Soil Chemical Properties and Yield of Maize As Affected by Organic Amendment of River Sand with Cow Dung and Poultry Dropping

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***Abstract*:-The study comprised the incorporation of poultry dropping (PD) and cow dung (CD) as means of amending river sand, and the subsequent use of the amended soil to grow hybrid maize in pots in Kaduna, Nigeria. The values of residual soil chemicals after harvest showed that the poultry dropping produced higher soil pH, electrical conductivity (EC), total nitrogen and available phosphorus (AP), with values of 7.4 -7.6, 0.06 – 0.066 dS/m, 0.0042 – 0.0075 and 2.39 – 5.15 mg/Kg, respectively, at the application rates of 500 g to 1,500 g per pot. The difference in the values is, however, not significant between PD and CD. Cow dung gave higher values in the % organic matter (O.M.) (0.21 – 0.46 %) and potassium (K) (44 – 49 mg/Kg). Generally there was significant difference in the residual chemical properties due to levels of application. The yield of maize due to the un-amended sand was zero, while the sand amended with cow dung produced higher mean yield (2.06 t/ha) than poultry dropping (1.87 t/ha). It was recommended that the amendment application rate be increased for more bio-available nutrients to improve yield, and that the soil be texturally modified through addition of clay portions to create the optimum texture (sandy loam) for best management practice of maize.**

***Keywords*: Sand, soil nutrients, organic amendment, yield, maize**

I. INTRODUCTION

Sandy soils as defined in the World Reference Base (FAO-ISRAC-ISSS, 1998) contain less than 18% clay and greater than 65% sand. Generally, the main Reference Group for sandy soils is the Arenosol (FAO-ISRAC-ISSS, 1998). Sandy soils are prevalent in tropical environments especially where felsic volcanic, or siliceous sedimentary rocks and their erosional products are found. Whereas some of these soils are only sandy in the surface layers, others are sandy throughout the root zone. Sandy soils occur in arid, semi-arid and humid rainfall zone the tropics and from coastal lowlands to high altitudes (Bell and Seng, 2005).

Sandy soil, especially river and alluvial sands are very common in Nigeria, and they are the most prevalent aggregate for building construction. It is also important for land reclamation and industrial application (Abam and Oba, 2018). Sand is mined mainly through an open pit but sometimes mined from beaches and inland dunes or dredged from ocean and stream or river beds.

Sand is mined in Nigeria mainly for construction purpose but not many studies are available on the use and improvement of sands for agriculture. Sands, being very available can be improved with amendments to serve as borrowed soils for topping unproductive landscapes and agricultural lands.

Tropical sandy soils have a wide range of limiting factors for agricultural use, these include nutrient deficiencies, low organic matter contents, low fertility, strong acidity, low water retention capacity and poor physical attributes. In addition, the clay fraction is low, the cation exchange capacity (CEC) mostly depends on organic matter which also serves as the major component of the adsorbing complex of water (Bell and Seng 2005; Sam and Vuong, 2008; Hoang, 2008; Bon, 1996). The environments in which they occur are prone to degradation risks from nutrient decline, erosion, leaching, salinity, and acidification. A range of opportunities exist to achieve sustainability of sandy landscapes through plantation forestry, agro-forestry, clay and other mineral soil amendments, maintenance of soil organic matter, balanced fertilization, strategic irrigation, and breeding species for adaptation to the constraints present (Bell and Seng 2005).

The application of organic amendment such as cow dung and poultry droppings has been proved to be reliable and effective in improving soil structure, fertility and biological activities (Scotti et al., 2013). The use of organic amendments to improve soil quality and fertility dates back to thousands of year ago. Greeks and Romans applied animal manure and human sewage to soil (Goss et al., 2013). Organic matter plays a critical role in soil ecosystem because it provides substrates for decomposing microbes (that in turn supply mineral nutrients to plants), improves soil structure and water holding capacity (Abiven *et al.*, 2009), and increases natural suppression against soil-borne pathogens (Bonanomi *et al.*, 2010). Addition of organic amendment to soil helps in maintaining soil organic matter, reclaiming degraded soil, and supply plant nutrients (Aggelides and Londra, 2000) In addition, It also increase soil macronutrients, water holding capacity, hydraulic conductivity and decrease bulk density and surface crusting (Haynes and Naidu, 1998).

The objectives of this study are to study the short term effect of organic amendments (poultry dropping and cow dung) on selected soil chemical properties and yield of potted maize.

II. MATERIALS AND METHODS

Study Area

The experiment was conducted during the 2016 farming season in the experimental farm of Federal College of Forestry Mechanization, Afaka, Kaduna, Nigeria (latitude $10^0 36^/$N and longitude $07^0 25^/$E). The climate of Kaduna is characterized by a clear distinction between dry and rainy seasons. The rainy season lasts from mid-April to early October. Kaduna has an annual mean rainfall of 1206 (FDMS, 2009). The temperature range is 31^0C to 33^0C for the maximum scale and 14^0C to 19^0C for the minimum scale.

Description of Experiment

The study was a factorial experiment comprising two organic amendments (poultry dropping (PD) and cow dung (CD) administered in three levels: 500 g, 1000 g and 1500 g, thoroughly mixed with sandy soil passed through a 2mm sieve to filter out coarser aggregates. The amendments were initially dumped in pits and wetted to allow its decomposition for a period of twelve weeks&&&&&&. Thereafter, the amendments were dried out at room temperature to a constant mass and then measured amounts were mixed with the sandy soil contained in perforated pots of dimensions 23 cm diameter and 60 cm depth. This is to correspond with the optimum rooting depth for maize (60-90 cm) as reported by NRCS (2019); NebGuide (2014). The control treatment did not receive any amendment. The treatments were laid in a randomized block design form. The experiment is described in Table 1.

Table 1: Description of experimental design

Treatment	Treatment tag	Description
T1	PD_0, CD_0	Control – Sandy soil, zero amendment
T2	$PD_{0.5}$	Sand mixed with 0.5 Kg poultry dropping
T3	$PD_{1.0}$	Sand mixed with 1.0 Kg poultry dropping
T4	$PD_{1.5}$	Sand mixed with 1.5 Kg poultry dropping
T5	$CD_{0.5}$	Sand mixed with 0.5 Kg cow dung
T6	$CD_{1.0}$	Sand mixed with 1.0 Kg cow dung
T7	$CD_{1.5}$	Sand mixed with 1.5 Kg cow dung

The treatments were replicated three times to give a total of twenty one plots, each plot comprising three potted units. Hence, the total number of potted units is 21 x 3 = 63.

Test Parameters and Sample collection

Before sowing, the composite sandy soil was analyzed for necessary chemical constituents as required in the study: pH, electrical conductivity, organic carbon, percentage total nitrogen, available phosphorus, potassium and nitrate. The parameters were also analyzed after harvest to evaluate the degree of amendment and their effects on the crop yield. Soil samples were taken from each plot by means of bucket type soil auger. Composite soil samples of each treatment were collected in labeled polythene bags, air dried and taken to the laboratory for analysis. In the laboratory the soil samples were sieved through 2mm mesh filter for sample preparation.

Sample Digestion and Parameters Determination

1g of sieved soil sample was weighed into a beaker and digested with Mehlich-3 reagent according to extraction procedures as described by Mehlich (1984) for bioavailability of soil nutrients, in this case, nitrogen (N), phosphorus (P), and potassium (K). The concentration of the phosphorus was determined by UV-Spectrophotometer S-67 model and the concentration of potassium was measured by Flame Atomic Emission Spectroscopy (FAES)

The soil samples were analyzed for pH (in 1:2 H_2O) using pH- meter, Organic matter (OM) by dry combustion method (Nelson and Summer, 1982), total nitrogen content by micro kjeldah (Nitrogen steam distillation apparatus) method and electrical conductivity(Ec) (in 1:2 soil water suspension) by EC meter.

III. RESULTS AND DISCUSSION

Soil chemical properties as Affected by Organic Matters

The effects of the application of poultry dropping and cow dung at the administered rates on residual chemical properties are presented graphically in Figures 1-7.

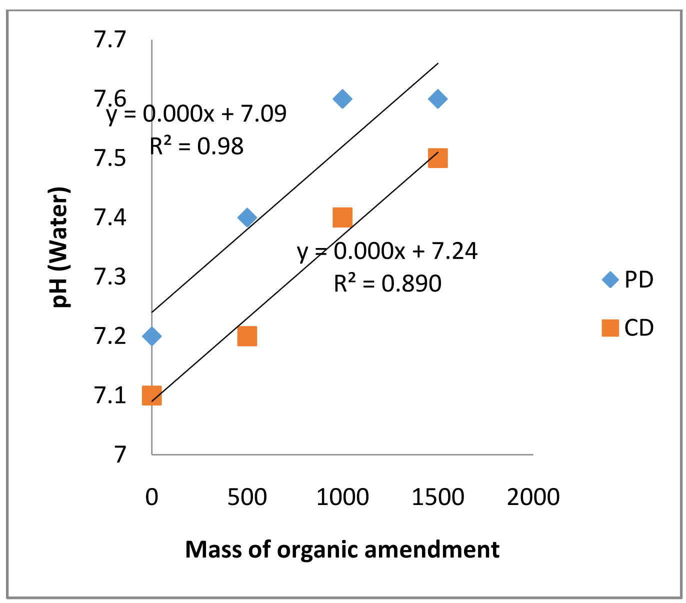

Figure 1: pH (H_2O) of soil as affected by poultry dropping and cow dung

The soil pH was generally higher in all the levels of application for PD than for CD. However, analysis of variance (ANOVA) of the pH shows that there is no significant difference in the pH due to PD and CD amendments, and due to the levels of application as administered in this study. In both cases, increase in the level of organic amendments produced increasing effects on the soil pH. This result is in conformity with UF-IFAS (2017) which stated that animal manure increases soil pH due to calcium and magnesium contents therein. These values were, however, within the pH range (6.0-7.5) for normal growth of most arable crops (Jauron, 2002; Jensen, 2002).

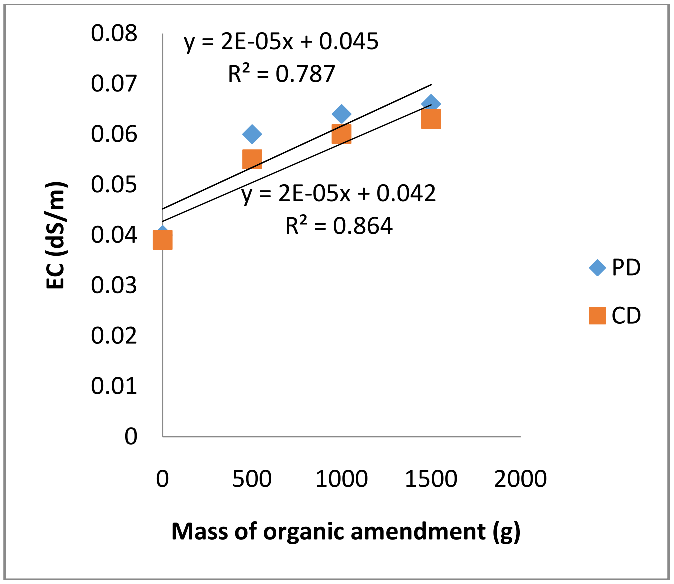

Figure 2: Electrical conductivity (EC) of soil as affected by poultry dropping and cow dung

Poultry dropping has higher effect on the soil electrical conductivity (EC) than cow dung but this difference is not statistically significant between the two ($P = 0.6990$; $P > 0.05$) at the same application rate. This agrees with the findings of Roy and Kashem (2014) in which the EC due to chicken manure was higher than that of cow dung at different incubation periods. The effect of the rate of application, however, showed a significant effect on the EC ($P = 0.0019$; $P < 0.05$). In both cases, the EC values, ranging between 0.039 dS/m and 0.066 dS/m, greatly exceed the threshold value (2 dS/m) for most sensitive plants (Brady and Weil, 2010).

The organic carbon content of the soil due to cow dung was generally higher than that of poultry dropping, however, the difference was not statistically significant ($P = 0.6559$; $P > 0.05$). Also, there was no significant difference due to the rates of application of the amendments ($P = 0.0703$; $P > 0.05$). The organic carbon content increased with the rate of organic amendments, with the poultry dropping giving a better correlation. Unlike the present study, Bakayoko et al. (2009) showed that poultry manure gave higher organic matter contents in soil than poultry manures in sandy soil grown with cassava in Abidjan, Ivory Coast. The general inference from the studies is that organic matter contents in soil increased with increasing rates of manure application, but the effect due to a particular type of manure compared to the other cannot be generalized as it primarily depends on the feed administered to the animals producing the manure.

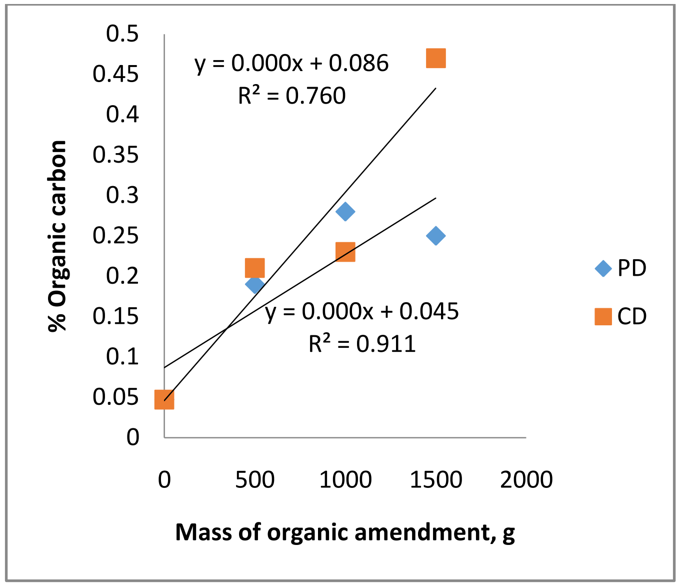

Figure 3: % organic carbon as affected by poultry dropping and cow dung

Total nitrogen (TN) content in soil due to PD was higher than that due to CD (Figure 4). The difference was, however, not significant ($P = 0.3106$; $P > 0.05$). Also, TN did not increase significantly with increased application rates ($P = 0.0815$; $P < 0.005$) at the administered rates. Roy and Kashem (2014) presented a similar result in which PD produced higher NH_4^+ -N in soil than CD, in a laboratory manure incubation experiment.

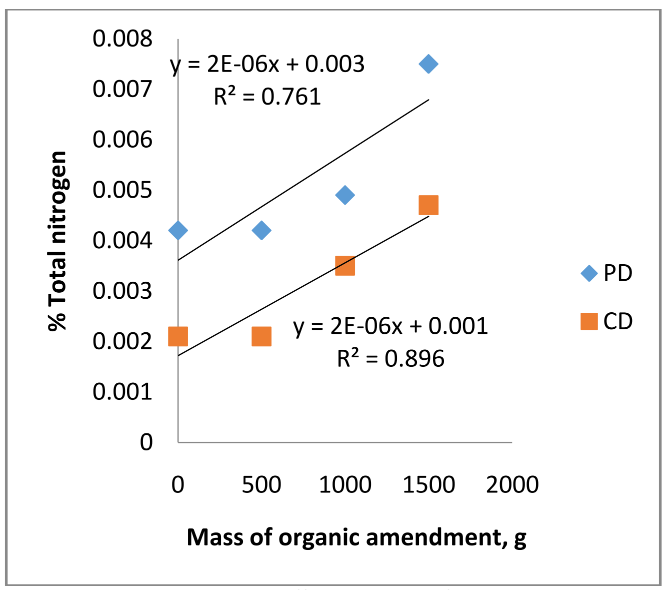

Figure 4: % Total nitrogen as affected by mass of organic amendment, g

Figure 5 showed that PD produced higher available phosphorus than CD at 500 and 1000 Kg application rate. The available phosphorus increased significantly with increase in application rate ($P = 0.001705$; $P < 0.05$) but did not increase significantly between PD and CD within same application levels. Farmwest (2019) showed that poultry manure contains more acid-soluble phosphorus than cattle manure. This is thought to occur because poultry produce very little of the phytase enzyme required to utilize phytate-P in grain (Barnet, 1994). In contrast, cattle generally produce sufficient phytase, although the amounts vary with age and health, which leads to fluctuations in acid-soluble phosphorus in the manure

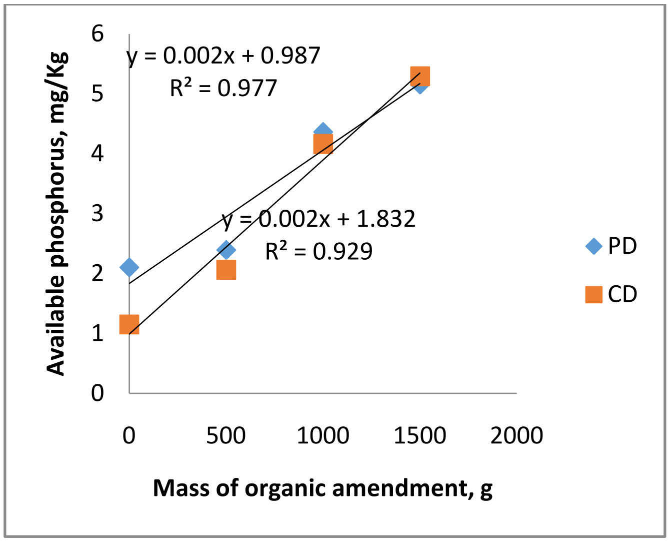

Figure 5: % Available phosphorus, as affected by mass of organic amendment, g

Residual soil potassium content (Figure 6) was not significant between the two amendments (PD and CD), and among application rate. The percentage composition of potassium in chicken manure and cow manure have been estimated to be about 0.5% each of the manure nutrient contents (Allotment Garden, 2019).

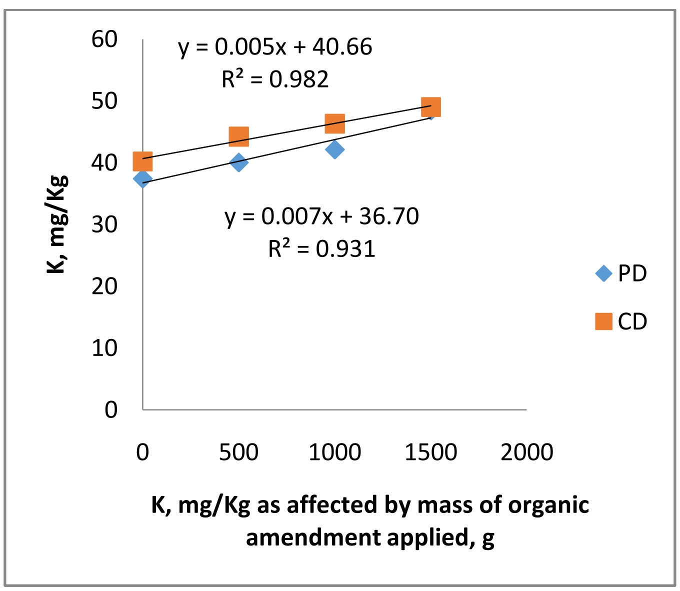

Figure 6: Potassium content as affected by organic amendments

Yield of Maize as Affected by Organic Amendments

The yield of the maize grown in pots with organically amended soils is given in Table 2. The highest yield was obtained from the treatment with 1500 Kg application rate using poultry dropping, followed by that due to cow dung at the same application rate, while the lowest yield was obtained in the treatment with 500 Kg application rate with poultry dropping.. Yield generally decreased with decreasing level of application. No yield was produced from pure sand without amendments. The yield of the maize is low compared to the mean yield in open field cultivation within the same area. Olaniyan and Lucas (2004) reported the mean yield of hybrid maize in Samaru, Kaduna State, within the same experimental region, to be between 5.72 to 6.12 t/ha. This represents 53% to 56% percentage reduction in yield. The yield can be improved upon by applying higher rates of the organic amendments and further modification of the sand by introducing some percentage clay to transform it to sandy loam which is more ideal for arable crops.

Table 2: Yield of maize as affected by different levels of organic amendment

Organic amendment level, Kg	Maize yield, t/ha	
	PD	CD
1500	2.7a	2.51a
1000	1.71b	2.23ab
500	1.21b	1.74b
0	0.00c	0.00c

Means followed by the same letter(s) within each column are not significantly different at $P \leq 0.05$

IV. CONCLUSION

Poultry dropping and cow dung affected the soil chemical properties positively by adding or increasing the soil macro-nutrients and soil organic matter content. The evidence of this can be seen in the zero yield performance of the treatment without organic amendments. The cow dung produced a relatively higher mean yield (2.06 t/ha) than poultry dropping (1.87 t/ha), howbeit; the difference is not statistically different. The yield is only about 44 % of what may be expected under good open field management practice for maize in the same location. The yield can be improved by increasing the organic amendment rates and by introducing a percentage of clay in the sand that will be enough to transform it to sandy loam textural group.

REFERENCES

[1]. Abam T.K.S. and Oba T. (2018). Recent case studies of sand mining, utilization and environmental impacts in the Niger Delta. Journal of Environ Geol. 2018; 2(2):64-70

[2]. Abiven S., Menassero S. and Chenu C. (2009). The effect of organic inputs over time on soil aggregate stability – a literature analysis. Soil Biol. Biochem. 41, 1-12.

[3]. Aggelides S.M. and Londra P.A. (2000). Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and clay soil. Bioresource Technology, 71(3): 253-259.

[4]. Allotment Garden (2019). NPK nutritional values of animal manures and compost.https://www.allotment-garden.org/

[5]. Bakayoko S., Soro D., Nindjin C., Dao D., Tschannen A., Girardin O. and Assa A. (2009). Effects of cattle and poultry manures on organic matter content and adsorption complex of a sandy soil under cassava cultivation. African Journal of Environmental Science and Technology, Vol. 3 (8), pp. 190 – 197, 2009.

[6]. Barnett, G.M. (1994). Phosphorus forms in animal manure. Biores. Technol. 49, 139-147.

[7]. Bell R.W. and Seng V. (2005). The management of the agro-ecosystems associated with sandy soils, Proceedings of FAO Symposium on management of tropical sandy soils for sustainable agriculture – a holistic approach for sustainable development of problem soils in the tropics, 27th November – 2nd December, 2005, Khon Kaen, Thailand.

[8]. Bon L.T. (1996). Properties of coastal sandy soil of Thua Thien province. Vietnam Soil Sci. J. 7:46-48

[9]. Bonanomi G., Antignani V., Capodilupo M. and Scala F. (2010). Identifying the characteristics of organic soil amendments that suppress soil-borne plant diseases. Soil Biol. Biochem. 42, 136-144

[10]. Brady N.C. and Weil R.R. (2010). Elements of the nature and properties of soil, 3rd ed., Pearson Education, Inc., New Jersey, P. 306

[11]. FAO-ISRIC-ISSS 1998. World Reference Base for Soil Resources. Acco Press, Leuven, Belgium.

[12]. Farmwest (2019). Phosphorus in livestock manures (https://farmwest.com/node/953)

[13]. Goss M.J., Tubeileh A., and Goorahoo D. (2013). A review of the use of organic amendments and the risk to human health. Adv. Agron. 120, 275-379.

[14]. Haynes R J. and Naidu R. (1998). Influence of lime, fertilizer and manure application on soil organic content and soil condition: a review Nutrients Cycle Agro-ecosystem, 51: 127-137

[15]. Hoang Thi Thai Hoa (2008). Soil characteristics, cropping patterns, and organic resources in the coastal sandy area of Thua Thien Hue province, Central Vietnam. PhD Thesis. Universite catholique de Louvain, Louvain-la-Neuve, Belgium

[16]. Jauron R. (2002). The meaning and importance of soil pH, Iowa State University, Extension and outreach. https://hortnews.extension.iastate.edu/2002/5-24-2002/soilph.html

[17]. Jensen T.L. (2010). Soil pH and availability of plant nutrients, IPNI Plant Nutrition TODAY, No. 2, www.ipni.nnet/pnt

[18]. NebGuide (2014). Corn soil-water extraction and effective rooting depth in a silt-loam soil; University of Nebraska, Lincoln Extension, Institute of Agric. And Natural resources, G2245.

[19]. NRCS (2019). Sprinkler irrigation, Natural resources Conservation Service, National Engineering handbook, Ch. 11, Section 15.

[20]. Sam Le and Vuong N.D. (2008). Real conditions of soil – water resources and desert threat, nature catastrophe in the sandy area of Binh Thuan province. Scientific collection in 2008. South Institute of irrigation science.

[21]. Scotti, R . Conte, P.Berns,A E. Alonzo, G; Rao, M. A.2013. Effect of organic amendments on the evolution of soil organic matter in soil stressed by intensive agricultural practices. Curr. Org. Chem. 17. 298-3005

[22]. UF-IFAS (2017). Does adding manure lower or raise soil pH? University of Florida, Institute of Food and Agricultural Sciences, http://blogs.ifas.ufl.edu/nassauco/2017/07/19/q-adding-manure-lower-raise-soil-ph/