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Influence of different leguminous crop on the ultisol that had been continuously cropped to cassava /maize for over six years

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Leguminous crops play an important role in developing sustainable and low input crop production system and have shown good potential for inclusion in alley cropping systems. Hence, a study was carried out at the Teaching and Research Farm of the Faculty of Agriculture, Chukwuemeka Odumegwu Ojukwu University to evaluate the productivity of an impaired ultisol under cassava/maize for over six years planted with different legumes. The experiment was laid out in a randomized complete block design. The treatments studied were, cowpea, groundnut, bambara groundnut, pigeon pea and control which is maize. Data collected was subjected to an analysis of variance test based on randomized complete block design (RCBD) and treatment means were separated using least significant difference (LSD<0.05). The findings from the study showed that there were significant (P<0.05) differences among the treatments in growth, yield and soil chemical parameters assessed as well as the texture of the studied soil. The legume crops planted on the impaired soil had good nodulation which helped to replenish soil nutrient lost and good yield of pigeon pea (0.34 tha^{-1}), Bambara groundnut (0.17 tha^{-1}) cowpea (0.12 tha^{-1}), Groundnut (0.10 tha^{-1}), respectively. The result of the soil chemical parameters assessed from post harvest soil analysis indicated that the nutrient content of the studied soil increased except for exchangeable acidity (EA), K and effective cation exchange capacity which generally reduced in all the plots planted with leguminous crop. The plots planted with Bambara groundnut and groundnut showed a slight reduction in exchangeable Mg^{2+} relative to pre planting soil analysis which was 50% reduction relative to the control, while exchangeable Na^{+} content reduced in plots planted with Bambara groundnut. Evidence from this study, then showed that leguminous crop can be used to reclaim an impaired soil and improve the fertility status of the soil.

Key words: Chemical properties, growth, legume crops, ultisol, yield.

INTRODUCTION

Humid and sub humid regions of tropical Africa are comprised of a wide range of soil types such as ultisols, oxisols and Alfisols for crop production (Kang and Juo 2011). Dudal (2010) classification showed that ultisols make up 46.6% and alfisols 12.5% of the land area in humid tropical Africa; while in the sub humid zones

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ultisols and oxisols make up 25.6% and alfisols 27.4% of the total land area. In south eastern Nigeria, more than 70% of the total land area is covered by ultisols (Mbagwu, 1992). These soils are highly weathered and have low activity clays**.** Further they are characterized by low pH, low cation exchange capacity (CEC), very low inherent fertility, low base saturation and multiple nutrients deficiencies and nutrient imbalance. According to Hartman (2011), Kang and Jou (2011), toxic levels of aluminium or manganese or both are among the main chemical constraints to growing crops on these strongly acid soils. These soils are prone to erosion and compaction, therefore soil fertility maintenance and erosion control and compaction are management problems in using the soils for crop production. Another contributory problem of the soil in the study area is the complexity of farming systems, which arise out of the small size of majority of the farms combined with management that reflect multiple objectives of the farming community coupled with the fact that the livelihood of farmers in the area study is generally poor.

As a result of the current farming system, the crop productivity and soil fertility have declined due to the shortening of fallow periods, which are needed to restore and maintain soil productivity. The implication is the increase in the use of inorganic fertilizer by the local farmers, with attendant reduction in the use of organic manure. Loss of organic matter (OM) results in soil acidity, low nutrient content and imbalance and low crop yield (Sharma and Mittra, 1991; Nweke, 2014). Also, the use of ammonium fertilizers over a long period of time in a particular piece of land causes nutrients imbalance and soil acidity. Continuous cropping and intensive land use leads to exhaustion of soil fertility, decrease in crop yield (Corsky and Ndikwo, 2008).

Thus, traditional farmers tend to retain certain trees and shrubs in their crop production systems to restore soil fertility exhausted by cropping (Moormann and Greenland, 2010). Increased cropping intensity has been found by Okigbo, (1982) to accelerate the erosion of top soil, degradation in soil physical condition, deterioration of nutrient status and changes in the number and composition of soil organisms. In view of this, there is the need to identify crop management practices that can maintain soil fertility under more intensive land use and continuous cropping activities. Legumes as it were, are important components of various cropping systems, as they fix and improve the N content of the soil and the productivity of the companion crop (Agboola and Fayemi, 2001; Crews and people, 2004; Nweke et al., 2013). However, most of these legumes require phosphorous (P) for N_2 fixation processes and growth (Nweke and Emeh 2013) which farmers fail to supply due to lack of the knowledge, management incompetence and way with all. Hence, the strategy that needs to be adopted in order to compensate for the lack of P fertilizer has been to select legumes adapted to low P soils (Sanginga et al., Therefore, the judicious management and conservation of the soil and crop nutrients to guard against crop yield decrease is a major challenging factor in intensive crop production and the involvement of N_2 fixing green legumes and their incorporation into the farming system will help in stabilizing the sustainable agronomic practices. Thus, the essence of this work is to evaluate the ability of different leguminous crops in enriching the fertility status of an ultisol at Igbariam that had been impaired to do continuous cropping to cassava/maize for over six years.

MATERIALS AND METHODS

Site location

The study was carried out at the Faculty of Agriculture Teaching and Research Farm Chukwuemeka Odumegwu Ojukwu University, Anambra State Nigeria. The site lies between latitude 06 14'N and longitude 06 45'E, the rainfall pattern is bimodal between April and October with mean annual rainfall of over 1300 mm. The relative humidity of the study area is moderately high all year round with the highest relative humidity of 85% during the wet season and the lowest 64% during the dry season. The physical and chemical parameters of the studied soil prior to treatment application are presented in Table 1.

Field method

The study area was cleared of the natural vegetation and debris removed and cultivated using hoe. The experiment was laid out in a randomized complete block design (RCBD) with four replicates and five treatments to give 20 plots, each measuring 3 m x 4 m. Plots were separated from each other by 0.5m path and each block was separated by 1 m alley. The treatments included cowpea (*Vigna unquiculata*), groundnut (*Arachis hypogeae*), bambara groundnut (*Vigna subterranea*), Pigeon pea (*Cajanus cajan*) and maize (control). The leguminous crops were planted two seeds per hole at a depth of about 5 cm at the spacing of 60 cm x 60 cm in their respective plots. The control plot was planted a hybrid maize (Oba super II) two seeds per hole, using a planting distance of 25 cm x 75 cm. Two weeks after germination, thinning and supply operation were done and 0.4 kg NPK fertilizer was applied to every plot by ring method to boast their vegetative growth. Weeding was manually done at two weeks interval till harvest. Eight plants per plot were randomly sampled for the number of nodules and root area index at 70 days after planting (DAP). At maturity, pod/grain yield per plot was measured, the pod/grain yield from the tagged plants (Eight/plot) were harvested, dried to 14% moisture content. The grain harvested from the tagged plant was weighed to get its yield per plot in tonnes per hectare. Soil samples were collected prior to the experiment from the surface of the plot in three different locations at the depth of 30 cm using auger, this was thoroughly mixed to form a composite sample. At the end of the study soil samples were collected from each plot, these soil samples were then analyzed for physical and chemical properties using standard procedure described by Black (1965).

Data analysis

Data generated from the field and laboratory, were analyzed using analysis of variance (ANOVA) test based on randomized complete block design (RCBD). Statistical significance differences between

Table 1. Physical and chemical parameters of the experimental site before treatment application.

Parameter	Value
Coarse	46%
Fine sand	43%
Silt	7%
Clay	4%
Textural class	sandy
pHH_2O	6.46%
Soil organic Carbon	0.71%
Soil organic Matter	1.23%
N	0.06%
Na^+	0.10 $CmolKg^{-1}$
K^+	0.12 " "
Ca^{2+}	2.4 " "
Mg^{2+}	2.0 " "
Exchangeable Acidity (EA)	0.40 " "
Effective Cation Exchange Capacity	8.62 " "
Base Saturation (BS)	82.29%
Available P	26.10 $mgKg^{-1}$

Table 2. Influence of different leguminous crop on the root area index, number of nodules, weight of pod (tha^{-1}); grain yield (tha^{-1}) in Ultisol cultivated cassava/maize for over six years.

Treatment	Root area index	Number of nodules	Weight of pod (tha^{-1})	Grain yield (tha^{-1})
Cowpea	41^c	2.41^d	0.47^d	0.12^c
Groundnut	38.75^c	42.91^c	0.40^c	0.10^c
Bambara groundnut	49^c	20.75^b	0.68^b	0.17^c
Pigeon pea	123.75^a	252.66^a	1.36^a	0.34^b
Control Maize	79^b	-	-	0.78^a
LSD 0.05	12.48	12.53	0.06	0.12

A,b,c,d,e figures with the same superscript in the same column are not significantly different (P<0.05).

treatment means was estimated using least significant difference at 5% alpha level according to Steel and Torrie (1980).

RESULTS

The result of the pre-planting soil analysis showed that the textural class of the studied soil is sandy, with a pH value of 6.46 and contain low level of major nutrient elements. The organic matter content (1.23%), organic carbon (0.71%) and percentage nitrogen (0.06%) as well as available phosphorous (26.10 $mgKg^{-1}$) at the soil were very low. The exchangeable acidity and effective cation exchange capacity (ECEC) of the soil were 0.4 $Cmolkg^{-1}$ and 8.62 $Cmolkg^{-1}$), respectively. The percentage base saturation (BS) was relatively high with value of 82.29%. Thus, the studied soil is impaired of these nutrient elements (Table 1). The result of root area index, numbers of nodules, weight of pod and grain yield were presented in Table 2. The value obtained for root area index was significantly different (P<0.05) among the crops. The pigeon pea had the highest value among the crops, the order of increase in root area index were pigeon pea>maize>Bambara groundnut>groundnut> cowpea. The value obtained from cowpea, groundnut and bambara groundnut were however statistically similar. The number of nodules and weight of pod values indicated significant differences among the treatment crops. The pigeon pea performed better than the other legume crops in the number of nodules and weight of pods, while the least value was observed in cowpea for number of nodules and groundnut for the weight of pods. The order of decrease in value relative to pigeon pea for the number of nodules and weight of pods were cowpea<Bambara groundnut<groundnut<pigeon pea and groundnut<cowpea<bambara groundnut<pigeon pea, respectively. The grain yield result showed that pigeon pea performance was higher compared to the other leguminous crops with a value of 0.34tha^{-1}, the yield value

Table 3. Influence of different leguminous crops on the chemical properties of an ultisol under cassava/maize cultivation for over six years.

1	pH (H_2O)	N (%)	OC (%)	OM (%)	P mg(Kg^{-1})	Ca Cmol(kg^{-1})	Mg Cmol(kg^{-1})	K Cmol(kg^{-1})	Na Cmol(kg^{-1})	EA Cmol(kg^{-1})	ECEC Cmol(kg^{-1})	BS (%)
Cowpea	6.76	0.140	0.65^{d}	1.11^{d}	73.40^{a}	4.00^{b}	2.00^{c}	0.102^{c}	0.113^{bc}	0.24^{b}	6.46^{c}	96^{ab}
Groundnut	6.82	0.156	0.85^{b}	1.46^{b}	51.20^{b}	3.20^{c}	1.60^{b}	0.082^{d}	0.131^{b}	0.24^{b}	5.25^{d}	95^{b}
Bambara groundnut	6.84	0.126	0.85^{b}	1.46^{b}	31.80^{c}	3.60^{bc}	1.60^{b}	0.113^{b}	0.078^{c}	0.40^{a}	5.79^{e}	93^{c}
Pigeon pea	6.90	0.070	1.05^{a}	1.81^{a}	27.30^{d}	5.20^{a}	2.40^{a}	0.077^{e}	0.191^{a}	0.40^{a}	8.27^{a}	95^{b}
Control	6.77	0.098	0.77^{c}	1.32^{c}	26.50^{d}	4.80^{a}	2.40^{a}	0.123^{a}	0.096^{bc}	0.24^{b}	7.66^{b}	97^{a}
LSD 0.05	NS	NS	0.06	0.07	0.84	0.47	0.27	0.005	0.043	0.08	0.35	1.50

A,b,c,d,e figures with the same superscript in the same column are not significantly different ($P<0.05$).

of cowpea; groundnut and bambara groundnut were statistically similar. The yield result showed significant ($P<0.05$) difference among the crops assessed. The growth and yield parameters assessed in this trial showed that pigeon pea performed competitively better in value obtained than the other leguminous crops.

The next in rank was bambara groundnut, while the least was cowpea. Table 3 shows the influence of leguminous crops on the soil chemical properties of an ultisol under cassava/maize cultivation for over six years, the result of the pH showed that the pH value increased after post harvest analysis, but was not significantly different ($P<0.05$) among the crops. The plots planted with pigeon pea, Bambara groundnut and groundnut increased respectively over the control, while the plot planted with cowpea showed a slight decrease in pH relative to the control value. The result of the total nitrogen (TN) showed non-significant difference among the leguminous crops, but the value obtained from cowpea, groundnut and Bambara groundnut showed increase in the TN content of the soil with highest value obtained from groundnut which shows a percentage increment of 37.18% over the control. The result of OC showed significant difference among the legumes, though the values of groundnut and Bambara groundnut were statistical similar, but significantly better than the control. The percentage increase in OC over the control with regard to pigeon pea, bambara groundnut and groundnut were 26.67, 9.41 and 9.41%, respectively. While cowpea showed a decreased in OC value relative to the control with a value of 18.46%.

The level of available phosphorous increased in all the plots in the post harvest soil analysis relative to the control plots. The plots planted with cowpea increased the available phosphorous content of the soil by 63.90% over the control. The percentage increases in P observed in groundnut and bambara groundnut over the control were 48.24 and 16.6%, respectively, while pigeon pea gave a slight increase with a value of 2.93% over the control. The available P result showed significant ($P<0.05$) differences among the crops, though the values obtained from pigeon pea and control were statistically similar. The result of exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) showed significant differences at $P<0.05$ following post harvest soil analysis. The table indicated that the Ca^{2+} level increased in all the plots at post harvest soil analysis relative to pre-planting soil analysis. The highest value of 5.20 $Cmolkg^{-1}$ $Ca^{2+}$was recorded in the plot treated with pigeon pea, which shows a 7.69% increase over the control plot. While the plots treated with cowpea, Bambara groundnut showed a decrease of 20, 33 and 50%, respectively to the control plots. The result of exchangeable Mg^{2+} showed that the level of Mg^{2+} were slightly reduced in plots treated with bambara groundnut and groundnuts at post harvest soil analysis relative to pre-planting soil analysis. The reduction in Mg^{2+} value of these two crops relative to the control was 50%.The exchangeable K^{+} and Na^{+} result in Table 3 indicated that K^{+} level slightly reduced in all the plots treated with legumes crops relative to the pre-planting soil analysis, while Na^{+} level showed slight increase in all plots except the plot treated with Bambara groundnut relative to pre-planting soil analysis.

The percentage decrease in K^{+} value of the leguminous crops relative to the control crop were 59.74% (pigeon pea); 50% (groundnut); 20.59% (Cowpea) and 8.85% (Bambara groundnut), respectively. The highest, Na^{+} value was observed in plots treated with pigeon pea which was 49.74% increase over the control. The exchangeable acidity result showed significant

Table 4. Influence of different leguminous crop on the physical properties of an ultisol under cassava/maize cultivation for six years.

Treatment	Sand (%)	Silt (%)	Clay (%)	Textural
Cowpea	77.0[b]	7.80[b]	15.20	Loamy sand
Groundnut	78.0[b]	6.80[c]	15.20	Loamy sand
Bambara groundnut	81.0[a]	3.80[e]	15.20	Loamy sand
Pigeon pea	79.0[ab]	5.80[d]	15.20	Loamy sand
Control maize	75.0[c]	9.80[a]	15.20	Loamy sand
LSD 0.05	2.04	0.19	NS	

A,b,c,d,e figures with same superscript in the same column are not significantly different ($P<0.05$).

difference among the leguminous crops, though the values obtained from cowpea and groundnut did not differ with each other. Also, the EA values of bambara groundnut and pigeon pea were statistically similar but significantly better than the control. The EA result equally indicated that there were a slight decrease in the plots planted with cowpea and groundnut at post harvest soil analysis relative to pre-planting soil analysis. The result of the soil chemical parameters in Table 3 indicated that the level of effective cation exchange capacity (ECEC) reduced in all the plots at post harvest soil analysis. The percentage decrease in ECEC relative to the control plots were 18.58% (cowpea); 32.30% (Bambara groundnut), 45.90% (groundnut), the result of pigeon pea showed a slight increase over the control with a percentage value of 7.38%.

The result of base saturation (BS) value presented in Table 3 indicated an increase in the base saturation of all the plots relative to the pre-planting soil analysis data. The highest value of 96% was recorded in the plot planted with cowpea, which shows a 1.04% decrease relative to the control plots. The BS values obtained from plots planted with cowpea, groundnut and pigeon pea were statistically similar, but significantly ($P<0.5$) better than the value obtain from bambara groundnut treated plots. The result of the particle size analysis indicated that the legumes crops change the textural class of the studied soil from sandy to loamy sand. There was no change in the clay content of the soil indicating no effect by the leguminous crops. However, the legumes have effect on the sand and silt content of the soil. There was an increase in the sand content and decrease in the silt content of the plot planted with the legumes crops relative to the control (Table 4).

DISCUSSION

The pre-planting soil analysis of the study area showed that the studied soil was found to be impaired in major plant nutrient elements and according to soil fertility evaluation criteria of Ibedu et al. (1988) and fertility rating of Landon (1991), the studied soil is regarded as being low in these soil major nutrients. This might be due to continuous use of the land for cassava/maize production which are nutrient consuming crops and therefore, might have used most of these major nutrients in the soil over the years hence, impaired in major soil nutrients. Cultivation diminishes plant chemical nutrients, soil carbon and substantially lowers nitrogen mineralization (Majaliwa et al., 2010). From the result presented in Table 2, Pigeon pea was observed to have recorded higher values in root area index, number of nodules, weight of pods and grain yield which are significantly ($P<0.05$) different in comparison with the other leguminous crops assessed in this trial. The next in rank after pigeon pea is bambara groundnut with regards to growth and yield parameters. The higher values observed in pigeon pea and bambara groundnut could be attributed to more root proliferation development and nodulation, showing that the plants can explore more soil for chemical nutrients and soil water as well as more nitrogen availability.

Nweke and Emeh (2013) found out that increase in length of root of Bambara groundnut led to more nutrients absorption that transformed into higher yield observed in their study. Root distribution patterns vary with plant species, Fischler (1999) observed that canavaila have a deeper root system than several other annual legumes. The expansive root system of legumes prevent evapo-transpiration of soil water, leaching of chemical nutrients, erosion and bind soil particles together to form a stable structure (Wu and McGechan, 2009). The productivity of soils can also be improved with the use of leguminous crops. In Ghana, Kamegieter (2006) observed increases in crop yield following a short-term fallow on which leguminous cover crops was grown and in southwest, Nigeria, the works of Lal et al., (2008) and Wilson et al., (2012) showed that leguminous crops improve soil physico-chemical properties and biological activities as was measured by earthworm cast production under centrosema pubescent, cowpea, mucuna pruriens and Bambara groundnut grown only for a short period. While Agboola (2010) found out that as live mulch, calapogonum, mucunoides, bambara groundnut and groundnut gave increases in maize yield equivalent to applying $55kgNha^{-1}$. The leaves can also be used for mulch, green manure and supplement high quality browse for small ruminants particularly during the dry season (Sumberg, 2004).

The nodulation efficiency of the cowpea in the studied soil was found out not to be effective, this could be attributed to both internal and external factors, this notwithstanding the result suggest that these legumes could be used as a cheap source of organic fertilizer for soil maintenance and fertility improvement in order to maintain stable and sustainable crop production in humid tropical countries like Nigeria. The following legumes: Albizia species; Peagon pea; Cassia; Cowpea; Bambara groundnut; Groundnut; Inga and Sesbaina, according to the works of NAS (2010); (2013) meet most of the required characteristics for the humid and sub-humid tropics. The result of the soil pH was observed to have increased after post harvest analysis which shows increase in soil nutrient availability, root proliferation, development and yield as indicated in Table 2 and Table 3. Low soil pH value limits soil productivity as it affects availability and uptake of nutrients by plant (Table 1). The TN result though not significantly different among the crops assessed showed increase in TN content of the soil (Tables 1 and 2). This showed that the legumes according to Crews and People (2004) may have added more nitrogen into the soil thus, increasing the N level. Legumes contribute to nitrogen economy of cropping systems when effectively nodulated. The works of Cacmakci et al. (2006) and Elkoca et al. (2008) showed that beneficial micro-organism can colonize individual plant roots and stimulate increase in plant nutrient up take which in turn improves plant size and yield, organic mulch according to Sugiyarto, (2009) support diversity of beneficial soil macro-invertebrate and nutrient to ensure the vegetative growth of plants and suitable environment. Though the activity is still under utilized in the tropics as Vallis et al., (2012) found out that in low nitrogen soils, the amount of nitrogen fixed is closely correlated with legume dry matter yield.

The observations of Lal et al. (2009) and Wilson et al., (2012) showed small increases in soil nitrogen content ranging from 0.01 to 0.06% over a 2 year of legume production. Wilson and Caveness (2010) and Hartman et al. (2011) observed that when legumes are used in live or in situ mulch the population of spiral nematode harmful to maize are suppressed. The non-significant differences may be attributed to negative N balances due to N removal in the grain. Karlen et al. (1994) found out that grain legumes obtain N from the atmosphere, but may have negative N balances due to significant N removal in the grain. The OC and OM content of the soil was found to have increased following the leguminous crop production. The advantage of this increment is the conservation of soil fertility, erosion control and enhancing carbon and nitrogen stocks in the soil, hence, remedied an impaired soil such as the studied soil. This is because organic matter is linked intrinsically to soil such as it is important in maintaining good soil physical, chemical and biological conditions. Thus, soil fertility is marked to be affected by not only quantity but also quality of the OM therefore, to maintain soil fertility planting, leguminous crops is needed as proved by the result of this study. There was increase in available P content of the soil relative to the pre-planting soil; this indicated that the leguminous crops influenced the available P content of the soil. Though the legumes require phosphorous for N_2-fixation processes and growth, there was no reduction in the P level of the soil, this might be due to 0.4kg NPK applied as blanket treatment to stimulate growth and boast vegetative growth of the crops as stated by Johnson (1968) or maybe as a result of micro-organism interaction with the plant roots leading to liberation of some weak acid chemicals, which act on insoluble soil minerals like phosphates to release P nutrient for plant growth. According to Wondewosen (2009) nitrogen and phosphorous are highly limited nutrients that support good growth and development of crops. In a P deficient soils, the available one is utilized to complete its processes and growth thereby reducing the P level in the soil (Sanginga et al., 1996), therefore, in the P deficient soils like the studied soil, P must be supplied from other sources to enable the crops to efficiently use N supplied by the legumes as suggested by Jama et al. (1998). The result of the exchangeable Ca^{2+} and Mg^{2+} showed that there was great improvement on the calcium content of the soil due to legume treatment when compared with pre-planting value (Table 1).

The concentration of Mg as observed in the study however is not of the magnitude of Ca concentration. The result could be linked to pH and OM content of the soil. The exchangeable K^+ and Na^+ result showed that the use of legumes have influenced the availability of K and Na, in the studied soil and chemical properties influenced by the leguminous plants provide sufficient nutrient to the soil organism for soil biological activity that will in turn improve the soil properties. The result of exchangeable acidity (EA), effective cation exchange capacity (ECEC) and base saturation (BS) showed a decline in the concentrations of EA and ECEC following legume treatment while there was an increase in the concentration of the BS of the soil, the nature of the results (EA, ECEC, BS) might be attributed to the soil pH, OM and interaction of other chemical nutrients in the root zone of the soil. The particle size result of the study showed that the legumes influenced greatly the textural class of the soil from sandy to loamy sand; both sand and silt content of the soil were significantly influenced by the legumes crops assessed in this study. According to the works of Smith et al. (1998), soil texture has been found to have good relationship with soil compatibility and some other properties which affect inherent productivity of the soil. While Brewbaker et al. (2012) reported that inclusion of herbaceous and woody forage legumes in crop production system improve soil structure and texture as well as develop sustainable low- input production system.

Conclusion

From the findings of this study, legumes could be used to improve soil properties. The result obtained showed that the legumes assessed improved soil chemical parameters and the soil texture. The grain yield of the legumes was equally improved; though the yield value was highest in control (Maize) when compared with the legumes plots probably the size of maize grain makes it to gain more weight. Hence, it therefore suggest that legumes can be used to reclaim degraded soil or improve the fertility status of an impaired soil like the studied soil which have been depleted of its major chemical nutrients due to continuous cassava/maize cultivation for over six years. The results of the study also show that among the leguminous crop studied, the most efficient is the pigeon pea, and this crop can therefore serve as best maize – legume combination cropping system in the region. The legume will tend to strike a balance to the exhaustive nature of soil nutrients by maize crop.

Conflict of Interests

The author has not declared any conflict of interests.

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