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GETTING MORE "BANG FOR THE BUCK": DIVERSIFYING SUBSIDIES BEYOND FERTILIZER AND POLICY BEYOND SUBSIDIES

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Summary: Input subsidies are the single greatest expenditure under poverty reduction programs in Zambia. Yet maize yields continue to fall well short of international standards. One major reason appears to be the yield limiting effects of acidity, which is highly common on Zambian soils. We suggest a diversification of the input subsidy scheme beyond fertilizer to include inputs that reduce acidity and raise the yield response to fertilizer application. We further discuss specific recommendations for diversifying productivity investments to put more emphasis on extension and agronomic research.

INTRODUCTION: Zambia has enjoyed two consecutive record-setting years of total maize production that coincided with massive increases in distribution of subsidized fertilizer through the Farmer Input Support Program (FISP). Research has demonstrated, however, that the primary cause of the growth in production has been unusually favorable weather rather than increased fertilizer use. Using the 2006, 2007, and 2008 harvests as the baseline, 15% of the additional maize production in 2011 is the result of increased fertilizer use, while 42% is attributed to differences in weather (Mason et al. 2011). The activities of the Food Reserve Agency (FRA) are responsible for much of the remainder, due to the incentives it has created to induce the expansion of maize farm land.

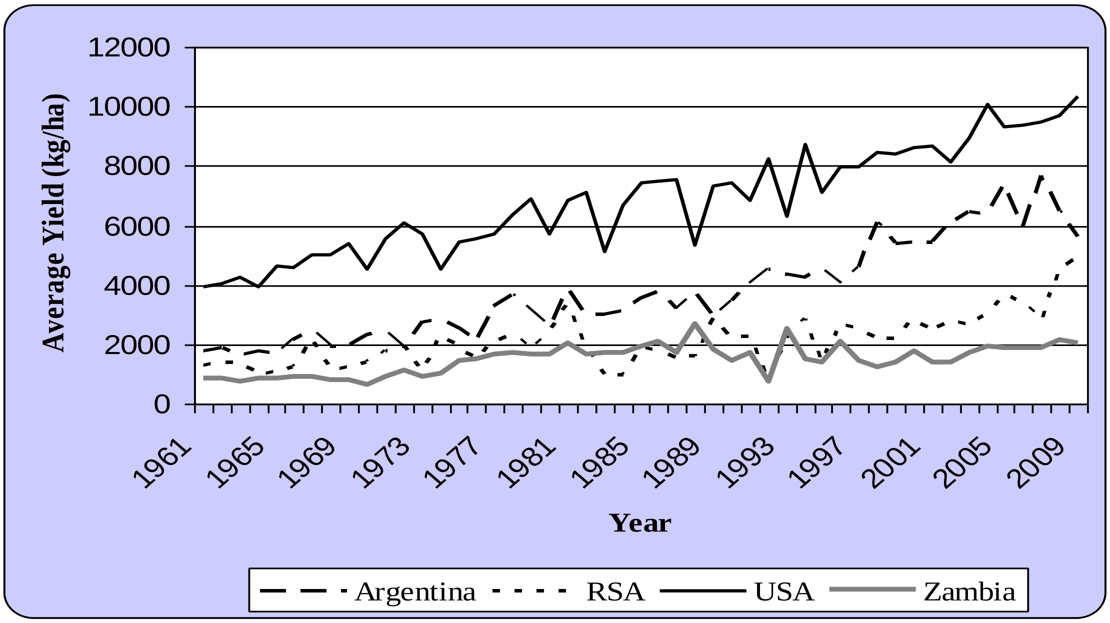
Whatever the source of the recent growth in maize production, the consecutive surplus harvests have masked the fact that Zambian land productivity still falls far short of the standard for other surplus producing countries such as South Africa, Argentina and the U.S. (Figure 1). In fact, maize yield in Zambia has been stagnant for decades, even despite the dramatic increase in the use of FISP fertilizer in recent years. The unfortunate fact remains that the majority of Zambia's small farmers still do not produce enough to feed their own families, and very few sell any substantial surplus.

As the newly elected government of Michael Sata forms agricultural policies that will guide investments over the next 5 years, it might be useful to ask why the input subsidies of previous governments did not increase productivity more effectively.

INEFFECTIVE INPUTS ON ACIDIC SOILS: Issues related to corruption and untimely input deliveries are often mentioned when Zambia's input program is criticized. Much less attention is given to the fact that inputs other than fertilizer could also be considered as a means to increasing productivity.

At the most sophisticated level of commercial farming, small variations in soil characteristics and other agronomic conditions dictate that the appropriate input technology can vary from one corner of a field to the other. As this synthesis is being written, there are commercial farmers in the Southern Africa region using photo sensing and infrared technologies to adjust input mixes and

Figure 1. Maize Yields in Zambia versus Global Exporting Countries (1961-2009)



Source: FAOSTAT accessed July 2011.

optimize input use on their maize fields with this level of precision. It is obviously unrealistic to expect the Government of Zambia (GRZ) to do this for all the farmers receiving input subsidies. However, this is the level of efficiency with which small surplus producing farmers will increasingly need to compete. Fortunately, policy makers *could* address at least one glaring disadvantage faced by small farmers. Specifically, one recent study demonstrates that soil acidity is a substantial limiting factor in Zambian maize production. This is not a new revelation, but the fact that nothing has been done to address it continues to impede most Zambian farmers' yields as well as their livelihoods. This issue particularly stands out because there are low-technology management practices to deal with it that could dramatically increase small farmer productivity and competitiveness.

For the most part Zambian soil is acidic by nature due to the parent material from which it was derived several thousand years ago and the prevailing pattern of rainfall. Over the past few decades, concentrated crop mixes and extensive fertilizer use have worsened the problem. Acidity on maize fields affects yield both directly, through the impact it has on the plants themselves, and indirectly through the impact it has on fertilizer's effectiveness. These effects can severely limit yield potential on maize fields (the photograph on page 4, for example, shows the effect of acidity on a maize field in Mississippi, USA). Basal fertilizer in particular, which contains primarily phosphorus, is vulnerable to nutrient lockup in the acidic soils that prevail throughout Zambia, rendering it of limited use to plants.

Phosphorus is a necessary element in the processes of storing the sun's energy and plant growth (Griffiths 2010). When phosphoric fertilizer is applied, it chemically bonds with other nearby elements in the soil, forming what is known as a phosphate. Not all phosphates are alike, however, and the type that is formed is highly correlated with soil acidity. On acidic soils, the phosphorus in basal fertilizer converts to aluminum and iron phosphates, which are unavailable for plant consumption. On neutral and semi-neutral soils, phosphorus will convert to mono- and di-calcium phosphates that are readily consumed by the plant.

Table 1. Changes in Zambian Yield Response to Basal Fertilization over a Range of Soil Acidity Levels

Soil pH	**3.1 - 4.3**	**4.4 - 5.4**	**5.5 - 7.1**
Additional kgs of maize harvested per kg of basal fertilizer applied (mean across fields)	2.1	3.7	7.6
% of maize fields nationwide in this category	51%	47%	2%

Source: Authors' calculations from FSRP/CSO Supplemental Survey data, 2004 and 2008 .

Table 1 shows the estimated average marginal yield response to basal fertilizer application in Zambia over a range of prevailing pH levels (pH is the standard unit of acidity measurement where lower values indicate greater acidity) and the distribution of fields in the nationally representative sample of the more than 7,000 fields used in this study. In the pH range below 4.4 (i.e., in very acidic soils) yield response to basal application is just 2.1 incremental kgs of maize per kg of fertilizer. Response is higher over the pH range from 4.4 to 5.5, where the average effect is 3.7 kg/kg. Above the 5.5 pH level (i.e., in semi-neutral soils) yield response increases considerably, more than doubling to 7.6 kg/kg, on average.

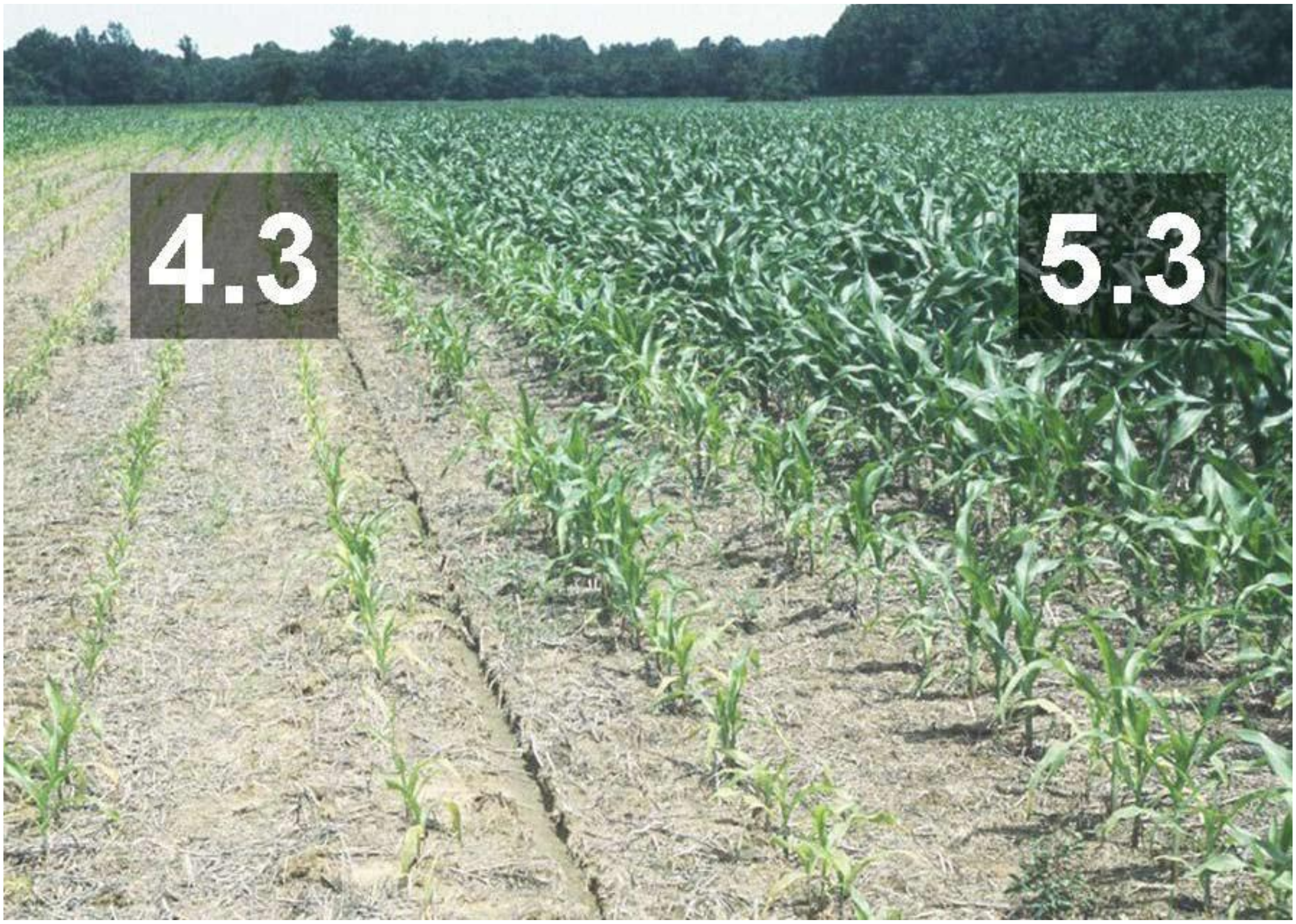
A vast body of agronomic literature on the limited effectiveness of phosphoric fertilizers on maize in acidic soils corroborates these findings. The unfortunate fact for Zambia is that the overwhelming majority of all maize fields (98% of those used in the study generating these estimates) are in areas where most soils are acidic and where basal fertilizer is relatively ineffective.

In his first speech to the new Parliament on October 14th, 2011, President Sata stated that GRZ would continue input subsidies "with a view of enabling farmers to be weaned-off" the program while continuing to use fertilizers they will then purchase commercially. At these response rates this vision is simply unattainable because using fertilizer without mitigating soil acidity is only profitable when it can be purchased at subsidized prices.

CHANGING THE STRATEGY: Much of the difference between Zambian yields and those of the other exporting countries illustrated in Figure 1 is driven by the fact that Zambian farmers are working on different soils than most of the farmers in those countries. Policies that ignore this fact will struggle to increase productivity in the long run. This calls for a shift in the design of agricultural productivity policies, away from fertilizer subsidies as the cornerstone and towards developing a more integrated program in support of farm productivity. This may include fertilizer subsidies along with other inputs and agronomic practices that are both sustainable and profitable. That a policy shift is necessary is clear, but how new investments should be prioritized is less so. Among other things, designing and implementing new programs will require significant research and extension.

The Zambian Agricultural Research Institute (ZARI) is the most logical place for this research to take place. The results of the study mentioned above were shared with several researchers and officials at ZARI. All agronomists and officials interviewed were fully aware of the fact that acidity affects the productivity of both maize plants and the fertilizer applied near them, and the fact that most Zambian soil is acidic. Indeed, Zambian agronomists even have working theories on how to solve the problem.

In the opinion of senior ZARI researchers, one approach to address this and other productivity limitations is to develop acid resistant seed varieties that are specifically designed to prosper on Zambian soils. There are, however, very limited resources dedicated to such endeavors. According to one official, the budget allocated to improved plant development for all



Source: Larson and Oldham 2008. The white numbers indicate the pH levels on two sides of this field in Mississippi, USA.

of Zambia is less than 0.5 billion Kwacha annually, while in fact the laboratories tend to receive less than half of that. This portion of the budget is frequently re-allocated to either FISP or FRA.

That said, additional research might not be necessary to improve yields in the short term because ZARI has generated Zambia-specific knowledge that has yet to be fully exploited. It is known to agronomists (and commercial farmers), for example, that lime application is the most direct management practice to solve the problem of soil acidity. Certain types of lime even have the added benefit of adding calcium and,magnesium (useful elements) to the soil, while neutralizing manganese and aluminum (harmful elements).

If Zambian officials are aware of both the acidity problem and at least one potential solution to it, one must wonder why smallholders do not attempt to manage their soil's pH. Less than 2% of this study's sample applied lime, and those who did applied at just 5-10% of the recommended rate, on average. According to officials, there are two primary constraints.

First, the cost of getting the appropriate amount of lime on to the field is high. The unit price of lime itself is relatively low (the retail price per kg is approximately 10% of that for basal fertilizer), but ZARI application recommendations are 1-2 tonnes per hectare (5-10 times greater than the recommended basal fertilization rate). Moving that quantity of lime has been cost prohibitive. For example, while a 50 kg bag of lime may cost 17,000 ZMK at the retailer, officials estimate the cost at the farm gate can be as high as 80,000 ZMK in more remote areas. If this is true, distributing sufficient lime would indeed cost more than twice the cost of distributing the current amount of basal fertilizer. That said, ZARI has experimental results demonstrating that lime alone can more than double yields on acidic soils, while phosphoric fertilization alone has almost no impact. In short, the added benefit of distributing lime would almost certainly outweigh the added cost. Unfortunately, these ZARI findings have never been broadly published.

The second constraint is the lack of farmer awareness regarding the negative impacts of soil acidity and the mitigating effects of lime application. For a brief period, The Program Against Malnutrition (PAM) included lime in the package of goods distributed to its beneficiaries. Not realizing the potential benefits, or in some cases believing lime would damage rather than enhance their soil, officials say the majority of the recipients either disposed of their lime or mixed it with water to use as paint for their houses. Moreover, if not finely ground, it may take several years after applying lime before its beneficial impacts are observed. This led many farmers to argue against including lime in subsequent subsidy packages after failing to see any benefits after the first year. Subsequent field trials have shown that lime application in powder form produces demonstrable benefits even in the first year of application.

Low awareness is a surmountable hurdle but, at current budget allocations, extension officials claim they are not adequately equipped to convince farmers to shift input strategies. For example, ZARI has produced production guides for several crops, including one for maize that discusses the importance of liming. Funding, however, has limited production of these guides to about 2,000 copies per crop. In a nation of nearly 1,500,000 small farming households, this is staggeringly inadequate. That said, extension officials claim that guides alone are not sufficient to change behavior without sustained sensitization efforts. On-the-ground evidence will be necessary, they say, through example plots that demonstrate the benefits of soil pH management over several years. Resources for maintaining such plots have not been allocated.

Officials estimate that one plot per District Camp would sufficiently sensitize farmers regarding the benefits of managing pH. There are roughly 1,700 such Camps in Zambia, each with an extension officer already in place. Roughly half of them are in areas where highly acidic soil is prevalent. By official reckoning, the additional cost of installing and managing each demonstration plot would be ZMK 2.5-5 million per year. A pilot program of 100 Camps over three years would thus cost less than roughly 1% of the government's allocation to FISP in 2011 alone. Using the high cost estimate, managing one demonstration plot in every one of the 800 Camps where soil acidity is the worst would cost 4 billion Kwacha per year. This is less than the 5.2 billion allocated to the annual Agricultural Show in 2011, a three day event held in the capital, which incidentally, is partially meant to be a farmer outreach program.

Liming is not the only solution to the productivity limitations of acidic soil. For example, it has been shown that applying small bands of fertilizer very near, around, or under the seed at the time of planting makes phosphoric fertilization more effective in acidic soil. This is known as banding application, as opposed to evenly spreading fertilizer over the entire field, or broadcasting, as is commonly practiced in Zambia.

Private firms in developed countries produce phosphorus enhancing fertilizer supplements that alter the soil chemistry near the fertilizer to protect it from becoming unavailable to plants. These fertilizer supplements have been tested extensively on US soils, where they have are found to increase yields by 15-20%. The benefits may be even greater on Zambia's more acidic soils.

Increasing farm productivity is an obtainable goal for Zambian policy makers. Results from the study discussed here demonstrate it will be important for new policies to acknowledge that there are potentially much more effective input alternatives to fertilizer alone. Acidity mitigating measures could be taken to improve yields in a meaningful way for the first time in decades. This may be through tailored application methods, the use of supplementary inputs such as lime and phosphorus enhancers, or some combination of pH mitigation and management practices. The optimal prescriptions are unknown and finding them will require investments in agronomic research specific to Zambia's agricultural systems.

Other practices that will need to be widely adopted to reduce the current wide gap between Zambian farmers' actual and potential yields include: planting on time; taking steps to ensure reasonable drainage on the plot to reduce potential waterlogging damage; using conservation farming techniques; using herbicides and insecticides when needed; using the appropriate plant population for the size of the plot; soil testing to identify plots' micro-nutrient deficiencies and then use the appropriate *fertilizer cocktails* to address them; and improving the soil structure and soil organic content of the plot.

One thing is clear; subsidy policies focusing on fertilizer alone will not succeed in producing long-term economic growth in Zambia. On August 3, 2011, shortly before becoming Vice President of Zambia, Guy Scott wrote openly in his column in The Post newspaper about the need to improve and diversify the input subsidy program. We wholeheartedly agree. In fact, there is a need to revise the set of productivity enhancing policies as a whole. Addressing the issues related to soil acidity and allocating more resources to agricultural research and meaningful farmer extension programmes would be a good start.

This synthesis draws on results presented in:

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For more information on the Food Security Research Project:
http://www.aec.msu.edu/fs2/zambia/index.htm