable or substantial proportion of topsoil nutrients is lost as a result of erosion. It is pertinent to mention here that since organic matter helps in retaining cations and EEC in soils and is very low in surface / top soil due to crop removal, leaching, erosion among others, this must have brought about the difference in ECEC values of the surface and sub-soils.

For Tables 1-10: T = treatment; 0-10cm, 10-25cm and 25-40cm are soil depths; 1, 2 and 3 denote the soil depths also while a, b and c are the blocks/ replicates (No. of blocks=No. of replicates).

Growth and Tuber Yield (in Solanum tuberosum)

Among all the apparent growth parameters (apart from number of stem) and in all the five cropping seasons (CS), treatments had significant effects on the growth and tuber yield of potato at 1% (P = 0.01) due to the influence of enhanced nutrient level. In the CS1, For instance, T4 had the highest values in plant height, number of leaves, collar girth and in tuber yield (9.36 ton/ha^{-1}).

The trend was not different in the CS2, CS3, CS4 and CS5 where T4 emerged as the treatment with highest mean values in growth indices and tuber yield with mean values of 10.41, 9.80, 9.73 and 11.96 ton/ha^{-1} respectively. This could be due to the fact that T4 had the highest level of green manure application in addition to the nitrogen fixation by the tree rows of *A. lebbeck* which must have brought about highest nutrient status for better growth, development and yield (Fig. 7).

CONCLUSION

The green manure and the tree rows of A, lebbeck had reasonably influenced the chemical properties of the soil at the experimental site. This is not unconnected with the fact that this tree species being a nitrogen fixing legume, improves the nitrogen status of the soil in addition to nutrients released from the green manure, which even raised the pH (thereby reducing the acidity level that was initially high) which concomitantly led to better fertility status of the soil. This was also evident in the control experiment that had poor nutrient status and the lowest yield due to the absence of green manure and the tree rows of A, lebbeck. Timely release of nutrients from the green manure was also feasible because it was applied to the alleys of the Albizia lebbeck tree rows 2-3 weeks prior to planting which paved way for complete decomposition and mineralization.

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