

Soil-Plant Interactions in *Ipomoea asarifolia* and *Cynodon dactylon* in Sudan Savanna Ecological Zone, Northwestern Nigeria

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ABSTRACT

The interaction effects of two cover crops, *Ipomoea asarifolia* L. (Ders.) Roem & Schult and *Cynodon dactylon* (L.) Pers. on soil properties was investigated. Soil samples (0-20 cm depth) taken before and after cover cropping were analyzed using appropriate methods. In the results, silt proportion shows marked improvement under cover cropping (8.37 to 20.52%) than in the control (7.90 to 9.25%). Increase in clay (2.15 to 2.50%) and decrease in sand (88.86 to 87.85%) were observed in soils under the cover cropping. The clay content under *I. asarifolia* (2.67 to 2.83%) did not vary significantly ($P < 0.05$) whereas that under *C. dactylon* (1.72 to 3.08%) had significant variation ($P > 0.05$). Bulk density (1.82 to 1.95g/cm³ and 1.69 to 1.85g/cm³ and moisture (1.25 to 1.33% and 1.83 to 2.25%) under *I. asarifolia* and *C. dactylon* respectively were lower than particle density (1.89 to 2.24 and 2.22 to 2.25 g/cm³ under *I. asarifolia* and *C. dactylon* respectively. Soil pH value ranges from moderately acidic (5.90) under *C. dactylon* to slightly acidic (6.47) under *I. asarifolia*. Organic carbon (0.24 to 0.29%) and organic matter (0.47 to 0.55%) were higher under *C. dactylon*. Nitrogen was higher (0.05 gkg⁻¹) under *I. asarifolia* and lower (0.03 to 0.04 gkg⁻¹) under *C. dactylon*. Available P was higher (0.88 to 0.93 gkg⁻¹) under dense cover and lower (0.56 to 0.76 mg/kg) under sparse cover of the two species. Exchangeable bases were generally higher under cover cropping than in the control: Ca²⁺ (0.35 to 0.62 cmolkg⁻¹), Mg²⁺ (0.27 to 0.71 cmolkg⁻¹) and K⁺ (0.90 to 1.09 cmolkg⁻¹) were higher under *I. asarifolia* whereas Na⁺ (0.82 to 0.85 cmolkg⁻¹) was higher under *C. dactylon*. The mixed cover cropping of the two species, having higher CEC values of 3.45 and 3.55 cmolkg⁻¹, is critical to sustenance of soil fertility against weather adversities and human activities. Cover cropping is best between farming seasons to avoid competition with cultivated crops.

Keywords: Soil-plant interaction, cover cropping, *Ipomoea asarifolia*, *Cynodon dactylon*, Sudan savanna

INTRODUCTION

Soil has been described as an outcome of five broad factors namely, parent material, climate, relief or slope, organisms and time (Maniyunda and Malgwi, 2011). Soils of the Semi-arid Sudan Savanna are generally known to have low nutrient status and evapo-transpiration well in excess of annual precipitation (Ejaro and Lawal, 2010). The soils are predominantly sandy, having coarse texture, low moisture holding capacity and dry out quickly, making them highly susceptible to erosion by wind and water (FAO, 1999). The traditional agricultural practices predominant in the study area, initially encouraged long fallow periods to restore and maintain soil fertility, a trend which is not practicable in the present context due to rapid increase in human population and high rate of urbanization. These changes brought about reduction in the size of farm holding per family or individual, increased tillage practices on farm lands thereby

Shelter the soil surface, the fine particles go into suspension and the thick mixture of water and soil quickly fills and closes the tiny interstices in the soil, thereby Establishment of total and permanent vegetation cover is the preferable option for effective soil resource conservation and erosion control in the area. The hope of achieving such ambition however diminishes due to the growing human interference with the vegetation and soil resources (Cleaver and Scheber, 1994; World Bank, 1996). Human activities that interfere with the stability of Careful selection, propagation and utilization of herbaceous species with excellent characteristics for cover cropping;

aggravating soil erosion and nutrient depletion. Consequently, there is general decline in soil fertility and crop yield, leading to introduction of improved cultivars, which are relatively expensive in addition to increased utilization of chemical fertilizers, with attendant negative consequences on the soil ecosystem (Noma and Yakubu, 2012).

Inadequate or lack of vegetation cover on the soil results into rapid erosion by water during rainy seasons as well as wind erosion during off seasons and at the onset of rainy seasons. In some instances, the soil particles on the land surface are removed by wind or water, then, the subsoil is exposed and the productive capacity of the soil is considerably reduced (Aliero and Anka, 2001). When rain falls on a bare or unprotected land area, the soil is unable to absorb water effectively, because the dashing rains reducing infiltration, increasing run-off and therefore, soil loss (Ibrahim, 2002).

vegetation and soil include agriculture, forestry, housing, road construction, mineral exploration and mining. These practices are largely responsible for the current trends in deforestation, reduction in biodiversity, destruction of soil structure, alteration of soil water balance and reduction in soil fertility (Lal, 1990, Harris *et al.*, 1996).

preferably during off seasons and their subsequent replacement with cultivated crops during production

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seasons could be a good option. Research reports have shown that *Ipomoea asarifolia* cover improves the properties and fertility of soil (Anka and Aliero, 2002). The root system of *Ipomoea* conserves water, binds sand particles together to help build a more friable soil structure, whereas its decayed roots add to organic matter content of the soil (Aliero and Anka, 2001). The shoot system accumulates organic matter around the plant's vicinity, prevents soil erosion and retains nutrients (Abdullahi *et al.*, 2011). *Cynodon dactylon* controls erosion and helps in dune stabilization (Glenn *et al.*, 2012). Its strong, stout rhizomes and stolons spread rapidly to provide quick soil cover, prevents weed invasion and resists drought (USDA, 2012), the two crops have great potentials for cover cropping. They are ground trailing, drought tolerant species that grow year-round except when damaged by severe drought (Purseglobe, 1992). They depend on both seed production and vegetative organs for their propagation. When established, they often leave a dense mesh-work of their roots in the soil, which bring out tillers from buds when growing conditions become favourable (Pieri, 1992). In a new environment, they succeed through the superiority of their growth characteristics, adaptations and survival mechanisms, which enable them to exploit environmental resources and successfully colonize new habitats (Yelwa, 2008; USDA, 2012). Their ability to produce new shoots at the nodes of stolons and rhizomes, offer them the mechanical strength and firm attachment to the soil (Badejo *et al.*, 2009).

The present study investigated the effectiveness of these two cover crops in improving soil fertility vis-à-vis their interaction with one another and the soil medium, both during and after their establishment for forty weeks on crop fields. Results obtained from the study were envisaged to provide the practical bases for the utilization of these species in the management of soil fertility in a highly cost-effective way. This would encourage the conservation drive of these locally available cover crops in the study area and beyond.

MATERIALS AND METHODS

The Study Area

Main Campus of the Usmanu Danfodiyo University Sokoto (UDUS) (Figure 1), where the study was carried out, is on latitude 13.13°N; longitude 5.20°E and altitude 351.0m above sea level, in the Sudan savanna ecological zone of Nigeria (SERC, 2015). Soil of the area is sandy to sandy loam in texture. It is friable and easily cultivated with poor water holding capacity. The soil of the University main campus area has been described as young, lacking horizon development and is classified as Entisol (Noma and Yakubu, 2012). Climate of the area is semi-arid; characterized by erratic and scanty rainfall during the usually short wet season. The area also experiences long

dry season that consists of a period of dry winds, dusty harmattan and a hot dry period (Singh, 1997). Precipitation data ranges between 458.19 and 755.03mm with mean annual of 585.15mm. Annual average temperature ranges from 22.90 to 35.98°C (SERC, 2015). Relative humidity of the area ranges from 21 to 49% in dry season and from 51 to 79% in wet season (USDA, 2012).

Plant Propagation and Soil Analysis

The cover crops were propagated by transplanting of seedlings obtained from pre-established donor site (nursery seed beds) in accordance with Rice and Rice (2006). Soil samples within 20 cm depth were collected from each treatment plot using appropriate tools. Soil sample collection was done before and after cover cropping experiments and the samples were subjected to appropriate analysis in the laboratory to determine the following parameters: -

Soil Particle Size Analysis was carried out using Hygrometer method outlined in Shieldrick and Wang (1993) to determine particle size distribution (sand, silt, and clay) and individual particles size proportions. Soil Density Analysis (particle and bulk) and porosity were determined by the core method of Blake and Hartge (1986) as well as the mathematical expressions in Lal and Shukla (2004). The pH value of soil samples for each treatment was measured using pH meter with glass electrode and soil analysis was carried out using the method outlined in Miller and Donahue (1992). Moisture content analysis was carried out using Gravimetric technique outlined in Klute (1986). Modified Walkley Black method as outlined in Jaiswal (2004) was used for organic carbon and organic matter contents determination. The nitrogen content analysis was achieved using the total kjeldahl nitrogen (TKN) method as described by Jaiswal (2004), while available phosphorus determination was done by the Olsen method of P extraction as outlined in Jaiswal (2004). Ammonium acetate extraction technique outlined in Jaiswal (2004) was utilized to determine exchangeable bases. Exchangeable K and Na were determined by the use of an EEL flame photometer whereas exchangeable Ca and Mg were determined by complexometric titration with EDTA as outlined in Pereira *et al.* (2011). Cation Exchange Capacity (CEC) was determined by the method outlined in Wang *et al.* (2004).

Data Analysis

Data was expressed as means \pm standard error of mean (SEM). Analysis of variance (ANOVA) using SAS was performed to test the differences between the groups mean. Significant differences between the treatment means were determined by Duncan's New Multiple Range (DNMR) Test and P values < 0.05 was regarded as significant (Sokal and Rohlf, 1995).

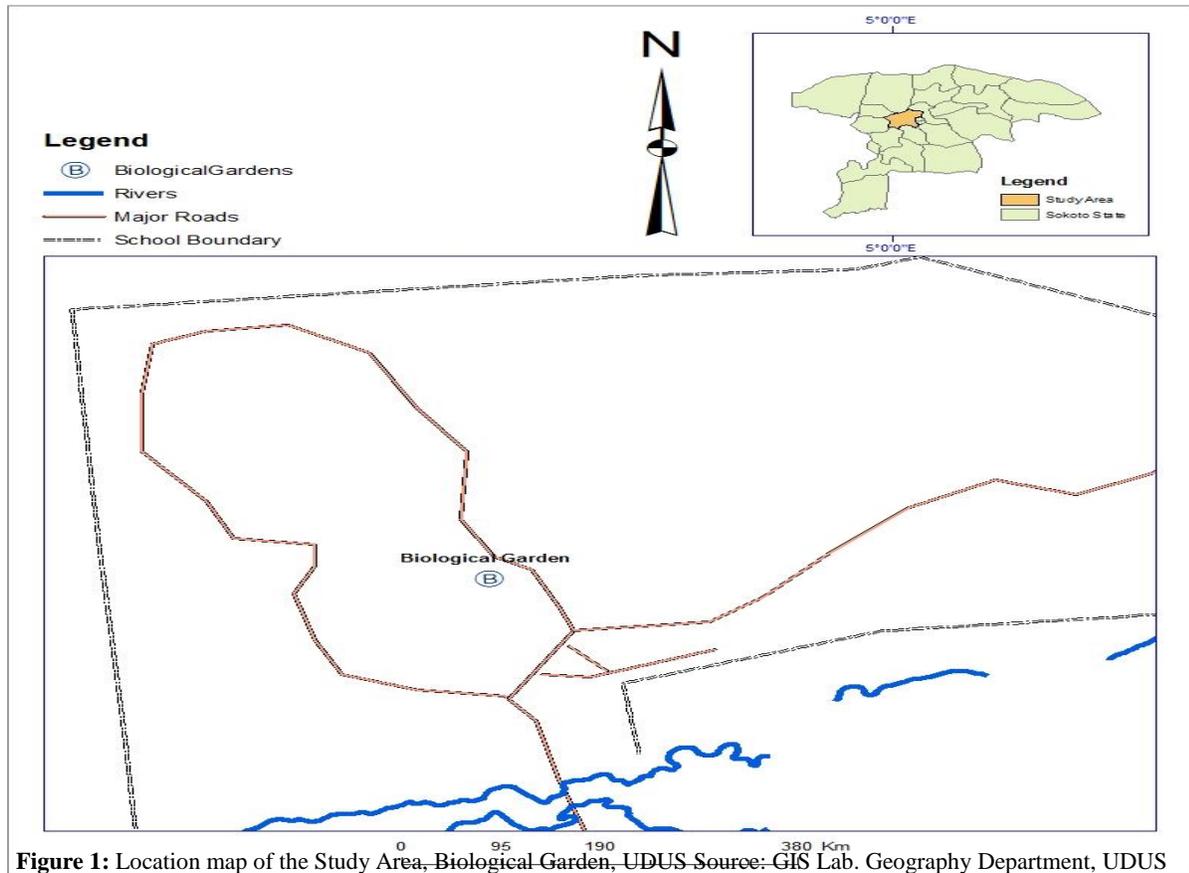


Figure 1: Location map of the Study Area, Biological Garden, UDUS Source: GIS Lab, Geography Department, UDUS

RESULTS

The textural characteristic of the soils prior to the cover cropping experiments was predominantly sandy with no significant difference ($P < 0.05$) between treatments in the physical and chemical properties except organic carbon and total nitrogen. Organic carbon was highest in 1:2 I/C (0.27%) and lowest in 2:1 I/C (0.07%) with significant difference ($P < 0.05$) between the two treatments. The other four treatments: DIC (0.11%), DCC (0.13%), SIC (0.19%) and SCC (0.12%) neither differ significantly ($P < 0.05$) from each other nor from 1:2 I/C and 2:1 I/C in organic carbon content. However, DIC had total N of 0.25 g kg^{-1} and differs significantly ($P < 0.05$) from SCC (0.05 g kg^{-1}) whereas DCC, SIC, 2:1 I/C and 1:2 I/C had 0.04 g kg^{-1} each. No significant difference ($P < 0.05$) was observed between the last five treatments (Tables 1 & 2). Results of soil analysis after the cover cropping experiments (Tables 3 & 4) have indicated significant variations ($P < 0.05$) in the soil properties due to the plant-soil interactions.

Soil Physical Properties

The result in Table 3 indicates higher sand proportions under SCC and 1:2 I/C with 88.97% and 89.07% respectively; least sand proportion of 86.43% under DIC; with intermediate proportions under DCC (88.23%), SIC (87.30%) and 2:1 I/C (87.10%). Clay proportions are higher under DIC (2.75%), DCC (3.08%), SIC (2.83%) and 2:1 I/C (2.67%); but lower under SCC (1.72%) and 1:2 I/C

(1.97%). There is no significant difference ($P < 0.05$) in the soil texture. Moisture content values of the soil are higher in DCC (2.25%) and 1:2 I/C (2.33%); moderate in SCC and 2:1 I/C, (1.83%) and low in DIC (1.25%) and SIC (1.33%). Bulk density of the soil is low with DIC having (1.95 g/cm^3), SIC (1.82 g/cm^3), SCC (1.85 g/cm^3), 2:1 I/C (1.79 g/cm^3), DIC and DCC (1.69 g/cm^3) and 1:2 I/C (1.72 g/cm^3). The treatment, 1:2 I/C had the highest mean particle density of 2.25 g/cm^3 closely followed by 2:1 I/C (2.24 g/cm^3); SCC (2.16 g/cm^3); SIC (2.10 g/cm^3) and DCC (2.22 g/cm^3), while DIC had a relatively low particle density of 1.89 g/cm^3 . Soil porosity is low in all treatments with DIC having 20.33% and is significantly ($P > 0.05$) higher than DCC (16.38%), SIC (17.60%), SCC (15.65%), 2:1 I/C (17.43%) and 1:2 I/C (15.08%). There is no significant difference ($P < 0.05$) within but between the highest, lowest and moderate proportions for each soil parameter.

Table 1: Physical properties of the soils before cover cropping with *Ipomoea asarifolia* and *Cynodon dactylon*

Treatment	Parameter							
	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	Bulk density	Particle density	Porosity (%)	Textural
DIC	89.70a	8.23a	2.07a	2.00a	1.75 a	2.17a	17.35a	Sand
DCC	89.03a	9.25a	2.17a	2.67a	1.77a	2.23a	17.28a	Sand
SIC	89.80a	8.13a	2.17a	2.42a	1.72a	2.20a	16.22a	Sand
SCC	88.70a	9.12a	2.25a	2.42a	1.75a	2.21a	16.95a	Sand
2:1 I/C	85.88a	8.45a	2.17a	1.58a	1.73a	2.17a	16.73a	Sand
1:2I/C	90.03a	7.90a	2.07a	1.67a	1.72a	2.19a	17.48a	Sand
SE±	0.41	0.39	0.12	0.57	0.03	0.01	0.60	
Significance	ns	ns	ns	Ns	Ns	ns	ns	

Values are expressed as mean ± standard error of means based on six replicates. Means in a column followed by same letter (s) are not significantly different (ns), * = significant (P < 0.05). DIC= dense Ipomoea cover; DCC= dense Cynodon cover; SIC= sparse Ipomoea cover; SCC= sparse Cynodon cover; 2:1 I/C ratio 2:1 Ipomoea cover and Cynodon cover respectively; 1:2 I/C= ratio 1:2 Ipomoea cover and Cynodon cover respectively.

Table 2: Chemical properties of the soils before cover cropping with *Ipomoea asarifolia* and *Cynodon dactylon*

Treatment	Parameter										
	Mean pH	Org C (%)	Org M (%)	TN (gkg ⁻¹)	Av P (mgkg ⁻¹)	Ca	Mg	K (cmolKg ⁻¹)		Na	CEC
DIC	6.15a	0.11ab	0.19a	0.05a	0.97a	0.39a	0.20a	0.84a	0.83a	0.83a	3.43a
DCC	6.18a	0.23ab	0.40a	0.04b	0.98a	0.31a	0.25a	0.81a	0.81a	0.81a	3.13a
SIC	6.05a	0.19ab	0.32a	0.04b	0.99a	0.36a	0.20a	0.92a	0.83a	0.83a	3.24a
SCC	6.18a	0.12ab	0.20a	0.05a	1.01a	0.44a	0.23a	0.84a	0.86a	0.86a	3.15a
2:1(I/C)	6.07a	0.07b	0.16a	0.04b	0.99a	0.41a	0.21a	0.99a	0.85a	0.85a	3.21a
2:1(C/I)	6.13a	0.27a	0.45a	0.04b	0.99a	0.31a	0.26a	0.94a	0.83a	0.83a	3.12a
SE±	0.190	0.050	0.090	0.003	0.025	0.045	0.023	0.027	0.034	0.034	0.155
Sig.	Ns	*	ns	*	ns	Ns	ns	ns	ns	ns	ns

Values are expressed as mean ± standard error of means based on six replicates. Means in a column followed by same letter(s) are not significantly different (ns), * = significant (P < 0.05). DIC = dense Ipomoea cover; DCC = dense Cynodon cover; SIC = sparse Ipomoea cover; SCC = sparse Cynodon cover; 2:1 I/C= ratio 2:1 Ipomoea and Cynodon cover respectively; 1:2 I/C= ratio 1:2 Ipomoea and Cynodon cover respectively. Org C = organic carbon; Org M = organic matter; TN = total nitrogen; Av P = available phosphorus

Soil Chemical Properties

The soil pH value of SIC (6.47) differed significantly ($P < 0.05$) from those of DIC (6.22), DCC (6.07), SCC (6.27) and 2:1 I/C (5.90) but do not differ significantly ($P < 0.05$) from that of 1:2 I/C (6.33). However, DIC does not differ significantly ($P < 0.05$) from DCC and 1:2 I/C, so also, DCC and 2:1 I/C. The 1:2 I/C and SCC had greater organic carbon contents of 0.29 and 0.27% respectively with no significant difference ($P < 0.05$) between the two treatments. The 2:1 I/C closely follows with 0.24% and DCC with 0.15% came third and differs significantly ($P < 0.05$) from the other five treatments. The DIC and SIC had relatively low organic carbon content of 0.09% each and differed significantly ($P < 0.05$) from the other four treatments. There was significant ($p > 0.05$) difference in the organic matter contents among the treatments with 1:2 I/C and SCC having the highest values of 0.55% and 0.47% respectively. While the lowest value of 0.17% was observed under DIC. Total N obtained shows that there was significant ($p > 0.05$) difference among the treatments. The highest values were obtained in treatments DIC (0.06 gkg^{-1}), DCC (0.05 gkg^{-1}), SIC (0.05 gkg^{-1}) and 2:1 I/C (0.05 gkg^{-1}), which were statistically at par; the least value (0.03 gkg^{-1}) was observed with 1:2 (I/C) treatment. Available P was higher under DIC (0.93 mgkg^{-1}), DCC (0.92 mgkg^{-1}), 2:1 I/C (0.93 mgkg^{-1}) and 1:2 I/C (0.88 mgkg^{-1}) with no significant difference ($P < 0.05$) between the four treatments. The SCC had moderate Av. P of 0.76 mgkg^{-1} , which is significantly ($P < 0.05$) different from those of SIC (0.56 mgkg^{-1}) and the first four treatments.

Calcium (cmolkg^{-1}) was highest under DIC (0.62), moderate under 2:1 I/C (0.46), 1:2 I/C (0.41) and SIC (0.35), low under DCC (0.26) and least under SCC (0.20) with significant difference ($P < 0.05$) found between DIC and the other five treatments. Similarly, SCC differs significantly ($P < 0.05$) from the other treatments except DCC. Magnesium is high under SIC (0.71 cmolkg^{-1}) and low under DIC (0.28 cmolkg^{-1}); DCC (0.23 cmolkg^{-1}); SCC (0.17 cmolkg^{-1}), 2:1 I/C (0.27 cmolkg^{-1}) and 1:2 I/C (0.19 cmolkg^{-1}) with no significant difference ($P < 0.05$) between the last five treatments. Potassium was greater under 1:2 I/C (1.09 cmolkg^{-1}) but not significantly different ($P < 0.05$) from DIC (1.00 cmolkg^{-1}) and 2:1 I/C (0.94 cmolkg^{-1}). The SIC having moderate potassium content of 0.90 cmolkg^{-1} was significantly ($P < 0.05$) different from the 1:2 I/C. The least are DCC and SCC having low potassium contents of 0.63 cmolkg^{-1} and 0.64 cmolkg^{-1} respectively. Sodium was higher in SCC (0.85 cmolkg^{-1}), DCC (0.82 cmolkg^{-1}), 1:2 I/C (0.77 cmolkg^{-1}) and moderate in 2:1 I/C (0.73 cmolkg^{-1}) and SIC (0.71 cmolkg^{-1}), with no significant difference ($P < 0.05$) between treatments. The CEC values were higher in 1:2 I/C (3.55 cmolkg^{-1}) and 2:1 I/C (3.45 cmolkg^{-1}), moderate in SIC and DIC (2.86

cmolkg^{-1} and 2.84 cmolkg^{-1} respectively) and low in DCC and SIC (2.76 cmolkg^{-1} and 2.53 cmolkg^{-1} respectively).

DISCUSSION

The soils of the study area prior to cover cropping experiments were predominantly sandy in texture (> 87% sand), moderately acidic (pH 6.13) in reaction and inherently low in available phosphorus (0.99 mgkg^{-1}), organic carbon (0.16%), organic matter (0.29%) and total nitrogen (0.04 g/kg) mainly due to poor vegetation cover. The relatively low sand, increased clay and silt proportions of DIC, SIC and 2:1 I/C obtained with the cover cropping had been attributed to high presence of *I. asarifolia* cover in these treatments. Presence of the Ipomoea cover in soil has been reported to effectively control soil erosion by preserving the rich top soil through its rich shoot network, which provides nearly complete ground cover Aliero and Anka, 2001; Mazza, 2006 and Abdullahi *et al.*, 2011). The prolonged maintenance of *I. asarifolia* cover in farmlands was reported to improve the textural characteristics of the soil due to accumulation of silt and clay in the Ipomoea inhabited soils (Abdullahi *et al.*, 2011). Clay content in soils had been reported to be instrumental in determining soil texture in addition to organic matter accumulation from plants litter (Miller and Donahue, 1992; Ogunwole *et al.*, 2010). The observed variation in plant density and species type between Ipomoea and Cynodon in this study may have affected the rate of water absorption by the plants, porosity level and infiltration rate of the soil. Similar result in Ogunwole *et al.* (2010) reported a decrease in soil moisture content due to increased photosynthetic and respiratory activities in a high population density of plants. In a related development, Adesoji *et al.* (2011) reported a reduction in soil bulk density due to incorporation of Lablab and soy bean and an increase in volumetric moisture content due to incorporation of Mucuna and Lablab.

The moderately acidic (5.90) to slightly acidic (6.47) pH in Ipomoea dominated cover, with Cynodon cover generally having lower pH values than Ipomoea in this study, differed slightly from the result of Abdullahi *et al.* (2011), who reported a slight decrease in soil pH at the vicinity of *I. asarifolia*. The result however agrees with Cuesta *et al.* (2011), who reported that ground cover cultivation under citrus tree canopy and inter-row spaces greatly influenced enzyme activity and raised the soil pH level. The raised organic carbon content in *C. dactylon* is due to its greater leaf material while its lower content in *I. asarifolia* is due to its higher proportion of stem material. Waziri and Aliero (2005) reported that organic carbon is retained in the leaves of plants after being obtained from the soil and atmosphere during the process of photosynthesis. Furthermore, Diack *et al.* (2000) explained that residues having a high proportion of leaf material may lose tremendous amount of mass, with little loss of cover because leaf material decomposes rapidly and is lighter compared to stem material.

Table 3: Soil physical properties after cover cropping with *Ipomoea asarifolia* and *Cynodon dactylon*

Treatment	Parameter							
	Sand %	Silt (%)	Clay (%)	Moisture (%)	Bulk density (g/cm ³)	Particle density (g/cm ³)	Porosity (%)	Textural class
DIC	86.43ab	20.52a	2.75a	1.25c	1.95a	1.89b	20.33a	Sand
DCC	88.23ab	9.50a	3.08a	2.25a	1.69d	2.22ab	16.38b	Sand
SIC	87.30ab	10.14a	2.83a	1.33c	1.82b	2.10ab	17.60b	Sand
SCC	88.97a	8.18a	1.72b	1.83b	1.85b	2.16ab	15.65b	Sand
2:1 I/C	87.10ab	8.88a	2.67a	1.83b	1.79bc	2.24ab	17.43b	Sand
1:2 I/C	89.07a	8.37a	1.97b	2.33a	1.72cd	2.25a	15.08b	Sand
SE±	0.52	0.39	0.16	0.12	0.03	0.05	0.72	
Significance	*	Ns	*	*	*	*	*	

Values are expressed as mean ± standard error of means based on six replicates. Means in a column followed by same letter(s) are not significantly different (ns), * = significant (P < 0.05). DIC = dense Ipomoea cover; DCC = dense Cynodon cover; SIC = sparse Ipomoea cover; SCC = sparse Cynodon cover; 2:1 I/C = ratio 2:1 Ipomoea and Cynodon cover respectively; 1:2 I/C = ratio 1:2 Ipomoea and Cynodon cover respectively. Org C = organic carbon; Org M = organic matter; TN = total nitrogen; Av P = available phosphorus

Table 4: Chemical properties of the soils after cover cropping with *Ipomoea asarifolia* and *Cynodon dactylon*

Treatment	Parameter									
	pH	Org C (g kg ⁻¹)	Org M (g kg ⁻¹)	TN (g kg ⁻¹)	Av P (mg/kg)	Ca	Mg	K	Na	CEC
DIC	6.22bc	0.09d	0.17d	0.06a	0.93a	0.62a	0.28b	1.00a	0.65c	2.84bc
DCC	6.07cd	0.15c	0.28b	0.05a	0.92a	0.26cd	0.23b	0.63c	0.82ab	2.76c
SIC	6.47a	0.09d	0.22c	0.05a	0.56c	0.35bc	0.71a	0.90b	0.71bc	2.86bc
SCC	6.27b	0.27a	0.47a	0.04b	0.76b	0.20d	0.17b	0.64c	0.85a	2.53c
2:1 I/C	5.90d	0.24b	0.23bc	0.05a	0.93a	0.46b	0.27b	0.94ab	0.73bc	3.45ab
1:2 I/C	6.33ab	0.29a	0.55a	0.03b	0.88a	0.41b	0.19b	1.09a	0.77ab	3.55a
SE±	0.110	0.020	0.040	0.003	0.02	0.04	0.052	0.043	0.033	0.182
Significance	*	*	*	*	*	*	*	*	*	*

Values are expressed as mean ± standard error of means based on six replicates. Means in a column followed by same letter(s) are not significantly different (ns), * = significant (P < 0.05). DIC = dense Ipomoea cover; DCC = dense Cynodon cover; SIC = sparse Ipomoea cover; SCC = sparse Cynodon cover; 2:1 (I/C) ratio 2:1 Ipomoea cover and Cynodon cover respectively; 1:2 (I/C) ratio 1:2 Ipomoea cover and Cynodon cover respectively. Org C = organic carbon; Org M = organic matter; TN = total nitrogen; Av P = available phosphorus

The greater N proportions in dense ground covered (DIC, SIC 2:1 I/C and DCC) and its lower proportions under sparse covered (SCC and 1:2 I/C) are due to shading. Possible mineralization of litter in the shaded portions may have added N to the soil. The total N values in this study are slightly higher than those reported in Malami *et al.* (2011). The lower values of total N under 1:2 I/C (0.03 mg/kg) and SCC (0.04 mg/kg) in this study resulted from the scanty vegetation cover which exposes the soil to volatilization, strong winds and run-off. Malami *et al.* (2011) attributed the low levels of nitrogen also to the low levels of phosphorus in the soil, availability of which has been found to increase the fixation of nitrogen in soil. The available P ranged of 0.56 to 0.93 mg/kg⁻¹ obtained in this study which averages 0.83 mg/kg⁻¹ indicates low available P in the soil based on Esu (1991) soil nutrient ratings. The greater proportions of the P obtained in DIC, 2:1 I/C and DCC ranging from 0.92 to 0.93 mg/kg⁻¹ relate to high population density of plants in the treatments. On the other hand, the low available P in SIC, SCC and 1:2 I/C (0.56 to 0.88 mg/kg⁻¹) are due to low population density of plants in the treatments. In a similar study, Malami *et al.* (2011) obtained high values of available P and attributed same to dense population of trees, which shed their leaves seasonally.

Sodium ions (Na⁺) obtained in this study, which ranges from 0.65 to 0.85⁻¹ are higher than that obtained in Malami *et al.* (2011) which ranged from 0.30 to 0.61 with a mean of 0.43 cmolkg⁻¹ but are generally lower than the control (0.81 to 0.86). This finding corroborates the work of Bantru (2007), which reported sodium to inhibit the absorption of calcium and magnesium into the plant system and also to disperse soil particles causing reduced water movement and accretion. By comparison with the standard, according to Landon (1991), that soils with exchangeable sodium level greater than 1.0 cmolkg⁻¹ are considered potentially sodic, the soils of the study area are therefore non-sodic. Calcium values are generally higher under thick plant cover, probably due to higher contribution of litter to the soil. Higher Mg²⁺ levels being restricted to *I. asarifolia*-dominated soils, may indicate the possible influence of the *Ipomoea* cover on Mg²⁺ content in the soil. Levels of Mg²⁺ obtained in this study ranges from 0.19 to 0.71 cmolkg⁻¹ with a mean value of 0.31 cmolkg⁻¹, which is higher than that of Malami *et al.* (2011). Based on Landon's (1991) grading that Mg levels of 0.5 cmolkg⁻¹ in soil are considered deficient in tropical environment, the Mg²⁺ levels in this study are deficient, except that under SIC, which is 0.7 cmolkg⁻¹.

Cation exchange capacity of soils in this study ranges from 2.53 to 3.55 cmol kg⁻¹ with a mean value of 3.00 cmolkg⁻¹ and are lower than the control which had 3.12 to 3.43 cmolkg⁻¹ with a mean value of 3.21 cmolkg⁻¹. Mixed cover cropping treatments of the two species, 2:1 I/C and 1:2 I/C

had 3.45 and 3.55 cmolkg⁻¹ respectively, and is slightly higher than the control value. The CEC obtained in this study is generally low according to Esu (1991) rating of <6 as low, 6-12 medium and >12 high. This may be due to low clay and organic matter contents of soil, which Sharu *et al.* (2013) observed are too low to have significant positive effect on the CEC.

CONCLUSION

Ipomoea asarifolia cover had been found to raise the soil pH level, total nitrogen content and exchangeable bases chiefly, Ca²⁺, Mg²⁺ and K⁺. It indicated strong association with increase in clay, silt and porosity. *Cynodon dactylon* cover lowered the soil pH, increased organic matter and moisture contents of the soil. Combined effects of the two cover crops have shown increased CEC and available P content in the soil. †. Based on the above findings, it could be concluded that the mixed cover cropping of *I. asarifolia* and *C. dactylon* will be more helpful in soil amelioration and fertility conservation through biomass accumulation and decomposition as indicated by the contribution of mineral nutrient contents under the two cover crop types.

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