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#### Changing the fertilizer conversation in Nigeria: The Need for Site Specific Soil-Crop Fertilizer Use

Blessing Agada

#### Introduction

Africa is the only continent believed not to have benefitted from the green revolution (Mbabazi et al, 2015). Several factors have been outlined as the reasons for this failure including varying soil types. Even the Malawian heralded Green revolution in Africa has not been without its downsides. Recent findings provide shocking discoveries of high use of synthetic/inorganic fertilizer at great financial cost to farmers and government. Such use has occurred alongside rising soil infertility due to low soil organic matter (SOM) levels that no longer supports maize growth or its responsiveness to fertilizer (Snapp, 2014).

Low soil fertility, is increasingly being recognized as a major biophysical cause for declining food security among small holder households in Sub Saharan Africa (SSA) where soil nutrient resource(s) are continually being depleted with shorter fallow periods and continuous use (Stoorvogel and Smaling, 1990). Soil nutrient resources are continually being depleted because of nutrient mining with no adequate replenishment. This downward spiral has largely led to a decline in crop yields, food insecurity and environmental degradation (Oldeman, 1994; den Biggerlaar, et al, 2004)

Erosion inevitably reduces soil productivity. The extent of the reduction depends on soil profile characteristics, the crop grown, soil management and the microclimate (Lal, 1983). Soil erosion is particularly problematic in the tropics due to high rainfall intensities and generally less fertile soils (Lal, 1998). The highly weathered soils of the tropics (Oxisols and Ultisols) are generally less fertile and thus require soil management to be productive.

Following the Abuja declaration in 2006 (where heads of Government in Africa pledged to increase fertilizer usage from the near 8-10 kg/ha to up to 50 kg/ha by 2015), there has been a renewed outcry for an increase in the use of inorganic fertilizers across many countries in Africa.

#### Key Findings

- Landscape positions dictates fertilizer need. Distinct features in terms of slope, water holding capacity and inherent soil fertility determine the amount and type of fertilizer to be used (ICRISAT, 2017). This needs to be understood and appreciated by farmers, extension agents and those involved in the design and implementation of farmer productivity programs, particularly those involving fertilizer.
- Soil rooting depth is critical. Having 10 -20 cm topsoil loss could decrease yield of corn even with added inorganic fertilizer. Complete total crop failure could occur (see figure 1) where, with increasing depth of soil loss, yields declined drastically even with added fertilizer at recommended rate for the area. Limitations within a soil profile will reduce its effective rooting depth affecting anchorage, growth and development. (Agada 2018 unpublished Ph.D. Dissertation).
- Rainfall characteristics such as high rainfall amounts, intensity and drop size will lead to loss of soil nutrients (weather added as organic or inorganic amendments) and loss of soil particles (Obi and Salako 1995; Agada et al, 2016) furthering the vicious cycle of erosion. Thus with varied environmental conditions across the country, real-time nutrient management strategies are necessary (Theriault et al, 2018).
- There is an urgent need to educate farmers on fertilizer management practice. This involves information on fertilizer placement and timing, soil depth, soil types, slope positions and other agronomic/ management practices. With increased variation in climate, changing, or modifying hitherto farmer knowledge of certain agronomic practices in order to improve agricultural productivity is key (Delgado et al, 2011).

(<https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/african-fertilizer-financing-mechanism/abuja-declaration/> ).

However, this increase of fertilizer usage may not guarantee the desired increase in yield. Various researchers have shown that though fertilizer usage in Nigeria has

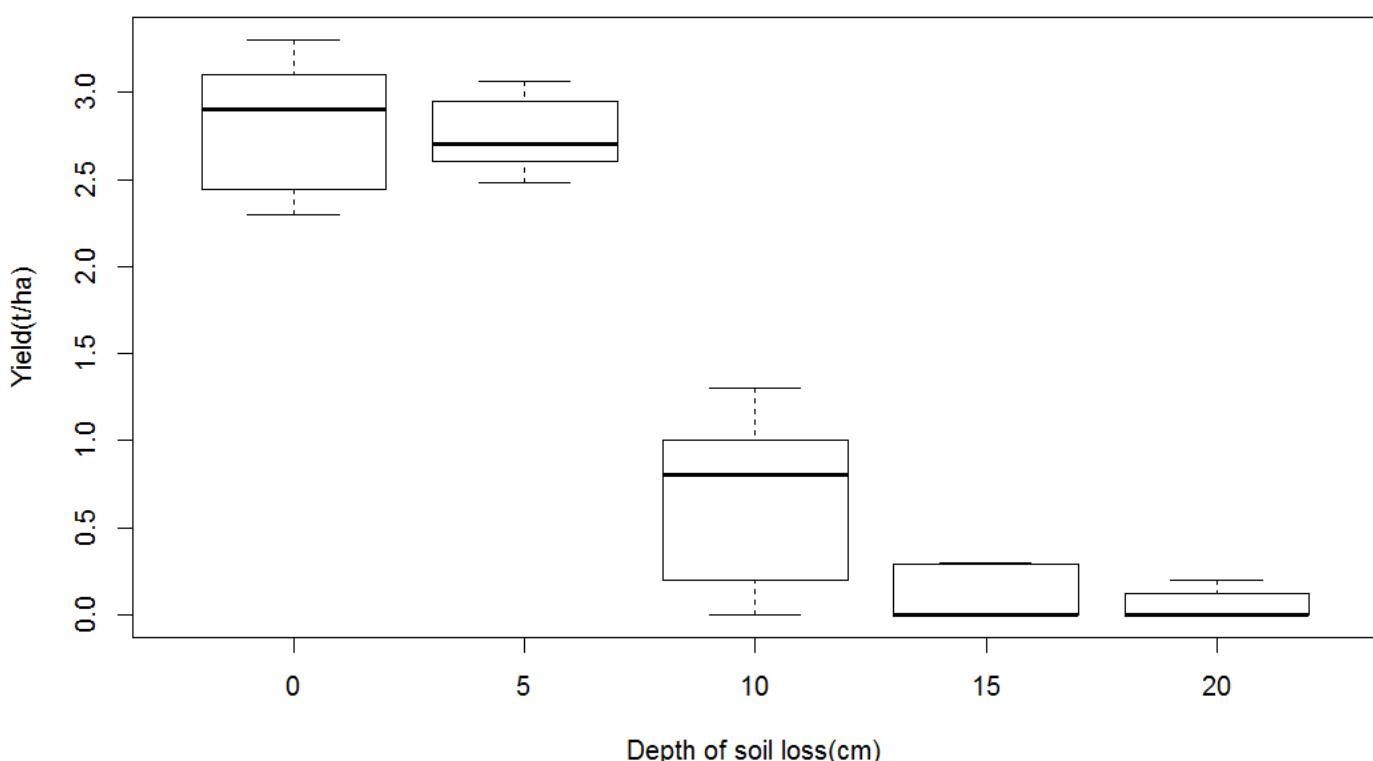
increased compared to earlier reports (Sheahan and Barret, 2014) the yield responses to inorganic fertilizer is still low for many cereals including maize (Liverpool-Tasie et al, 2017; Liverpool-Tasie, 2016). This finding of low yield response to inorganic fertilizer is quite consistent across the continent (Pan and Christiansen, 2012; Mather et al. 2016).

Nitrogen is overwhelmingly the most important nutrient needed to increase yield. However, its availability depends

on an understanding of its dynamics, soil organic matter formations and crop use efficiency. Although nitrogen (N) is very important amongst the other 16 essential elements and abundant in the atmosphere, it is highly mobile and limiting especially in the tropics.

Mineralization of N is rapid with high temperatures as well as high losses due to leaching and erosion from high intensity rains of the tropics (Agbede, 1986).

### Distribution of Depth of Topsoil Loss against Yield



**Figure 1: Shows yield losses in relation to incremental depths of topsoil loss (simulated erosion).** Top soil loss at 15cm and at increasing depths resulted in complete total crop failure. Implying that as erosion occurs on a field due to high intensity rainfall, conventional tillage methods, kinds of soil management, soil properties which influences productivity are affected as the effective rooting depth (soil bulk) is truncated. This finding brings to the fore issues of soil types, limitations within a soil profile as well as varying rainfall characteristics as obtained in the tropics (Lal and Moldenhauer ,1987; Obalum et al, 2012).

The current approach in Nigeria and most African countries is to provide blanket recommendations of inorganic fertilizer application rates that do not take into account land scape positions, rainfall characteristics, soil types and soil characteristics.

Thus, this method of application is based on soil chemical fertility with still poor yields. Soil is a dynamic entity. Increasing yields requires a holistic approach to managing and manipulating the physical chemical and biological fertility of soils. There is therefore a need, for “site specific” nutrient management. Such management

practice needs to be tailored to specific soil type, soil rooting depth, inherent soil productivity, slope, crop yields potentials and environmental conditions as these varies across agro climatic zones and farmer fields. It is only when these factors are properly managed, that Nutrient limitations can be easily addressed for increased crop yields.

Preliminary results from on-farm trials with maize in Indonesia, the Philippines, and Vietnam clearly indicate significant opportunities to increase yield and profitability, if crop and nutrient management are fine-tuned to site-specific conditions (Witt et al, 2006) Farmers however, will need to adjust both the timing and amount of fertilizer nutrients (N, P, and K), to allow for better match of crop demand for nutrients.

Site specific management optimizes how the soil supplies nutrient over time and space and matches it to crop requirements so that crop productivity is increased and the efficiency of fertilizer use improved, ultimately reducing cost. It uses the 4R's principle of *Right source/product, Right rate, Right placement, Right Timing* to fertilizer application.

As the call for fertilizer use increase is made across the continent (often via expensive government and development programs), particular attention needs to be made to site specific management. This is necessary to ensure that such efforts translate to increase productivity and greater returns on investment as well as reduce Nitrogen losses through volatilization, leaching and runoff ensuring a safer environment.

## References

- Agada B. I.; Obi M. E, and Ali A. (2016). Rainfall characteristics at Makurdi, North central Nigeria II. Int. Journal of Sci. Tech. Vol. 5(1) pp 40-46.
- Agada B. I.; (2018). Soil productivity and Soil Loss Tolerance Limit(s) Evaluation in Makurdi, Benue State. Unpublished Ph.D. Dissertation, Federal University of Agriculture Makurdi, Nigeria.
- Agbede O. O (1986). Mineralization of Nitrogen in Soils with varying Carbon Nitrogen Ratios and fertility levels. Nigerian Journal of Agronomy, 1(3): 92 – 96.
- Delgado J.A.; Groffman, P.M., Nearing, M.A., Goddard, T., Reicosky, D. Lal, R., Kitchen, N.R., Rice C.W., Towery D, and Salon P.(2011) Journal of Soil and Water Conservation . vol. 66 no. 4 118A-129A.
- den Biggelaar, C., Lal, R., Wiebe, K.,Eswaran, H., Breneman, V., and Reich, P. (2004). The Global Impact of Soil Erosion on Productivity \*II: Effects on Crop Yields and Production over Time. 81. 10.1016/S0065-2113(03)81002-7.
- <https://agrilinks.org/sites/default/files/.../MalawiGreenRevolutioninJeopardySnapp.pdf> Snapp S.S. (2014) Malawi Green Revolution in Jeopardy.
- <http://EXPLOREt.icrisat.org> ICRISAT (2017). Feeding degraded soils in Ethiopia to feed the people and the environment.
- Lal, R. (1983). Soil erosion and its relation to productivity in tropical soils. In El- Swaify, S. A; Moldenhauer, W. C. & L Andrew L. O. (edh.1: Proceedings to the international Conference of Soil Erosion and Conservation, Hawaii: 237-247.
- Lal, R., and Moldenhauer W.C, (1987) Effects of soil erosion on crop productivity, Critical Reviews in Plant Sciences, 5:4, 303-367, DOI: 10.1080/07352688709382244
- Lal, R (1998). Drop size distribution and energy load of rainstorms at Ibadan, western Nigeria. Soil Tillage Research. 48,103-114.
- Liverpool-Tasie, L. S. O. (2016). Is fertilizer use inconsistent with expected profit maximization in sub-Saharan Africa? “Evidence from Nigeria” Journal of agricultural economics. DOI 10.1111/1477-9552.12162.
- Liverpool-Tasie, L. S. O., Omonona, B. T., Sanou, A., & Ogunleye, W. O. (2017). Is increasing inorganic fertilizer use for maize production in SSA a profitable proposition? Evidence from Nigeria. Food Policy, 67, 41–51. <http://doi.org/10.1016/j.foodpol.2016.09.011>
- Mather, D., B. Waized, D. Ndyetabula, A. Temu, and I. Minde. (2016). The Profitability of Inorganic Fertilizer Use in Smallholder Maize Production in Tanzania: Implications for Alternative Strategies to Improve Smallholder Maize Productivity. GISAIA Working Paper No. 4. Dar es Salaam, Tanzania: GISAIA.
- Mbabazi J., M.Bah, M.E., Chouchane,A.V., abd Africa Development Bank. (2015). Transforming Africa's Agriculture to Improve Competitiveness. World Economic forum, Africa Competitiveness Report.
- Obi and Salako F.K., (1995) Rainfall parameters influencing erosivity in South Eastern Nigeria. Catena, V. 24, pp 275-287. <https://www.pambazuka.org/activism/myth-malawis-green-revolution-success-story-exposed>
- Oldeman, L.R. (1994). The Global Extent of Soil Degradation. In: Greenland, D.J. and Szabolcs, I., Eds., Soil Resilience and Sustainable Landuse, CAB International, Wallingford, 99-119.

- Pan, L. and L. Christiaensen. (2012). Who Is Vouching for the Input Voucher? Decentralized Targeting and Elite Capture in Tanzania. *World Development* 40.8: 1619-33.
- Sheahan, Megan; Barrett, Christopher B. (2014) Understanding the agricultural input landscape in Sub-Saharan Africa: recent plot, household, and community-level evidence (English). Policy Research working paper; no. WPS 7014. Washington, DC: World Bank Group.
- Snapp, S., T.S. Jayne, W. Mhango, J. Ricker-Gilbert, and T. Benson (2014). Maize Yield Response to Nitrogen in Malawi's Smallholder Production Systems. IFPRI Working Paper No. 9. Malawi Strategy Support Program. Washington, DC: International Food Policy Research Institute.
- Stoorvogel, J. J.; Smaling, E.M.A (1990). Assessment of soil nutrient depletion in Sub-Saharan Africa 1 1983-2000. Volume II Nutrient balances per crop and per Land Use System. Wageningen (The Netherlands), The Winand Staring Centre. Report 28.
- Sunday E. Obalum, Mohammed M. Buri, John C. Nwite, et al., (2012) "Soil Degradation-Induced Decline in Productivity of Sub-Saharan African Soils: The Prospects of Looking Downwards the Lowlands with the SawahEcotechnology," *Applied and Environmental Soil Science*, vol. 2012, Article ID 673926, 10 pages, <https://doi.org/10.1155/2012/673926>
- S. Sur, R. Singh & S. S. Malhi (2008) Influence of simulated erosion on soil properties and maize yield in Northwestern India, *Communications in Soil Science and Plant*
- Theriault, A., Smale, V. M., and Haider, H. (2018). Economic incentives to use fertilizer on maize under differing agro-ecological conditions in Burkina Faso. *Food Security* (2018):1-15, <https://doi.org/10.1007/s12571-018-0842-znalysis> 29:17-18, 2647-2658, DOI: 10.1080/00103629809370140.
- Witt, J. M. Pasuquin; and Dobermann A. (2006). Towards a Site-Specific Nutrient Management Approach for Maize in Asia. *Better Crops*, Vol. 90: No.

### About the Author

Agada is a PhD candidate from Federal University of Agriculture Makurdi. Her dissertation deals with the impact of soil characteristics on the usefulness of fertilizer treatment. This policy brief was written by Mrs. Agada at Michigan State University as part of her activities as a Project Scholar of the Feed the Future Nigeria Agricultural Policy Project. The analysis was done using R software and the policy brief was done under the supervision of Dr. Saweda O. Liverpool-Tasie of MSU

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