

Strengthening researcher-extension-farmer participation in soil fertility restoration for sustainable crop production in western Kenya

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Abstract

Food insecurity in sub-Saharan Africa (SSA) results mainly from common and prolonged droughts, fertility depleted soils, poor economies and insignificant researcher-extension-farmer contacts to demonstrate technologies. The soils are predominantly deficient in N and P nutrients, soil organic matter and are generally acidic. In these soils nutrient additions have raised maize (staple) yields in western Kenya from 0.5 to 3-5 t/ha/season, when 75 kg N, 26 kg P and 2 t/ha agricultural lime are applied. Farmers always indicate the unaffordable costs of these materials. To mitigate these problems, cooperation among international institutions has been launched in the region to diversify fertilizer and lime applications, to reach 50,000 farmers by 2012. Use of low cost materials such as phosphate rocks, lime and manures is emphasized. This paper highlights some of these efforts.

Key words: Crop production, soil fertility restoration, sustainability, western Kenya

Résumé

L'insécurité alimentaire en Afrique sub-saharienne (ASS) résulte principalement des sécheresses prolongées et fréquentes, des sols dépourvus de fertilité, des économies pauvres et du contact chercheur-développement-fermier insignifiant pour démontrer des technologies. Les sols sont principalement pauvres en nutriments N et P, en matière organique et sont généralement acides. La supplémentation de ces sols en nutriments a relevé les rendements de maïs (qui est un aliment de base) de 0.5 à 3-5 t/ha/saison au Kenya occidental

quand 75 kg N, 26 kgP et 2 t/ha d'engrais calcique sont utilisés. Les fermiers affirment d'habitude que ces matériaux ont des coûts exorbitants. Pour atténuer ces problèmes, la coopération entre les institutions internationales a été lancée dans la région pour diversifier les usages d'engrais et de chaux, pour atteindre 50.000 fermiers d'ici 2012. L'utilisation des produits à prix réduit tels que les phosphates naturels, la chaux et les engrais est soulignée. Cet article met en évidence certains de ces efforts.

Mots clés: Production végétale, restauration de la fertilité du sol, durabilité, Kenya occidental

Background and Literature Summary

Food insecurity and poverty substantially contribute to the unending world food aid in sub-Saharan Africa (SSA). Reasons for this gloomy situation are numerous and well-documented, but consist of the prevalent and prolonged droughts, declining soil fertility resulting from continuous land cropping with negligible nutrient inputs, poor economies and the overall non-adoption of sustainable agricultural production technologies, among others (Keating *et al.*, 1992; Sanchez *et al.*, 1997; Okalebo, 2009).

To pinpoint the soils constraint, strong evidence exists regarding the limitations of nitrogen (N), phosphorus (P), organic matter and soil acidity in the highly weathered and leached soils (acrisols, ferralsols, nitisols, luvisols, etc.) in the croplands of western Kenya (Woomer *et al.*, 2003; Okalebo, 2009). There is also substantial documentation on the results of many field trials conducted in this region of Kenya over the past 80 years, whereby crop responses to fertilizer N and P have been found (e.g. Okalebo, 2003). Despite these demonstrated responses to nutrient inputs, the main gap today is the non to slow adoption of soil fertility amelioration technologies in SSA as a whole.

The problems of fertilizer unavailability and its rising costs are readily expressed by the smallholder farmers. In addition, the practice of liming acid soils is rather "new" and hence not adequately demonstrated and documented in SSA. In Kenya, about 13% of arable soils (7.8 million ha) are acidic and aluminum (Al) saturation in most of these soils is above 30%, the levels associated with reduced maize (staple) production through Al toxicity (Olmos and Carnago, 1976). Overall, maize yields on smallholder farms in western Kenya hardly exceed 1 ton/ha/season, whereas N, P and lime interventions raise the yields to 3-5 t/ha (Nekesa, 2007). On the other hand, the

commonly grown dry beans, cowpea, soybean etc. yields are disappointingly low, below 0.2 t / ha / season in western Kenya. Obura (2001) and Kanyanjua *et al.* (2002) have reported maize yield reductions of about 26, 16 and 30% from Al toxicity, P and N deficiencies in soils, respectively, in Kenya.

In this paper we highlight the problem of infertile soils, including acidity in western Kenya. We also describe the results of crop responses to nutrients and lime additions, thereby presenting evidence for our current activities and thrust to increase and sustain agricultural production through intensified or extended nutrient and lime applications on acid and nutrient depleted soils of western Kenya.

Study Description

Nutrient status of cropland soils. To enhance farmer participation on soil fertility restoration, farm visits (140 farms across western Kenya) were made to obtain information on the fertility of farmlands in 2002; farmers also identified to the researchers both the fertile and poor areas in their fields. Soils from the two contrasting areas were sampled and analyzed to detect nutrient limitations, with the overall aim to map out these soils for interventions and for site selection for specific experimentation.

Responses to phosphorus and agricultural lime. To generate site specific recommendations, maize and legume responses to P and lime were investigated at four on-farm sites in four districts in Kenya (Siaya, Bungoma, TransNzoia and Uasin Gishu). The main objective was to delineate between the P and liming effects of the effective Minjingu phosphate rock (MPR, containing 10 – 13% P and 38% CaO), mined in Tanzania, in comparison with direct P effects from the two commonly used P soil acidifying sources in Kenya, viz, diammonium phosphate (DAP) and triplesuperphosphate (TSP). Thus the rates of 0 – 90 kg P/ha and 0 – 1.5 t/ha agricultural lime (21% CaO) from Koru, Kisumu, Kenya, applied alone and to DAP and TSP, were designed to increase maize and legume production and also to create a favourable soil environment for crop growth. Field experimentation is described elsewhere (Nekesa, 2007), but nitrogen was applied at a blanket recommended rate of 75kg N/ha to each treatment, except the absolute controls.

Strategy towards diversified input applications. While formulating the strategy to increase crop yields, the target is

increased fertilizer use in Africa from the current 9 to 50 kg / ha by the year 2015, one of the Millennium Development Goals. Furthermore, TSBF–CIAT envisages increased soybean production through inoculation of seed of high yield potential using effective commercial rhizobia inoculants. Soybean is well-known for its diversified uses, particularly on human and livestock nutrition. This strategy was initiated in 2009 in western Kenya by several global (abbreviated as AGRA, TSBF, IMPHOS, RUFORUM) and local (KARI, Moi University) institutions among others. This collaborative effort focusses on increased input use across a large number of farmers, targeting upto 50,000 farms in two districts of western Kenya (AGRA target) by the year 2012. Inputs are applied at recommended rates ($75 \text{ kg N} + 26 \text{ kg P} + 2 \text{ t lime/ha}$) to large plot areas of 250 m^2 for clear demonstrations of input effectiveness, including wider coverage of area for fertility restoration. Training of personnel at Moi University, input producers, distributors, stockists and retailers, credit facilitators and information media, is emphasized, to foster the adoption process. Field day demonstrations are also incorporated.

Research Application

The magnitudes of soil parameters from 140 farms across western Kenya are presented elsewhere (Woomer *et al.*, 2003); showing the overall acidic, low available P, C and N in the surface sandy to loam acrisols, ferralsols and cambisols. In a parallel soil fertility diagnostic study in western Kenya, soil pH, C, N and available P levels in surface soils were lower in areas where farmers considered to be infertile on their farmlands (Kamau, unpubl.).

Responses to P and agricultural lime. This study (2005-2006) delineated the effects of P and lime application from a cheaper, but an effective MPR source from Tanzania and compared the effects of these two factors (P and lime) with those of the commercial DAP and TSP sources when applied solely or in combination with lime, on maize and legume (soybean and groundnut) performance in the field. Four districts (above) under different agro-ecozones and soils were selected and the detailed experimentation is given elsewhere (Nekesa, 2007). Positive changes in soil pH and available P were found from monthly measurements during crop growth in three successive seasons; these occurred from MPR, DAP + Lime and TSP + lime treatments. But DAP on its own depressed the soil pH, confirming its acidifying reaction in soils, associated with P retention and also resultant Al toxicity in relation to crop

production (Kanyanjua *et al.*, 2002). All treatments gave significant ($p<0.01$) maize and legume yield increases across all sites (Table 1), ranging from 0.6 to 5t/ha/season from maize but from 0.2 to 0.5 t/ha/season groundnut. There was a positive effect of combining lime with DAP to create a favourable pH on acid soils for enhanced crop production. Results of this experiment mainly form the background for the current tasks to diversify fertilizer and lime applications in western Kenya.

On-going activities to promote and to diversify fertilizer, lime and other agricultural inputs. Through the current collaborations among the global and Kenyan institutions

Table 1. Maize and groundnut intercrop yields (t/ha) from phosphate and agricultural lime applications in western Kenya, first rains 2005 (Nekesa, 2007).

Treatment	Maize yield of grains			Groundnut yield of kernels	
	Kuinet Uasin Gishu	Bungoma	Siaya	Bungoma	Siaya
Control	1.36	0.58	0.52	0.22	0.22
MPR	5.38	4.54	4.40	0.59	0.33
DAP only	5.42	4.42	3.90	0.47	0.40
Lime only	5.36	4.48	2.32	0.55	0.31
DAP + lime	6.19	5.49	4.52	0.48	0.40
TSP + lime	5.45	4.62	4.57	0.58	0.35
Mean	(5.30)	(4.45)	(3.73)	(0.52)	(0.35)
LSD _{0.01}	1.45	2.10	1.25	0.30	0.22

MPR = Minjingu phosphate rock from Tanzania, DAP = diammonium phosphate, TSP = triplesuperphosphate. Values of crop yield given in this Table are the means from phosphate at 0, 30, 60 and 90 kg P/ha and lime from 0, 0.5, 1.0 and 1.5 t/ha. No linearity was detected on P and lime responses in this study.

(AGRA, BMGF, IMPHOS, TSBF, RUFORUM, KARI) and Moi University, substantial efforts have been initiated to restore the fertility of depleted soils, including soil acidity reduction through lime applications in western Kenya. These efforts include the following:

- Sensitizing smallholder farmers in particular, on the problem of soil fertility decline with its resultant low and unstable yields in this region.

This activity is being done through direct contacts between farmers and all project stakeholders through sharing information in workshops, field demonstrations focusing mainly the clear maize responses to fertilizer N, P and K nutrients and agricultural

lime on acid soils. Plot sizes for these demonstrations are large, viz, 250m² for each of the treatments: DAP, DAP + lime, MPR, ROTUBA (organic input from market refuse combined with modest DAP). The no input plots (control), planted alongside each fertility treatment above, do serve to demonstrate clearly the effects of no nutrient input application.

Other sets of treatments are also being tested, depending on protocols from cooperators above. Field days are regularly convened to demonstrate technologies and to spread the use of effective / promising technologies to other farmers.

- Through enhanced stakeholder interactions, farmers, through their own organizations (e.g. CBOs) or groups, are being encouraged to buy inputs (including quality seed) from producers, such as MEA Nakuru, Homa Lime, Athi River Company in Kenya, who produce /blend inputs and distribute them to stockists in the country. This targeted direct acquisition of inputs ensures their availability and discount prices.
- Farmers are being encouraged to put up or hire storage facilities for inputs and produce, with an overall aim for them to sell produce when prices are favourable or profitable.
- Farmers are also encouraged, through information sharing, to know the roles of current credit facilitators (e.g. CFC, Banks, (Equity Bank in Kenya), so that they can obtain loans to enhance the purchases of inputs and also repay these loans for continuity of services and hence sustained crop production.
- TSBF, BMGF and Kenyan Universities, are screening the commercially available rhizobia and micorrhizae strains that are effective in N₂ –fixation through the BNF process and enhanced P acquisition by plant roots by micorrhizae. This is a very important task, considering the very low grain legume yields, commonly below 0.2 t / ha / season in most countries in SSA and the need for low cost N.
- RUFORUM, a human capacity building institution in SSA, trains graduate students across this region on wide disciplines to increase and sustain agricultural production.

Conclusion

Collaboration efforts to increase agricultural productivity and hence food security and poverty reduction are highlighted in this paper. Preliminary findings will also be reported at this Conference/Meeting.

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