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Original Research Article

Influence of herbaceous cover crops' interaction on soil physical properties in Nigeria's Sudan Savanna

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Influence of interaction between *Ipomoea asarifolia* L. (Desr.) and *Cynodon dactylon* (L.) Pers. on soil physical properties was investigated at Biological Garden, Usmanu Danfodiyo University Sokoto Nigeria. Soil samples (0-20 cm depth) were collected before and after the experiments and analyzed using appropriate field and laboratory techniques. The data obtained were subjected to statistical analysis using SAS statistical package (SAS, 2003). Results have shown improvement in soil texture from sand to loamy sand, with significant increase (P< 0.05) in silt (8.23 to 10.52%), clay (2.07 to 4.05%), porosity (19.40 to 28.50%) and particle density (2.17 to 2.24%) under *I. asarifolia* inhabited soil. Similar treatment with *C. dactylon* had also improved the soil texture from sand to loamy sand particularly under thick Cynodon cover, with significant increase (P< 0.05) in soil moisture content. Soil moisture content increased significantly (P< 0.05) (1.83 to 2.25%), along with particle density (2.17 to 2.24 mgkg^{-1}). Interaction of the soil particles with mineral nutrients in the soil and organic matter deposits from the two cover crops may have improved the soil physical properties including aggregate stability, aeration, infiltration and water holding capacity. Maintaining a mixture of the two cover crops between cropping seasons is therefore recommended in the study area for improvement of the soil properties and sustainable agricultural productivity.

Key words: Interaction, influence, herbaceous cover crops, soil physical properties, sudan savanna, Nigeria, *Ipomoea asarifolia, Cynodon dactylon*.

INTRODUCTION

Cover crops limit soil disturbance through erosion control and improvement of soil fertility, water infiltration and organic matter storage depending on the soil type, cropping system and prevailing climatic conditions (Holland, 2004). Organic matter interacts with mineral nutrients in the soil to improve its physical properties including aggregate stability, aeration, infiltration and water holding capacity.

Deliberate conversion of cropland to grassland through replacement of field crops with perennial cover crops such as alfalfa (*Medicago sativa* L.) significantly improved the soil physical properties by decreasing its bulk density along with pH and increasing its aggregate stability along with organic carbon and total nitrogen (Guo et al., 2010). Both legume and cereal cover crops play important role through addition of biomass by incorporation into the soil as green manure and conservation of soil moisture by providing surface mulch (Veentra et al., 2006).

Ipomoea asarifolia (Convolvulaceae) and *Cynodon dactylon* (Poaceae) are known for their great potential as cover crops. 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 favorable (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 (USDA, 2012). The ability to produce new shoots at the nodes of their stolons and rhizomes, give them the mechanical strength and firm attachment to the soil (Badejo et al., 2009).

The soils of the study area 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). This research was carried out to investigate the effect of different cropping patterns of *I. asarifolia* and *C. dactylon* on the soil physical properties.

MATERIALS AND METHODS

The study Area:

The Biological Garden at the Main Campus of Usmanu Danfodiyo University Sokoto (UDUS) is on Latitudes 11° 30'N and 14° 00'N, Longitudes 4° 00'E and 6° 40'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 area has been described as young, lacking horizon development and is classified as Entisol (Noma and Yakubu, 2012).

Seed Procurement

Plant Propagation and Soil Sampling:

Seeds of *C. dactylon* were purchased from the National Animal Farm Research Institute (NAFRI), Shika-Zaria in Kaduna State, Nigeria. *I. asarifolia* seeds were collected locally from surrounding farm areas and road-side vegetation in the main Campus of Usmanu Danfodiyo University Sokoto in May, 2011. Five (5) kilograms each of the seed types were obtained. Seed weight was determined by putting additional quantities of seed in a pre-weighed container placed on a weighing balance, until the desired weight was obtained of each seed type. The seeds were germinated in nursery bed/donor site and allowed to grow into seedlings for a period of two months, from June to August, 2011.

The established cover crops were propagated by transplanting of seedlings obtained from the pre-established donor site in accordance with Rice and Rice (2006). The experiments comprised of six treatments laid out in randomized complete block design (RCBD) with six replications. The treatments were Dense ipomoea cover (DIC); dense cynodon cover (DCC); sparse ipomoea cover (SIC); sparse cynodon cover (SCC); row ratio 2:1 Ipomoea/Cynodon cover respectively (2:1 I/C); row ratio 2/1 Cynodon/Ipomoea cover respectively (1:2 I/C designated as A, B, C, D, ,E and F respectively. No fertilizer (organic or inorganic) was added. Soil samples within 20 cm depth were collected from each treatment plot using soil auger. Soil collection was done before and after the field trials, which covered a period of 26 months from June, 2011 to July, 2013, including the two months nursery activities. Pre-trial samples were taken on Wednesday, 6th July, 2011 from the prepared transplant site. Post-trial samples were collected from the 6 various treatments on Saturday, 13th July 2013 after all field experiments were completed. The soil samples were subjected to analysis in the laboratory to determine the following parameters:-

Soil Particle Size Analysis

Hydrometer method as outlined in Sheldrick and Wang (1993) was used to determine particle size distribution (sand, silt, and clay) and individual particles size proportions were calculated for each treatment.

Soil Density and Porosity Analysis

Soil density (particle and bulk) were determined by the core method of Blake and Hartge (1986). Individual densities and total porosity were calculated using the expressions in Lal and Shukla (2004).

Moisture Content Analysis

Gravimetric technique as outlined in Klute (1986) was used to analyze moisture content of the soil samples and percentage moisture content was determined accordingly.

Data Analysis

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

RESULTS

Pre-trial soil analysis

Textural class of the soil prior to establishment of the cover crops was predominantly sandy with no significant difference ($P > 0.05$) between treatments in the physical properties (Tables 1).

Post-trial Soil Analysis

Results of soil analysis after establishment of the vegetation cover indicated significant ($P < 0.05$) variation between treatments in all the soil physical properties except silt content as follows:-

Soil Physical Properties

Significantly ($P < 0.05$) high sand proportions obtained under SCC and 1:2 I/C were 88.97% and 89.07%

Table 1. Physical Properties of the Soil Medium before the Field Trial with *I. asarifolia* and *C. dactylon*

Treatments	Parameters							
	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	Bulk density (g/cm³)	Particle density(g/cm³)	Porosity (%)	Textural class
A	89.70a	8.23a	2.07a	2.00a	1.75 a	2.17a	19.40a	Sand
B	89.03a	9.25a	2.17a	2.67a	1.77a	2.23a	21.70a	Sand
C	89.40a	8.13a	2.12a	2.42a	1.72a	2.20a	21.80a	Sand
D	88.63a	9.12a	2.25a	2.42a	1.75a	2.21a	20.80a	Sand
E	89.38a	8.45a	2.17a	1.58a	1.73a	2.17a	20.30a	Sand
F	90.03a	7.90a	2.07a	1.67a	1.72a	2.19a	21.40a	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). A represents DIC = dense Ipomoea cover; B represents DCC = dense Cynodon cover; C represents SIC = sparse Ipomoea cover; D represents SCC = represents sparse Cynodon cover; E represents 2:1 I/C = ratio 2:1 Ipomoea and Cynodon cover respectively: and, F represents 1:2 I/C= ratio 1:2 Ipomoea and Cynodon cover respectively.

respectively. The lowest sand proportion of 85.43% was recorded under DIC, which however is not significantly (P> 0.05) different from the first two treatments. The other treatments, DCC (87.42%), SIC (87.03%) and 2:1 I/C (87.10%) are also not significantly (P> 0.05) different from each other.

The four treatments with significantly (P< 0.05) higher clay contents both had their textural class improved from sand to loamy sand i. e. DIC (4.05%), DCC (3.08%), SIC (2.83%) and 2:1 I/C (2.67%). The other two treatments, SCC (2.85) and 1:2 I/C (1.97%), having significantly (P< 0.05) low clay content each retained their original sandy texture. There is no significant (P> 0.05) difference in silt content despite variations in values across the treatments.

Moisture content of the soil was generally below the requirement for optimum growth and productivity of mineral soils. Values obtained are however relatively higher in DCC (2.25%) and 1:2 I/C (2.33%); moderate in SCC and 2:1 I/C, having 1.83% each and low in DIC (1.25%) and SIC (1.33%).

Bulk density is relatively low with DIC having the highest value of 1.95 g/cm³, which differ significantly (P< 0.05) from the other five treatments. But SIC (1.82 g/cm³), SCC (1.85 g/cm³) and 2:1 I/C (1.79 g/cm³) are not significantly (P> 0.05) different. Similarly, DIC and DCC, having 1.69 g/cm³ are not significantly (P> 0.05) different from 1:2 I/C, which had 1.72 g/cm³.

The highest mean particle density of 2.25 g/cm³ was obtained in 1:2 I/C and is not significantly (P> 0.05) different from 2:1 I/C (2.24 g/cm³); SCC (2.16 g/cm³); SIC (2.10 g/cm³) and DCC (2.89 g/cm³). But DIC shows relatively high particle density of 2.24 g/cm³, which is not significantly (P > 0.05) different from 1:2 I/C.

Low soil porosity was generally observed in all treatments with DIC having 28.50%. This value is significantly (P< 0.05) higher than those of the other five treatments i. e. DCC (22.90%), SIC (13.30%), SCC (14.80%), 2:1 I/C (20.10%) and 1:2 I/C (23.60%) (Table 2).

DISCUSSION

The initial (pre-trial) analysis revealed that soil of the study area was predominantly sandy (> 88% sand) in texture with no significant difference (P> 0.05) in the other soil physical properties i. e. particle density, bulk density, porosity, moisture content and primary soil particles: sand, silt and clay proportions. The significant (P< 0.05) decrease in sand and increase in clay proportions coupled with high though not significant increase in silt in *I. asarifolia* inhabited soil are attributable to its thick vegetation cover. Presence of the Ipomoea cover in soil has been reported in several researches (Aliero and Anka, 2001; Mazza, 2006 and Abdullahi et al., 2011) to provide effective protection against erosion due to the binding ability of the rhizoids in the root system, in addition to its firmly rooted shoot networks, which are not easily displaced by the forces of wind and water erosion.

The improvement in textural class of the soil under *I. asarifolia* and dense *C. dactylon* cover from sand to loamy sand is attributable to the cover thickness and perennial nature of the two species, which trap clay and silt particles along with the water and wind-transported sediments. This agrees with the result of Abdullahi et al. (2011), who reported high

Table 2. Physical Properties of the Soil Medium as Influenced by *I. asarifolia* and *C. dactylon*

Treatments	Parameter							
	Sand %	Silt (%)	Clay (%)	Moisture (%)	Bulk density (g/cm³)	Particle density (g/cm³)	Porosity (%)	Textural class
DIC	85.43b	10.52a	4.05a	1.25c	1.60d	2.24ab	28.50a	Loamy sand
DCC	87.42ab	9.50b	3.08a	2.25a	1.69d	2.89a	22.90b	Loamy sand
SIC	87.03ab	10.14b	2.83a	1.33c	1.82b	2.10ab	13.30b	Loamy sand
SCC	88.97a	8.l8b	2.85b	1.83b	1.85b	2.16ab	14.80b	Sand
2:1 I/C	87.10ab	10.23b	2.67a	1.83b	1.79bc	2.24ab	20.10b	Loamy sand
1:2 I/C	89.07a	8.96b	1.97b	2.33a	1.72cd	2.25a	23.60b	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.

proportions of silt and clay contents in *I. asarifolia* inhabited soils in the same study area and further recommended long term maintenance of the Ipomoea cover for improvement the soil texture. Increase in clay content of soils had been identified in Miller and Donahue (1992) and Ogunwole et al. (2010) to be instrumental in determining soil texture in addition to organic matter accumulation from plants litter.

Relatively high though not statistically significant (P> 0.05) porosity coupled with low moisture content were obtained in DIC. On the other hand, high particle density and moisture content coupled with low bulk density and porosity were recorded in 1:2 I/C. This finding is attributable to variation in the two plant species and density of their vegetation cover, which affected rate of water absorption from the soil and in turn influenced porosity level and consequently, 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 study, Adesoji et al. (2011) observed no significant influence (P> 0.05) in soil bulk density and volumetric moisture content in a sparsely grown wheat crop, but later reported a reduction in the bulk density due to incorporation of Lablab and soy bean and an increase in volumetric moisture content due to incorporation of Mucuna and Lablab.

Conclusion

Maintenance of *I. asarifolia* and thick *C. dactylon* cover crops for two consecutive years (24 months) on the soil significantly improved the soil texture from sand to loamy sand due to addition of clay and silt usually trapped within the thick vegetation cover. The significant increase (P< 0.05) in clay and decrease in sand contents under the Ipomoea cover have helped to raise the particle density and porosity all of which could be related to organic matter addition in the dense Ipomoea cover. Dense *C. dactylon* cover had also improved the soil texture from sand to loamy sand due to possible increase in organic matter content from the addition of leaf litter which decomposes rapidly in the soil. Particle density and moisture content of the soil have significantly increased under *C. dactylon* cover. Based on the findings of this study, it is concluded that a combination of the two cover crops is desirable for improvement of the soil physical properties and hence the sustainability of biomass production in the two cover crops.

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Conflict of interests

The authors declare that they have no conflicting interests

REFERENCES

Abdullahi AA, Ibrahim SA, Yusuf S, Audu M, Abdu N, Noma SS and Shuaibu H (2011) *Ipomea asarifolia* (Desr). A potential cover crop for Soil Fertility Improvement In the Sudan Savanna Region, Nigeria. Nigerian J. Bas. Appl. Sci., 19 (1): 155-161.

Aliero BL, Anka SA (2001). Biological Soil Conservation A Field Guide. The University press Ltd. Usmanu Danfodiyo University, Sokoto pp 46-54.

Badejo BY, Ojo AR, Hamzat OS, Duru HI, Jayeola HI (2009). Environmental protection: The Role of Forestry. Proceedings of the Fourth International Conference on Sustainable Development IRDI, Uyo, Nigeria, 4 (1): 64 -70.

Blake GR, and Hartge KH (1986). Bulk density P. 363-375. In: A. Klute et al. (ed) Methods of soil analysis part 1: Physical and Mineralogical Methods. Monograph Number 9 (second edition). ASA, Madison, WI Available at:

http://groups.ucanr.org/danranlab/soil/analysis/ Accessed: June 18, 2010.

FAO (1999). World Reference Base for Soil Resources. Rep. Vol. 84. Food and Agricultural Organisation of the United Nations, Rome, 161p.

Guo ZB, Yan G, Zhang R, Li F, Zeng Z, Liu H (2010) Improvement of soil properties and aggregate Associated C, N, and P After cropland was converted grassland in semiarid Loess Plateau. Soil Science 175 (2): 99-104.

Holland JM (2004). The environmental consequences of adopting conservation tillage in Europe: Reviewing the evidence. Agr Ecosys Environ. 2004. 103:25.

Klute A (1986). Water retention: Laboratory methods. Pp. 635 - 662. In: A Klute (ed.) Methods of soil analysis part I. Physical and mineralogical methods. ASA Monograph No. 9. available at http://groups.ucanr.org/danranlab/soilanalysis/ Accessed: June 18, 2010.

Lal R, Shukla MK (2004). Principles of Soil Physics. Marcel Dekker Inc., New York. pp. 149-161.

Mazza C (2006). Cranell gardening resources using organic matter in the garden, http://www.gardening.cranell.edu/factsheets (Accessed 22/05/2015).

Miller RW, Donahue RLK (1992). An introduction to Soils and Plant growth 6th ed. Prentice – hall inc., New York Pp 50-52, 102-103, 124-128

Noma SS, Yakubu M (2002). Classification and Properties of Soils in the Main Campus of Usmanu Danfodiyo University, Sokoto - Nigeria. J. Agric. Environ. 3 (1): 155-166.

Ogunwole JO, Iwuafor ENO, Eche NM, Diels J (2010). Effect of organic and inorganic soil amendments on soil physical and chemical properties in a West African Savanna Agroecosystem. Tropical and Subtropical Agroecosystems, 12: 247-255.

Pieri C (1992). Fertility of soils. A future for Farming in West African Savanna. SpringerVerlag. Berlin Heidelberg, New York, 15p.

Purseglobe JW (1992). Tropical Crops: Monocotyledons. Longman Scientific and Technical Ltd., London, 126p.

Rice LW, Rice RP (2006). Practical Horticulture 6th ed. Pearson, Prentice Hall, New Jersey, Pp 65-75

SAS (2003). Statistical Analysis System (SAS/STAT), Institute Inc. Guide for Personal Computers, 6th edition, Carry N.C., USA. pp. 967-978.

SERC (Sokoto Energy Research Centre, Usmanu Danfodiyo University, Sokoto) (2015). Climatological Summary of Sokoto from 2011 to 2014.

Shieldrick BH, Wang C (1993). Particle - size Distribution. Pp. 499 - 51l. In: Carter, M. R. (ed.) Soil Sampling and Methods of Analysis Canadian Society of Soil Science, Lewis publishers, Ann Arbar, MI.

Sokal RR , Rolf FJ (1995). Biometry: The principles and practice of statistics in Biological Research, 3rd Edn., W. H. Freeman and Co., New York, 887pp.

USDA (2012). A plant profile of Ipomoea asarifolia from the USDA plant Database. Retrieved 29/06/2013 from plants.usda.gov/java/profile%3Fsymb.

Veentra JJ, Horwoth WR, Mitchell JP, Munk DS (2006). Conservation tillage and cover cropping influence soil properties in San Jaoquin Valley cotton-tomato crop. California Agriculture 60 (3): 146-153.