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INFLUENCE OF UREA AND SHEEP-DROPPINGS ON SOIL pH CHANGES IN SANDY LOAM SOILSOF YOLA, NORTH EASTERN, NIGERIA

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ABSTRACT
Anexperiment was conducted to assess the influence of urea and sheep dropping applications on soil pH changes in sandy loam soils of Yola, North Eastern Nigeria. The experimental layout was completely randomized design (CRD) with three main factors. The factors werehalf of recommended rate (50%),full recommended rate (100%) and one and half (150%) recommended rate. The treatments were urea, sheep droppings and combination of urea and sheep droppings.The experiment was replicated three times giving a total of 36 pots. The soils texture was sandy loam, bulk density was below the critical value. The soil was slightly acidic, electrical conductivity was low. The soil had low organic matter and total N, and medium available P levels. Exchangeable Ca was low, Mg and Na were medium and exchangeable K was high. The fertility status of the soils was rated low to medium and could only produce moderate to low yield for most crops. Application of urea, sheep droppings and their combination at half (50%) of the recommended rate, recorded highest pH of 7.40 at 6th week of the experiment on pots amended with 25 urea ha^{-1} + 2.5 tons SD ha^{-1}. Application of the recommended rate (100%), recorded highest pH value of 7.55 at first week of the experiment on pots amended with 10 tons PD ha^{-1}, while application of one and half (150%) of the recommended rate, recorded highest pH value of 7.85 at 3rd week due to application of PD at the rate of 15 tons ha^{-1}. On the overall the application of SD increased pH from slightly acidic to neutral due to application of 5 tons (50%) and 10 tons (100%) of the recommended rate, while the pH values changed from slightly acidic to slightly alkaline on pots amended with SD at 15 tonsha^{-1} (150%) of the recommended rate. Based on the results, application of 10 tons SD ha^{-1} could be recommended for amelioration of soil acidity in sandy loam soils of Yola, North Eastern, Nigeria. Field experiment could also be recommended to ascertain the result obtained.
Key words: urea, sheep droppings, sandy loam soils

INRODUCTION
Soils in the Nigerian Savannah agro-ecological zones are highly weathered and fragile with low activity clays. The soils are predominantly sandy in texture, low organic matter content, poor water-holding capacity, low nutrient availability as well as buffering capacity (Odunze, 2006). Due to the nature of soil, nutrient depletion is not only commonbut also constitute a serious constraints to sustainable crop production (Shehu*et al*. 2015). Low pH and lack of appropriate soil fertility restoration practiceshas also been reported as some of factors that leads to low crop yield in the area (FMARD, 2022).

Soil pH influence nutrients availability, controls biological processes and serves as important parameter for amelioration of problem soils (Jackson and Meetei, 2018). Generally, soil pH is affected by the mineral composition of soil parent material, heavy rainfall,and application of nitrogenous fertilizers (Halilu, *et al*., 2023).Application of urea and sheep droppings has been reported to increase crop production in Nigeria and many parts of world (Waniyo, *et al*., 2013; Ahmet, 2019). The increase in crop yield due to fertilizer application is expected to have positive impact on food production and improvement of livelihood among local farmers (Usman and Kundiri, 2016; Sajid*et al*., 2016; Mbabah*et. al*., 2024).

In addition tosupply of essential nutrients andincrease in crop yield, application of urea and sheep droppings could affect soil pH and availability of some nutrients.Lungu, and Dynoodt, (2008), conducted experiment on the effects of urea application on soil pH and reported that applications of urea resulted in decrease of soil pH,particularly on plots with higher application rates of urea. Decrease inexchangeable Ca and Mg was also observed on the plots treated with urea. This indicates that continuous application of urea could have a negative impact on soil pH and nutrients availability.

On the other hand, application of animal manures couldincrease soil pH of an

acid soil together with reduction in exchangeable acidity (Ano and Ubochi, 2007), This is an indication that application of urea and organic fertilizers could not only supply essential nutrients but also ameliorates extreme soil pH and moderates other soil properties (Tosin and Jamal, 2012). Thus, this experiment was conducted to assess the effects of urea and sheep droppings on soil pH variations in sandy loam soils of Yola, North East, Nigeria.

MATERIALS AND METHODS

Study Area

The experiment was conducted in the Department of Soil Science Faculty of Agriculture ModibboAdama University Yola, Adamawa State, Nigeria. It is located on longitude 9.35^0 N and latitude 12.5^0E. Mean annual rainfall of the study ranges between 700 to 1000mm, while annual temperature ranges from 15.2 – 39ºC. Relative humidity varies seasonally in the state. It is extremely low (20 – 30 %) between January and March. It starts increasing as from April and reaches its peak (above 70 %) in August and September (Adebayo *et. al.,* 2020).

The area is characterized by high grassland with many shrubs and few trees. Common grasses in the study area include: *Cassia ssp.*, *Chloris pilosa*,and*Tridaxprecumbens.* The soil in the study is deep, sandy loam on the surface and sandy clay loam in the sub-surface. The colour of the soil is yellowish brown and poorly drained. The pH is slightly acidic (6.5 – 6.9) with low organic carbon, total N, available P and CEC but medium in ESP and PBS. The soil of the area was classified as Alfisols and Inceptisols (Musa*et al*., 2007). The geological formation of the soil consists of sandstone, shales with thin limestone at some places (Musa *et al*., 2007).

EXPERIMENTAL LAYOUT

The experiment design was completely randomised design (CRD) which consisted of three main factors andthree treatments and control. The three main factors were (50%) of recommended rate, full dose of recommended rate (100%)andone and half dose (150%) of recommended. For urea, the treatments were:(T_1) = 50kg, T_2 = 100kg and T_3 = 150kg urea ha^{-1}. For SD, the treatments are: T_1 = 5 tons, T_2 = 10tons and T_3 = 15 tons SD ha^{-1}. While for F_3,the treatments were: T_1 = 25kg urea ha^{-1} + 2.5 tons SD ha^{-1}, T_2 = 50kg urea ha^{-1} + 5 tons SD ha^{-1} and T_3 = 75kg urea ha^{-1} + 7.5tons SD ha^{-1}. The experiment was replicated three times with the total of 36 pots containing 20kg soil per each pot.

SOIL SAMPLING AND ANALYSIS

Soil samples were taken from all the pots prepared and stored for physical and chemical analysis. Soil texture was determined by the Bouyoucos hydrometer method. Soil pH was measured using pH meter in a 1:2.5 soil-water suspension. Organic carbon and total nitrogen were determined by Walkey-Black oxidation and Micro-Kjeldahl distillation methods respectively. Available P was determined by Bray 1 method. Exchangeable cations were analysed using EDTA (diethylene triaminepenta acetic acid) titrimetric method (FAO, 2020).

RESULTS AND DISCUSSIONS

Soil Physical Properties

Physical properties for soil of the study area is presented in Table 1, the result indicates that sand particleswas dominantamong the soil separates which had the mean of 67.80%. The sand particles recorded, is lower than 87.83% earlier reported for the soils of the area (Tahir, *et al*., 2022), though is similar with other reports within northern savannah region of Nigeria(Abdulrashid, *et al*., 2024). The silt was generally low (mean = 9.87 %).The clay content was medium (mean = 22.33 %) and within the range of 2.8 to 30.2 % earlier reported by Bapetel *et al*. (2024) for soils of Boramjifloodplain. The soil textural class was predominantly sandy loam, while the bulk density of the soil was lower than the critical value of 1.65g cm^{-3}but within limit for soils of the region (Ezeaku, *et al*., 2022).The soilporosity is relatively high indicating the predominance of macro-pores which is a typical characteristic of savannah sandy soils of Nigeria (Moberg, and Esu, 1991).

Table 1: Physical Properties of Soil Used In the Experiment.

Sample	Sand (%)	Silt (%)	Clay (%)	Textural Classes	B.D. (%)	P.D. (%)	Porosity (%)	WHC (%)
T_1	71.2	8.8	20.0	SL	1.47	2.66	44.74	22.93
T_2	62.0	9.0	29.0	SCL	1.39	2.67	47.94	32.52
T_3	70.2	11.8	18.0	SL	1.48	2.65	44.15	23.59
Mean	67.80	9.87	22.33		1.45	2.66	4.5.61	26.35

Chemical Properties

The soil chemical properties presented in Table 2 indicates that the soil pH of the study area was 6.37 (mean) and rated as slightly acidic (Usman, 2005) and is higher than the mean of 5.7 reported for soils of BoramjiBenue River floodplain (Bapetel*et al*., 2024), thoughthe pHobserved in thisstudy is within the rangereported for some soils of Northern savannah region (Jimoh, *et al*., 2016).Slightly acidicsoil pH couldnot affect nutrient availabilitysince most of the nutrients are released when the soil pH is slightly acidic toneutral in reaction(Jackson, and Meetei, 2018).Electrical conductivity, organic matter and total nitrogen were low, though similar to what was earlier reported (Tahir *et al*., 2022). Available phosphorus was mediumwhich recordeda mean of 13.33 mg kg^{-1},but is higher than the mean of 5.80mg kg^{-1} earlier reported for Geriyofloodplain (Bapetel, *et al*., 2021).Higher available P recorded could be attributed to the depositionof silt along with dissolved particles of P when flood waterhavereceded (Tahir *et. al*., 2006).

The exchangeable Ca of the soil in the area was low (4.61 cmol (+) kg^{-1}), exchangeable Mg was medium (2.34cmol (+) kg^{-1}), similarly exchangeable Na was also medium (0.52cmol (+) kg^{-1}),while exchangeable K was high (0.64cmol (+) kg^{-1}) based on the ratings of Usman (2005) for soils of Adamawa State. The amount of the exchangeable bases is similarly to what was reported for the soils of the area (Alpha *et al*., 2011).The soils also had low exchangeable acidity and high base saturationbut is similar with was earlier reportedby Moberg and Esu, (1991). With low organic matter content, total nitrogen and exchangeable bases,soil fertility status for the soils could be rated as low and it agrees with earlier results for the study area (Bapetel *et al*., 2024). Soils with low fertility status could only the support low yield and therefore require fertilizer application for sustainable cultivation of crops
.

Table 2: Chemical Properties for Soil of the Study Area.

Sample	pH (1:2.5)	EC (dS m^{-1})	OC	OM	TN	AvP (mg kg^{-1})	Ca	Mg	Na	K	TEB	TEA	ECEC	PBS
							Cmol kg^{-1}							(%)
T_1	6.27	0.15	1.08	1.86	0.11	13.51	4.61	2.11	0.41	0.621	7.751	2.25	10.00	77.50
T_2	6.48	0.19	0.92	1.58	0.09	11.21	5.11	2.01	0.62	0.632	8.372	1.98	10.35	80.87
T_3	6.36	0.21	0.81	1.39	0.08	15.28	4.11	2.89	0.53	0.67	8.20	2.31	10.51	78.02
Mean	6.37	0.18	0.94	1.61	0.09	13.33	4.61	2.34	0.52	0.64	8.11	2.18	10.29	78.80

EC = Electrical conductivity, OC = Organic carbon, OM = Organic matter, TN = Total nitrogen, Av P = Available phosphorus, Ca = Calcium, Mg = Magnesium, K = Potassium Na = Sodium, TEB = Total exchangeable bases, TEA = Total exchangeable acidity, ECEC = Effective cation exchange capacity, PBS = Percentage base saturation

Half (50%)of the Recommended Rates of Urea and Sheep droppings (SD)

Effects of the application of half dose (50%) of the recommended rates of urea and poultry droppings on soil pH(Table 3) indicated that there were significant effects among the treatments exceptat $2^{nd}$and 4^{th}weeks after application. During the first week of the experiment, highest pH of 6.26 was recorded on pot amended with 5 tonsha^{-1} of sheep droppings (SD), at second week, highest pH of 6.25 was recorded on pots amended with urea and SD at the rates of 25kg and 2.5tons ha^{-1} were applied. For week three,application of5 tons SDha^{-1} gave the highest pH of 7.21.At 5^{th} week of the experiment, highest pH of 6.43 was recorded on pots amended with 5 tons SDha^{-1}, while at the 6^{th} week highest pH of 7.40 was recorded on pots where 25kg urea and 2.5tons SD ha^{-1} were applied.

Highest pH value of 7.40 was recorded on pots amended with 25kg urea + 2.5tons SD ha^{-1},followed by pH of 7.21 recorded at the third week of the experiment on pots amended with 5 tons SD ha^{-1} (Table 3). The highest pH of 7.40 recorded is within the neutral range (Usman, 2005)but is higher than what was reportedfor the soils of the region (Halilu*et al*., 2023). The result indicates that the soil pH changedfrom slightly acidic on the control plots to neutral with the application of SD alone as well as combined application of urea and SD.The observation agrees with what was earlier reported byAno and Ubochi (2007). Neutral soil pH is more conducive for maximum nutrient release and availability, which alsofavours increased microbial activities along with release of nutrients embedded in organic substances (Jackson and Meetei, 2018).

Table 3: Changes of Soil pH due to 50% below the Application rates of Urea and Sheep Droppings

TRT/Weeks	W1	W2	W3	W4	W5	W6
Control	5.41_c	5.84^a	6.61^b	6.20^a	5.66^d	6.30^b
50 kg urea ha^{-1}	5.78^b	6.20^a	6.28^c	6.25^a	6.43^a	5.65^b
5 tons SD ha^{-1}	6.26^a	5.75^a	7.21^a	6.20^a	5.91^c	5.67^b
25 kg urea ha^{-1} + 2.5 tons SD ha^{-1}	6.20^a	6.25^a	6.32^c	6.33^a	6.22^b	7.40^a
SE	0.13	0.55	0.066	0.58	0.049	0.45

TRT = Treatment, WK1 ….WK6 = week 1 to week 6, SE = Standard error, SD = Sheep droppings

Full (100%) of the Recommended Rates of Urea and Sheep droppings (SD)

Effects of the application of recommended rates (100%) of urea, SD and their combination is presented in Table 4. The results indicated that there were significant effects of the application throughout the six weeks of the experiment. For the first week, highest pH value of 7.55 was recorded on pots amended with 10 tons SD ha^{-1}, at second week highest pH of 7.45 was recorded on pots that received combined applications of urea and SD at the rates of 50kg urea + 5tons SD ha^{-1}.At three weeks, there was a slightdecrease in soil pH, with the highest of 6.33 recorded on pots amended with 10 tons SD ha^{-1}, at 4^{th}week of the experiment, highest pH of 7.15 was also recorded on pots amended with 10 tons SD ha^{-1}. General decrease in soil pH at 5^{th} and 6^{th} weeks of the experiment were observed,with the highestpH values of 6.34 and 6.45recorded on pots amended with 10 tons SD ha^{-1}.

Overall highest pH recorded during the first week of experiment in pots amended with10 tons SD ha^{-1} is within the neutral range,though higher than what was earlier reported for study area and other areas within savannah agro-ecological zone (Shehu*et al*., 2015; Tahir *et al*., 2022; Ezeaku, *et al*., 2022). Highest pH value recorded during the first week of the experiment could be attributed to the increase in pH due to nutrient released from product of decomposition of sheep droppings. Alexandra and Jose(2015) reported that when organic amendments decomposed,they are converted into CO_2 and humus with a simultaneous release of nutrientsthat could increase the soil pH. According toAno, and Ubochi (2007),animal manures significantly increased soil pH from 4.6 to 5.6. These are good indications that application of urea and organic fertilizers could not only supply essential nutrients, but also ameliorates extreme soil pH and moderates other soil properties such as water-holding capacity(Tosin and Jamal, 2012).

Table 4: Changes in Soil pH due to Application of the Recommended Rate of Urea and Sheep Droppings

TRT/Weeks	W1	W2	W3	W4	W5	W6
Control	5.41^d	5.41^b	5.61^a	5.20^a	5.66^b	5.30^a
100kg/ha Urea	5.65^c	6.22^{ab}	6.33^b	6.30^a	5.66^b	6.20^{ab}
10 tons/ha SD	7.55^a	5.60^b	6.28^b	7.15^a	6.34^a	6.45^a
50kg/ha U+5tons/ha SD	6.21^b	7.45^a	6.26^b	6.20^a	5.37^c	5.92^b
SE	0.082	0.628	0.059	0.585	0.067	0.153

TRT = Treatment, WK1 ….WK6 = week 1 to week 6, SE = Standard error, SD = Sheep droppings

One and Half (150%) of the Recommended Rates of Urea and Sheep droppings (SD)

Effects of the application one and half recommended rates for Urea, SD and their combinations ispresented in Table 5. There were significant effects of the application except at 4thweek of experiment where no significant effect was recorded. At first week, highest pH of 5.91 was recorded due to application of 15 tons SD ha^{-1}. At second week, application of both 150 kg urea and 15tons SDha^{-1} gave the highest pH of 5.90. At the third week of the experiment, highest pH of 7.85 was recorded on pots where 15 tons SD ha^{-1} was applied. Similarly, the highest pH of 6.27 was recorded at 5th week with the application of 15 tons SD ha^{-1}, while highestpH of 6.33 was recorded at6th week of the experiment on pots where combined applications of urea and SD at the rate of 75kg urea ha^{-1} + 7.5 tons SD ha^{-1}were made. Highest pH value of 7.85 recorded at the third week of the experiment is slightly alkaline in reaction based on ratings for the soils of the area (Usman, 2005). Alkaline soil pH could benefit microbial activities and availability of some essential nutrients, but it could have some detrimental effects on the availability of micronutrients(Jackson and Meetei, 2018; Israel and Mira. 2021).

Table: 5 Changes in Soil pH due to the Application of 150% above the Recommended Rate of Urea and Sheep Droppings

TRT/Weeks	W1	W2	W3	W4	W5	W6
Control	5.41^{d}	5.41^{b}	5.61^{c}	5.20^{a}	5.66^{b}	5.30^{a}
150kg/ha Urea	5.91^{ab}	5.90^{a}	6.83^{b}	6.32^{a}	5.53^{b}	5.30^{b}
15 tons/ha SD	5.34^{a}	5.90^{a}	7.85^{a}	6.15^{a}	6.27^{a}	5.65^{b}
75kg/ha U+7.5tons/ha SD	5.19^{a}	6.35^{a}	6.28^{d}	6.50^{a}	5.62^{b}	6.33^{a}
SE	0.24	0.68	0.059	0.46	0.064	0.18

TRT = Treatment, WK1 ….WK6 = week 1 to week 6, SE = Standard error, SD = Sheep droppings

CONCLUSION

The soil of the study areawas slightly acidic with the mean of 6.37, electrical conductivity waslow (0.18). The soil had low organic matter, total nitrogen and medium P levels. Exchangeable Ca was low, exchangeable Mg and Na were medium and exchangeable K was high. The fertility status for the soils was rated low to medium and could produce moderate to low yield for most crops.

On the overall the application of SD increased soil pH from slightly acidic to neutral due to application of 5 tons (50%) and 10 tons' ha^{-1} (100%) of the recommended rate, while the pH values changed from slightly acidic to slightly alkaline due application of SD at 15 tons' ha^{-1} (150%) of the recommended rate. Based on the results, application of at 10 tons SD ha^{-1} could be recommended for amelioration of acidity in sandy loam soils of Adamawa State. Field experiment could also be recommended to ascertain the result obtained.

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