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Breaking the "Fertilizer Poverty" and Food Insecurity Traps in Smallholder Maize Based Farming System in Southern Africa: Experiences and Lessons from Soil Fertility Network/Economics and Policy Working Group (EPWG)[1]

Mulugetta Mekuria, Stephen Waddington and Shephard Siziba,

Mlugetta Mekuria, Senior Agricultural Economist, CIMMYT Southern Africa, P.O. Box MP 163 Mount Pleasant, Harare, Zimbabwe, Tel: +263 4 369120/3, Email: m.mekuria@cgiar.org

Abstract: Smallholder farmers in southern Africa face acute food insecurity because the productive capacity of their soils has declined. These resource-poor farmers increasingly cannot afford mineral fertilizers Farmers mentioned the lack of fertilizers for their depleted soils as the most important constraint- "Empty Soils, stomachs and pockets" In response to this challenge, Soil Fert Net researchers in southern Africa have developed and promoted a range of "best-bet" soil fertility management technological (SFMT) options for farmers. This paper presents a review of financial, adoption, institutional and policy analysis undertaken by EPWG members on the use of SFMT by smallholders. Financial and risk analysis tools, selected econometric models and policy analysis matrix were employed to measure profitability, incidence and intensity of adoption and to understand the effects of policy instruments necessary to promote SFMTs. Financial analysis of 'best bets' indicates that (even with current unfavorable input and output prices) there are positive payoffs to investing in SFMTs. Adoption studies in Malawi, Zimbabwe, Zambia and Mozambique revealed that farmers need to make a significant initial investment in terms of labor, land and capital before they start to obtain benefits. SFMTs are also management and information intensive and farmers' limited skills and knowledge are critical factors influencing adoption. Profitability and subsequent adoption decisions are sensitive to changes in maize grain price, crop yield and the cost of borrowing capital. The study recommend institutional and policy support and advocacy for better access to credit, input availability, market linkages to scale up the diffusion and promotion of SFMTs

Keywords

Policy briefs, Policy analysis matrix, markets, cropping systems, legumes, N fertilizer

Introduction

Southern Africa combines old soils with resource-poor smallholder farmers. The smallholder maize-based cropping systems of Southern Africa are characterized by persistent and recurring drought and widespread soil fertility decline resulting in stagnant or decreasing food production. Under smallholder production systems, yields of most staple food crops have been less than 1 tonne/hectare. Low soil fertility is now widely recognized as a major factor contributing to low productivity and non sustainability of existing production systems and long-term food insecurity in Southern and Eastern Africa (see Sanchez et al. 1997; 2002). As well as a direct contributor to reduced productivity, soil infertility is a major source of inefficiency in the returns to other inputs and management committed to smallholder farms, including N fertilizer, seed and labor (Mekuria and Waddington 2002). Thus, ways to reduce and manage soil infertility have received major attention from agricultural research and development agencies and donors in recent years (Sanchez et al. 2002).

This paper attempts to synthesize recent experience of an institutional network that has operated in Southern Africa, Soil Fert Net, in better addressing this constraint through the promotion of appropriate soil fertility technologies and identification of constraints to adoption. It draws lessons from those experiences

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to advocate institutional and policy support measures that are critical for the wider promotion and scaling up of soil fertility management options with smallholder farmers in Southern Africa.

Soil fert net and best bet soil fertility technology

An institutional innovation known as *Soil Fertility Management and Policy Network for the Maize-based Farming Systems of Southern Africa (Soil Fert Net)* operated from 1995 to 2003)[2] to deal with the challenges of developing and testing alternative soil fertility management technology options for smallholder farmers in the region. Soil Fert Net (coordinated by CIMMYT and financially supported by the Rockefeller Foundation) had a wide membership drawn from different institutions and agricultural science disciplines in Malawi, Zambia, Zimbabwe and Mozambique.

Soil Fert Net has cultivated networking in a region where human and financial resources for agricultural research and development are scarce. Networking helps use these resources efficiently to undertake collaborative research on high priority themes (e.g. on mixes of inputs external and within the farm, on ways to substitute for scarce N fertilizer by green manure and grain legumes), share available information and learn from each other. The Network has allocated small financial grants for network trials and start-up/top-up funding; supported and encouraged participatory technology testing; facilitated peer review of proposals; assisted members in sourcing of funds, helped with planning or priority setting; enabled information exchange and collective learning; organized conferences, training workshops and field tours; and produced a wide range of publications.

Soil Fert Net researchers developed, recommended and promoted what are known as “Best Bet” soil fertility management technologies (SFMT). The SFMTs have resulted from widespread participatory research and testing with the farmers on their farms in Malawi and Zimbabwe and recently in Zambia and Mozambique. They include a range of organic and mineral (inorganic) soil-fertility technology and cropping system options for smallholders in southern Africa (Mekuria and Waddington 2002). Most of the SFMTs provide some short-term soil fertility and crop productivity benefit, and several end uses, which makes them potentially attractive to farmers. They are compatible with farmer circumstances and effective within farmer resource constraints (cash, labor and land). These technologies offer farmers the “Best Bets” for improved productivity, sustainability, useful products and income[3]. Researchers in soil science, agronomy and socio economics have attempted to understand the benefits and uses of the SFMTs and the extent of their adoption.

Helpful Best Bet technology options

A wide range of helpful organic and inorganic soil-fertility technology and cropping system options (Table 1) has been developed for smallholders in southern Africa. The technologies resulted from widespread participatory research and testing on farmers’ fields in Malawi and Zimbabwe. Criteria used in the selection of the most useful “Best Bet” options included (Mekuria and Waddington, 2002):

- Longer-term contribution to raising soil fertility.
- Ability to raise crop yields and generate profit in the short term (1-2 years).
- Appropriate for many farmers across important agroecologies.
- Compatibility with other components of the farming system.
- Small additional cash and/or additional labour requirements.
- Only a small reduction in maize yields or substitution by production of other crop.
- Where possible, little competition for arable land (

Because most of these cropping systems are in unimodal rainfall zones with a long dry season, legume green manures and improved fallows can only be grown in the main cropping season and so they replace food crops on the land).

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[2] This is now being expanded into a broader Consortium that involves a wider range of institutions and disciplines, target agroecologies and farming systems.

[3] For more details of criteria used to select best bets see Mekuria and Waddington (2002).

Table 1. "Best Bet" soil fertility input and cropping system technologies for smallholder maize-based farming systems in Malawi and Zimbabwe.

Technology	***Target***		**Expected Ease of Adoption by Farmers**[1]	**Adoption potential**[2] **(number of farmers)**
	Agro-ecology	**Farm type**		
Malawi				
Soil-fertility technology				
Area-specific NP fertilizer recommendation for hybrid maize	All areas by soil type and market or home use	Richer and middle income farmers	++	900000
Optimum combinations of organic and mineral fertilizers	Most of Malawi		++	1000000
'Magoye' promiscuous soybean	All mid-elevation areas	Richer cash croppers	++	300000
Tithonia spp. biomass transfer to maize	Zones with *Tithonia* spp.	*Tithonia* spp growing on farm and labour available	+++	40000
Fertility-enhancing cropping system				
Groundnut in rotation with maize, and pigeonpea intercropped with other grain legumes	All mid elevation areas	Medium to large holdings	+++	400000
Tephrosia undersowing of maize	Mid elevation and lakeshore areas	Medium to large	++	400000
Mucuna + maize rotations	Most of Malawi, poorer soils.	Medium to large	+	200000
Faidherbia albida trees in cropland	Adaptation range (500-1000 masl)		++	500000
Sesbania undersowing	Mid elevation areas	Larger holdings	+	100000
Pigeonpea + maize intercropping	South and central Malawi	Smaller holdings	++++	1000000
Off-season "Dimba" maize to exploit fertile wetlands	Dambo (seasonal wetland) areas throughout Malawi	Access to dambo	++	200000
Soil fertility x *Striga* interactions	*Striga* affected areas		+++	150000
Zimbabwe				
Soil-fertility technology				
Fertilizer management package for maize (conditional on rainfall) and grain legumes	Subhumid and semiarid areas	All except poorest farms in driest areas	+++	1000000
Liming on acidic sandy soils	Acidic soils in subhumid areas	Higher-input farms	++	300000
Phospho-compost	Subhumid zones	Farmers near Dorowa rock P mine plus cattle kraal	++	50000
Optimum combinations of organic and mineral fertilizers	Subhumid and wetter semi-arid areas		++	600000

Improved cattle manure management, including anaerobic composting	All, except driest areas where farmers reluctant to use manure	Farmers with cattle	+	250000
Fertility-enhancing cropping system				
Pigeonpea rotations and intercropping	Subhumid areas		++	150000
Soybean (inoculated and promiscuous) in rotation with maize	Subhumid areas on better soils	Cash crop farmers	+++	300000
Mucuna + maize rotations	Subhumid areas		+	100000
Other grain-legume rotations	Subhumid and wetter semi-arid		+++	700000
Cowpea/maize intercrop	Subhumid and wetter semi-arid	Most farmers	++++	1200000

[1] + = low ++ = moderate +++ = high ++++ = extremely high
[2] Numbers of farmers that should find a technology beneficial and accessible. From estimates by key informant scientists.

Economic analysis and adoption of SFMTs

Financial analysis of velvet bean(*Mucuna*)green manure-maize rotations in Zimbabwe and Malawi (Mekuria and Siziba 2003a) revealed that pay-offs to investing in *Mucuna* as a green manure in both Zimbabwe and Malawi were positive but small for both land constrained and land adequate smallholder farmers. The risk of farmers suffering losses after investing in *Mucuna* was substantial for land constrained farmers who have to forgo one season of maize harvest to grow *Mucuna*. In Zimbabwe, SFMTs offer significant yield gains over current practice, but when combined with current farm management practices and current pricing policies the impact on income is very limited – except for soyabean.

Chilongo (2003) in Malawi used a Policy Analysis Matrix to compute the private and social profitability of several SFMT options (Table 1). It indicated that all the soil fertility technologies, except for undersown *Tephrosia*, did help build the fertility status of the soil better than modest rates of mineral fertilizer (69:21:0:4S), a current farmer practice. *Mucuna* fed the soil the best and gave the highest maize grain yield increase (of about 1.5 t/ha), but groundnut and pigeonpea had the highest net returns because they produced higher value and more marketable legume grains than did other legume grains. *Mucuna* had relatively poor net returns (US$19/ha), because currently the grain is of little economic importance to farmers. Chilongo (2003) showed that groundnut-maize rotations, pigeonpea/maize intercrop and soyabean-maize rotations are likely to be adopted (with marginal rates of return (MRR) of at least 100%). Though *Mucuna* had positive returns, it is unlikely to be taken up by farmers because of a low MRR. *Tephrosia,* with negative returns, is very unlikely to be adopted.

Studies have been conducted by Soil Fert Net's Economics and Policy Working Group (EPWG) in Malawi (Phiri 2003), Zimbabwe (Gatsi et al. 2000; Mano and Rugube 2003), Zambia and Mozambique (Mekuria and Siziba 2003b) to understand the adoption benefits, constraints and challenges that farmers face. Table 2 shows highly variable use and use intensity for a range of SFMTs in northern Zimbabwe. These studies revealed that despite many SFMT options for farmers, and efforts to popularize and promote them, their use and adoption has been very slow and the future is uncertain. These studies have identified that lack of appropriate information about technologies, their often modest potential financial returns, lack of input availability and affordability, no access to credit and output marketing, are factors that constrain adoption of SFMTs. Farmers need to make a significant initial investment in knowledge, land, capital or labor. The existence of a time lag before the farmer starts to obtain benefits from legume options and often more complex management requirements have been identified to be additional critical factors in the adoption process. Private profitability of introducing legumes into the system was found to depend on the opportunity cost of land and family labor. Under these circumstances, smallholder farmers who have limited resources at their disposal tend to be risk averse to invest in SMTs.

Table 2: Partial budgets of soil fertility technologies compared to farmers fertilization practice (69:21:0:4S) in Malawi-US$/ha (from Chilongo, 2003)

	Soil fertility cropping pattern				
	Mucuna-maize rotation	**Groundnut-maize rotation**	**Pigeonpea / maize intercrop**	**Tephrosia/maize undersowing**	**Soyabean-maize rotation**
Yield increase of maize (kg/ha)	1580	1190	655	-65	985
Yield of intercrops (kg/ha)			1059		
Yield of rotated crop (kg/ha)	2073	4215			1170
Total benefits (US$/ha)	606.45	4160.70	964.70	86.60	1116.80
Total costs (US$/ha)	508.23	623.95	79.63	125.93	543.71
Net benefits (US$/ha)	98.22	3536.75	885.07	-39.33	573.09
Marginal Rate of Return (%)	19	567	1112	-31	105

Table 3: Farmer awareness, frequency and intensity of adoption of a range of soil fertility management technologies (SFMT) in selected sites of northern Zimbabwe, 2001-2002. (from Mano and Rugube, 2003)

	Aware	**Willing to use**	**Using**	**Rate of application (kg/ha)**	**Recommended rate (kg/ha)**	**Percent arable area under technology**
	Percent of farmers					
Fertilizer	99	90	97	193	400	65
Cattle manure	98	93	86	1224	6000	20
Lime	81	74	13	18	300 per yr	6
Soybean rotation	85	93	58	-	-	-
Green manure	51	88	35	3% of maize area	50% of maize area	6
Termite mound	94	65	45	-	-	-

A synthesis of SFMT adoption studies by EPWG-Zimbabwe (Mano, 2003) confirmed that the likelihood of adoption is influenced by type of technology, farmer specific socio economic characteristics and crosscutting economic policies and institutional parameters. For mineral fertilizers and cattle manure, the most important determinants of adoption among the farming households were relatively large land size, more wealth and those with more experience (and for manure older) than average, and higher rainfall.. In the case of lime use, households with more land and more wealth, active membership in an extension group and high rainfall are more likely to adopt. Table 2 depicts that a higher percentage of farmers reported to have adopted mineral fertilizers and cattle manure. Incidence of adoption for lime, green manure and termite mound are low. In the semiarid areas of Zimbabwe, both the pattern and intensity of adoption of SFMTs are very low.

Promotion of Best Bet technology

Different ways have been employed to promote the use of Best Bets in Malawi and Zimbabwe (Mekuria and Waddington 2002). Information brochures were developed on Best Bets and many thousands of copies have been produced and distributed to farmer advisors in extension services, colleges, farmer unions and NGOs. There has been participatory extension and farmer training with the technologies, involving widespread on farm testing, modification and promotion through a range of partnerships with extension services, farmer groups and NGOs. Farmer feedback on the technologies (Snapp et al. 2002), their fit into their systems and types of support they need have been obtained. Pilot scale activities have been undertaken to multiply and distribute inputs such as seed of Best Bet legumes to farmers, farmer groups, and NGOs. Several technologies were promoted in an extension led initiative over four years with almost 4000 farmers in Chihota Communal Area, Zimbabwe (see Mekuria and Waddington 2002). There, farmer groups conducted 100s of group demonstrations and farmer experiments on several technologies including liming, soybean rotation, groundnut rotation, velvet bean and sunnhemp green manuring. Farmers also got involved in ways to improve the attractiveness of new technologies, particularly soybean, through sharing of recipes and dishes. The project emphasized field days, group learning and farmer-to-farmer sharing of knowledge.

Institutional arrangements such as Commodity Task Forces on maize in Malawi and soybean in Zimbabwe also helped to focus awareness and channel resources into large-scale efforts to disseminate some of the Best Bets. The Maize Task Force in Malawi mounted more than 2000 demonstrations throughout the country at village level on area specific fertilizer recommendations for maize and this approach helped Malawi's area specific fertilizer recommendations to be accepted by the extension service in 1997 and their policy implications to be assessed with Government. These more flexible recommendations are now promoted nationwide. Soil Fert Net members within the Maize Task Force provided the technical input on expected benefits from technology options and helped develop input support strategies for a nationwide initiative to give fertilizer, and maize- and legume-seed starter packs to all 1.8 million smallholder households in Malawi during the 1998/99 and 1999/2000 cropping seasons. Collectively the Government of Malawi, UK Department for International Development, European Union and the World Bank provided over US$23 million for this program in 1998/99. It has had a major impact on human nutrition and household food security in Malawi, and is an excellent example of where technical scientists have influenced Government and donor policy.

The foregoing biophysical and economic assessments show that some Best Bet soil fertility technologies are viable options for southern Africa's smallholders to tackle soil fertility problems and increase maize production and food security. However, the adoption of Best Bet options by local farmers has often been very selective (Mekuria and Waddington 2002), while the number using mineral fertilizers has declined. Analysis of awareness and adoption patterns in selected sites in Zimbabwe revealed that 86% of farmers use cattle manure, 58% soybean, 35% green manure and only 13% lime (Mano 2003). Institutional factors often constrain adoption. For example, in a recent farmer survey in Mozambique, 12% of farmers had some access to credit and 76% had never seen an extension agent. It is now becoming clear that to enhance the use and adoption of soil fertility Best Bets from promotion initiatives in the region will require policy support to improve access to input supply (particularly seeds and fertilizer) and market linkages for outputs. Adoption of grain legumes will increase when farmers can market their surplus production at favourable prices. For example in Zimbabwe, lack of a cowpea grain market discouraged adoption of cowpeas by farmers

Lessons for institutional and policy support

Economic reforms introduced since the early 1990s have not favored small scale agriculture in general as market imperfections still persist within regional economies. The rate of liberalization of input markets was much faster than that of output markets, especially that of maize. Maize has been re-controlled in some countries. The changing policy framework in grain marketing in Zambia and Zimbabwe has created uncertainty and a vacuum in the delivery of inputs and output marketing. The low producer pricing policies adopted by governments heavily tax smallholders while subsidizing urban consumers. In the last two years, the maize producer price in Zimbabwe has been 30% of the import parity price. Low producer prices reduce the financial ability of farmers to invest in SFMTs, contributing to low yields, reduced maize production and to national food insecurity.

Absence of market outlets selling SFM inputs for green manures (*Mucuna*), grain legumes (cowpea, soyabean seed and *Rhizobium*), lack of competitive providers of marketing services linking farmers to markets, distance to input and output market are major institutional constraints that require the attention of policy makers. New market innovations that are likely to reduce transaction costs and increase farm level returns to the adoption of SFMTs are being examined in the region. Pilot studies in Zimbabwe and Malawi demonstrated the potential role of trained rural agro dealers in bringing inputs and information nearer to farmers and making them available in small packages. Alternative output marketing arrangements that would reduce marketing costs and encourage the adoption of SFMTs are also being tested. Findings from EPWG studies need to be urgently communicated to policy makers. Identification of technology-specific policy support and advocacy strategies required for improving soil fertility have been limited. Under the new regional Soil Fertility Consortium, members plan to produce policy briefs that document these lessons, and identify the policy implications and policy instruments required to enhance the adoption and promotion of SFMTs.

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