POLICY BRIEF

Declining Soil Fertility in Kenya's Grain Basket: A Threat to Food Security

Soil Factors that Constrain Crop Production in Kenya

Approximately 30 % of the world's total land area consists of acid soils and upto 40 % of the world's arable lands are acidic (1). Soils are considered acidic when the pH value is < 5.5. The soils in the tropics and subtopics are highly weathered and are generally acidic due to the underlying parent materials that are low in the basic cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}). These elements are leached from the soil, reducing pH and the buffering capacity of the soil (2). The two main factors limiting the fertility of acid soils are nutrient deficiencies such as phosphorus (P), molybdenum (Mo), calcium (Ca), Magnesium (Mg) and potassium (K) and the presence of phytotoxic elements such as soluble aluminium (Al) and manganese (Mn).\

The total phosphorus is abundant in the soils but is unavailable for plant absorption because it is adsorbed onto soil particles or bound by Al and Fe in the case of acid soils.In Kenya acid soils form upto 13 % of the arable land mainly in western and central regions (3,4) where 70% of maize production takes place (Figure 1). These soils contain between 4 % and 64 % Al saturation, levels that are toxic for many crops and have high phosphorus fixation capacity (5). Thus, much of the added P is fixed and is not readily available for crop use. The situation is worsened by the fact that phosphorus reserves will be depleted by the year 2050 (5).

This is a threat to sustainable crop production and food security.The low phosphorus status of highly weathered acid soils is a problem because large amounts of phosphate fertilizers need to be applied in order to raise concentration of available soil P to adequate levels.
This is beyond the means of resource constrained small holder farmers who form the majority of farming communities in Kenya.

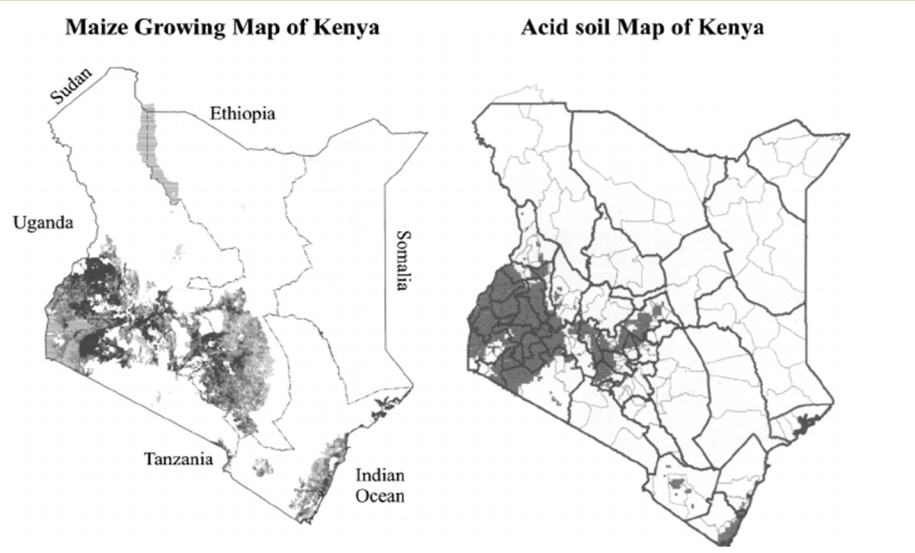

Figure 1. Distribution of maize growing areas (left) and areas with acid soils (right) as indicated by the dark shaded areas. The maps have been modified from (3,11).

Farmers often use acidifying fertilizers such as urea and diammonium phosphate (DAP) to correct N and P deficiencies.This has led to a marked increase in acidity on a soil that is naturally acidic (7). A majority of the Kenyan population relies on maize as staple food and more often than not is a basis for food security. Acidic soils cause up to 69 % of maize yield loses (8). here is therefore need to apply the correct agricultural inputs and promote adoption of the existing acid-tolerant maize varieties in order to realize better yields. Breeders could also use such varieties for breeding and improving existing varieties that are otherwise high yielding but susceptible to acid stress. The breeders should therefore do target-breeding for various regions with acid soils in the country.

Management of Acid Soils

Soil acidity is conventionally corrected by applying agricultural lime. However, farmers can also use wood ash as an alternative. It has been shown that application of 11.2 t/Ha of lime and wood ash raises the pH of the soil from 4.8 to 6.0 with concomitant release of Al-bound P by 160%, Fe-bound P by 22% and an increase of Olsen (available) P by 132% (9). However, low rates of lime (2 t/ha) with moderate levels of P (30 kg/ha) has been shown to correct acidity and improve maize growth and production (12,13). Therefore farmers who cannot afford to apply high rates of lime and inorganic fertilizer can apply micro-doses of the same and still achieve good yields.Attempts have been made by Kenyan researchers to screen crop varieties adapted to acid stress. Inventories of acid-tolerant phosphorus efficient maize and sorghum varieties and legumes exist and could be exploited for improved yields in acidic soils. It is evident that addressing challenges of crop production in acid soils of Kenya requires a holistic approach by all stakeholders. Despite the fact that agriculture is a devolved sector, the national government through the ministry of agriculture, livestock and fisheries has to ensure that enough resources are allocated.

Government Input Subsidy Program

Input subsidy programs (ISPs) are among the most important development agenda in sub-Saharan Africa. ISPs aim at providing farmers with fertilizer and in some cases seed at below market prices. These programs were phased out during the 1990s because the governments assumed that ISPs weakly contributed to agricultural productivity, food security and poverty reduction (10). However, in the early 2000s several African governments reintroduced ISPs after accepting to raise expenditures on agriculture under the 2003 Maputo declaration. By the year 2010 at least tenAfrican countries, Kenya included, had adopted second generation ISPs designed to enhance agricultural productivity in a market smart way. In the year 2011 to 2014, the estimated expenditures on ISPs by the ten African countries ranged between 600 million to 1 billion USD per year.

Kenya is among seven African countries with large input subsidy programs. The Kenyan government spend 251 million USD on 318 metric tons of ISP in the year 2011-2014. In Kenya, the ISP program targets the resource poor farmers of both gender through the Accelerated Agricultural Input Access Program (NAAIAP). The subsidy program is useful in cushioning the farmers against fluctuating market prices of inputs. This is a good move that will ensure that the farmers produce enough food beyond subsistence and hence enable the government achieve one of the Big Four Agenda. However, the current ISP in Kenya entails provision of inorganic fertilizers mainly DAP for planting and CAN as an additional N source. The inputs lack lime as a component required to correct soil acidity. There is therefore need to incorporate lime in the fertilizer formulations destined for regions with acidic soils. Other non-acidifying inorganic fertilizers such as triple superphosphate (TSP) and single superphosphate (SSP) should be used as phosphorus sources.

What are the key issues?

- Soils in the arable lands of Kenya are acidic and highly degraded and cannot sustain sufficient crop production
- The soils are deficient in essential mineral nutrients and have high phosphorus fixation ability
- The natural phosphorus nutrient reserves will be depleted by the year 2050
- Farmers use inadequate amounts of inorganic fertilizers and rarely use organic manure
- Farmers use soil acidifying fertilizers such as DAP and Urea
- Farmers lack knowledge on use of lime and organic manure to correct soil acidity
- There exists crop varieties that are tolerant to acidity and efficient in acquisition and use of essential soil nutrients

Policy recommendations for different players in crop production in regions with acid soils

Target	Policy Recommendation
 *Farmers*	• *Application of correct doses of lime* • *Application of non-acidifying inorganic fertilizers such as single superphosphate (SSP) and triple superphosphate (TSP), as sources of P and calcium ammonium nitrate (CAN) as N source.*
 *National Government of Kenya*	• *The input subsidy program should include lime and the non-acidifying fertilizers for regions with acid soils*
 *Fertilizer Manufacturers*	• *Incorporate lime into the fertilizer formulations*
 *County Governments*	• *Establish soil testing centers* • *Provide soil testing services and give appropriate recommendations*
 *Agricultural Extension Workers*	*Farmer education to create awareness on* • *Importance of periodic soil testing* • *Importance of lime* • *Using the right fertilizers* • *Growing the right crops*
 *Research Institutions*	• *Breeding of crops that are adapted to acid soils*
 *Seed Companies & Suppliers*	• *Promotion of acid-tolerant crop varieties*

Benefits of implementing the policy recommendations and consequences for not taking any action

Benefits	Consequences
• *Correction of soil acidity hence healthier soils*	• *Further degradation of soils*
• *Availability of soil nutrients for crops and hence application of low rates of fertilizers*	• *Use of high rates of fertilizer and hence economic loses*
• *Enhanced crop yields hence food security and improved livelihoods*	• *Food insecurity due to low crop yields*

References

1 Von Uexküll HR. Mutert E (1995). Global extend, development and economic impact of acid soils. In Plant-soil Interactions at Low pH: Principles and Management, (Date, R.A., Grundon, N.J., Rayment M.E. Probert M.E. (eds). Kluwer Academic Publisher, Dordrecht, Netherlands. pp 19.

2 Kidd PS. Proctor J (2001). Why plants grow poorly on very acid soils: are ecologists missing the obvious? J.Exp.Bot. 52:791-799.

3 Kanyanjua SM. Iren I. Wambua S.Nandwa SM (2002). Acidic soils in Kenya: constraints and remedial options. KARI Technical Notes No. 11. pp 28.

4 Obura PA. Schulze DG. Okalebo JR. Othieno CO. Johnston CT (2010). Characterization of selected Kenyan soils. 19th World Congress of Soil Science: Soil Solutions for a Changing World. Brisbane, Australia.

5 Kisinyo PO. Othieno CO. Gudu SO. Okalebo JR. Opala PA. Maghanga JK. Ogola BO (2013). Phosphorus sorption and lime requirements of maize growing on acid soils of Kenya. Sustainable Agriculture Research. 2: 116-123

6 Balemi T. Negisho K (2012). Management of soil phosphorus and plant adaptation mechanisms to phosphorus stress for sustainable crop production: a review. Journal of Soil Science and Plant Nutrition. 12(3):547-561

7 Opala PA. Okalebo JR.Othieno C (2013). Comparison of effects of phosphorus sources on soil acidity available phosphorus and maize yields at two sites in western Kenya. Achieves of Agronomy and Soil Science. 59(3): 327-339

8 Tanzi L. Mutengwa CS. Ngonkev ELM. Gracen V (2018). Breeding maize for tolerance to acidic soils: a review. Agronomy. 8(84): 1-21.

9 Melese A. Yli-Halla M (2016). Effects of applications of lime, wood ash, manure and mineral P fertilizer on the inorganic P fractions and other selected soil chemical properties on acid soils of Farta district, Northwestern highland of Ethiopia. African Journal of Agricultural Research. 11(2): 89-99

10 Jayne TS. Marson NM. Burke WJ. Ariga J (2018). Taking stock of Africa's second generation agricultural input subsidy program. Food Policy. 75:1-14

11 Muhammad L. Underwood E (2004). The Maize agricultural context in Kenya. In Andow DA, Hilbeck A (eds), Risk Assessment of Genetically Modified Organisms: A case study of Bt. Maize in Kenya. Vol. 1. CABI publishing, Wallingford. pp. 21-56

12 Kisinyo PO. Opala PA. Palapala V. Gudu SO. Othieno CO and Ouma E (2015). Micro-dosing of lime, phosphorus and nitrogen fertilizers effect on maize performance on an acid soil in Kenya. Sustainable Agriculture Research 4(2): 21-30

13 Opala PA (2017). Influence of lime and phosphorus application rates on growth of maize in an acid soil. Advances in Agriculture. https://doi.org/10.1155/2017/7083206

Acknowledgements

The development of this policy brief was supported by the Agrifose2030 program and the International Livestock Research Institute (ILRI) with financial support from the Swedish International Development Agency (SIDA).
I thank my mentor, Geraldine Matolla for her input.

CONTACT ADDRESS
Emily Jepkosgei Too
Department of Biological Sciences
University of Eldoret. Kenya
E:mail: emiltoo2002@yahoo.com
E:mail: emilie.too@gmail.com

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

AgriFoSe2030
Agriculture for Food Security 2030
- Translating science into policy and practice

SLU · Lund University · SEI · University of Gothenburg

University of Eldoret
flame of knowledge and innovation