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SOIL FERTILITY MANAGEMENT AND AGRICULTURAL PRODUCTIVITY IN MALAWI

Hardwick Tchale und Johannes Sauer[*]

Abstract

In this paper we analyze the factors that influence the productivity of maize among smallholder farmers. We use farm-household survey data in order to compare the productivity of smallholder maize production under integrated (ISFM) and chemical-based soil fertility management using a normalized translog yield response model. The results indicate higher maize yield responses for integrated soil fertility management options after controlling for the intensity of fertilizer application, labour intensity, seed rate, land husbandry practices as well as selected policy factors. The estimated model is highly consistent with theoretical conditions. Thus we conclude that the use of ISFM improves maize productivity, compared to the use of inorganic fertilizer only. Since most farmers in the maize-based farming systems are crowded out of the agricultural input market and can hardly afford optimal quantities of inorganic fertilizer, enhancement of ISFM is likely to increase their maize productivity. We finally highlight areas of policy support needed to enhance ISFM uptake in smallholder maize-based farming systems.

Keywords

Malawi, smallholder agriculture, soil fertility management, yield response model

1 Introduction

Maize is the dominant crop in most smallholder farming systems in Africa south of the Sahara. In Malawi, it is the main staple crop, estimated to be grown on over 70 % of the arable land and nearly 90 % of the cereal area, making Malawi the world's highest consumer of maize at 148 kg per capita per year (SMALE and JAYNE, 2003). Thus, maize will remain a central crop in the food security equation of Malawi even if the agricultural economy is diversified. The dominance of maize as a staple crop mainly emanates from self-sufficiency policy which the Government adopted after independence in the mid 1960s. This resulted from the need to produce enough food to feed the growing rural population as well as keep staple food prices low. In this paper, we analyze the factors that influence productivity of maize among smallholder farmers, given that unfavourable output and input market conditions throughout the 1990s, have compelled smallholder farmers into unsustainable agricultural intensification. Currently, the most comprehensive studies of smallholder productivity in Malawi have been conducted by CHIRWA (1996), CHIRWA (2003) and EDRISS et al. (2004). The first two studies have used data collected from a sample of farmers from Machinga Agricultural Development Division (ADD). EDRISS et al. (2004) used national level data to analyze the levels of maize productivity given the labour market liberalization. All these studies use parametric approaches to estimate the efficiency of Malawian smallholder farmers in maize production. Our study complements these studies in a number of ways. First, the first two studies have been restricted to only one agro-ecological zone and their results may not be applicable to other agro-ecological zones, whereas our sample is drawn from three agro-

[*] Dr. Hardwick Tchale, Worldbank, Malawi; Assistant Professor Dr. Johannes Sauer, Royal Veterinary and Agricultural University, Institute for Food and Resource Economics, Rolighedsvej 25, 1958 Copenhagen, Denmark, js@foi.dk.

ecological zones and thus accounts for agro-ecological variations. Secondly, both studies did not account for the theoretical regularity conditions in their analysis. Therefore it is highly likely that policy conclusions drawn from these studies may have been flawed due to lacking regularity of the estimated functions. Thirdly, our study considers the productivity effect of alternative soil fertility management options available to smallholder farmers. This is important because while many alternative soil fertility management options have been developed for smallholder farmers, very little is known about their impact on improving smallholder farmers' productivity. The obvious weakness of the study by EDRISS et al. (2004) is the use of national level data that masks the farm-level variations. We improve on that by using farm-level data.

2 Review of Smallholder Maize Productivity in Malawi

Despite the central role that maize plays in food security in Malawi, its productivity has not been impressive especially from the early 1990s when stagnation in maize yield led to frequent food security problems. SMALE and JAYNE (2003) have attributed the decline in maize yield to four main reasons: (i) removal of subsidies; (ii) devaluation of the Malawi Kwacha; (iii) increase in world fertilizer prices; and (iv) low private market development because fertilizer dealers require substantial risk premiums to hold and transport fertilizer in an inflationary economy with uncertain demand (CONROY, 1997; DIAGNE and ZELLER, 2001; BENSON, 1997; 1999). The situation is exacerbated because maize price changes follow export parity while fertilizer price changes reflect full import costs. Since most fertilizer in Malawi is used on maize (and tobacco), the removal of implicit subsidies in the form of overvalued exchange rates had a strong negative effect on fertilizer use. Furthermore, since almost all of Malawi's fertilizer supply is imported, the depreciation of the real exchange rate has also invariably raised the nitrogen to grain price ratios (MINOT et al., 2000; HEISEY and SMALE, 1995). One critical consequence of the increase in fertilizer prices relative to maize grain prices is that most farmers over the past decade have continued to over-exploit the natural soil fertility. This is because the improved maize varieties released by the National Agricultural Research (i.e. MH17 and MH18) proved to yield more than local maize without fertilizer at the seed prices that prevailed through the early 1990s. This implies that it made economic sense for farmers to grow hybrids even if they could not apply fertilizer (HEISEY and SMALE, 1995; BENSON, 1999). This has resulted in soil fertility mining, leading to unsustainability, as the inherent soil fertility is no longer capable of supporting crop growth at a rate that is required to feed the growing population. This calls for concerted efforts to promote smallholder soil fertility management using relatively more sustainable options such as integrated soil fertility management (ISFM) i.e. involving incorporation of grain legumes and inorganic fertilizer in maize production systems. However, farmers' choice of the available soil fertility management options depends to a large extent on the relative returns of the options.

3 Theoretical Review

A number of functional forms have been used to specify yield response functions, most commonly the Cobb-Douglas, quadratic, square root, translog, Mitscherlich-Baule (or MB) as well as the linear and non-linear Von-Liebig functions. The rationale for choosing a particular functional form depends on the research questions and the underlying production processes to be modeled. Furthermore, the choice of a functional form should be based on the need to ensure rigorous theoretical consistency and factual conformity within a given domain of application as well as flexibility and computational ease (LAU, 1986; SAUER et al., 2004). For example, while the Cobb-Douglas is simpler and easier to estimate, it assumes invariant returns to scale and does not ensure the attainment of a yield response plateau, thereby resulting in an overestimation of the optimal input quantities (ACKELLO-OGUTU et al., 1985). While the polynomial functions (i.e. the quadratic and square root) allow for the diminishing marginal returns of inputs as well as flexible input substitution, they are also lacking when it comes to the yield response plateau. The non-linear Von-Liebig and MB functions are the most widely used functions, especially in the field of agronomy. However, because they are highly non-linear, especially when a number of inputs are involved, their estimation is cumbersome and liable to several parametric restrictions. The other weakness of the MB function is that it may not be appropriate for modeling farm production in developing countries because it is only appropriate for stage II production (where marginal product increases at a decreasing rate). But research shows that most constrained farmers in developing countries still largely operate within stage I where marginal product increases at an increasing rate (FRANKE et al., 1990; KEYSER, 1998). The following analysis uses a primal production function rather than the dual profit function as the latter is conditioned on prices. Relevant prices in the study area suffer from a considerable bias of aggregation as it is fairly difficult to capture the variation in prices on household level. Given further the uncertainties in expected agricultural prices and production, it is unlikely that the correspondence between expected prices and production would give a good model fit.

4 The Empirical Model

In this analysis, we use a normalized translog functional form because we assume that yield response depends on nitrogen use efficiency and a second order polynomial function can approximate such a relationship. The normalized translog models have been widely used for describing the crop response to fertilization and tend to statistically perform better than other functional forms. BELANGER et al. (2000) compared the performance of three functional forms (quadratic, exponential and square root) and concluded that although the quadratic form is the most favoured in agronomic yield response analysis, it tends to overstate the optimal input level, and thus underestimating the optimal profitability. Other studies that have reached similar conclusions include BOCK and SIKORA (1990), ANGUS et al. (1993) and BULLOCK and BULLOCK (1994). Our choice of the normalized translog is based on two further reasons: First, it is the best-investigated second order flexible functional form and certainly one with the most applications (SAUER et al., 2004); secondly, this functional form is convenient to estimate and proved to be a statistically significant specification for economic analyses as well as a flexible approximation of the effect of input interactions on yield. The normalized translog maize production model can be expressed as:

$$\ln(\frac{q}{q'}) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln(\frac{x_i}{x_i'}) + \frac{1}{2}\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} \beta_{ij} \ln(\frac{x_i}{x_i'}) \ln(\frac{x_j}{x_j'}) + \sum_{k=1}^{m} \gamma_k z_k + \varepsilon_i \qquad \varepsilon_i \in N(0,\sigma^2) \qquad [1]$$

Where q is the yield (kg/ha), x_i are the variable inputs (fertilizer, labour and seed), z is a vector of productivity shifters such as land husbandry practices (i.e. weeding and date of planting) as well as rainfall. All variables are normalized to the sample mean by dividing by the mean value (q', x_i', x_j'). We also include a dummy variable for soil fertility management (i.e. integrated management or use of inorganic fertilizer only) in order to assess the impact of soil fertility management choice on yield response as well as other control variables. a_i are the linear input parameters, β_{ij} are the quadratic and interaction parameters, δ_k are the parameters for the productivity shifters and ε_i is the error term assumed to be randomly distributed with zero mean and constant variance σ^2.

In the case of a (single output) production function monotonicity requires positive marginal products with respect to all inputs and thus non-negative elasticities. With respect to the normalized translog production model the marginal product of input i is obtained by multiplying the logarithmic marginal product with the average product of input i. By further adhering to the law of diminishing marginal productivities, marginal products, apart from being positive should be decreasing in inputs. However, both restrictions (i.e. $\left[\partial(q/q')/\partial(x_i/x_{i'})\right]>0$ and $\left[\partial^2(q/q')/\partial(x_i/x_{i'})^2\right]<0$) should hold at least at the point of approximation.

The necessary and sufficient condition for a specific curvature consists in the semi-definiteness of the bordered Hessian matrix as the Jacobian of the derivatives $\partial(q/q')/\partial(x_i/x_{i'})$ with respect to x_i: if $\nabla^2 Y(x)$ is negatively semi-definite, Y is quasi-concave, where ∇^2 denotes the matrix of second order partial derivatives with respect to the normalized translog production model. The Hessian matrix is negative semi-definite at every unconstrained local maximum[1]. The conditions of quasi-concavity are related to the fact that this property implies a convex input requirement set (see in detail e.g. CHAMBERS, 1988). Hence, a point on the isoquant is tested, i.e. the properties of the corresponding production function are evaluated subject to the condition that the amount of production remains constant. Hence, with respect to our normalized translog production model it has to be checked a posteriori for every input bundle that monotonicity and quasi-concavity hold. If these theoretical criteria are jointly fulfilled the obtained estimates are consistent with microeconomic theory and consequently can serve as empirical evidence for possible policy measures.

With respect to the proposed normalized translog production model quasi-concavity can be imposed at a reference point (usually at the sample mean) following JORGENSON and FRAUMENI (1981). By this procedure the bordered Hessian is replaced by the negative product of a lower triangular matrix Δ times its transpose Δ' (see appendix A1). Imposing curvature at the sample mean is then attained by setting

$$\beta_{ij} = -(\Delta\Delta')_{ij} + \alpha_i\lambda_{ij} + \alpha_i\alpha_j \qquad [2]$$

where i, j = 1, …, n, $\lambda_{ij} = 1$ if i = j and 0 otherwise and $(\Delta\Delta')_{ij}$ as the ij-th element of ΔΔ' with Δ a lower triangular matrix. As our point of approximation is the sample mean all data points are divided by their mean transferring the approximation point to an (n + 1)-dimensional vector of ones. At this point the elements of H do not depend on the specific input price bundle. The estimation model of the normalized translog production function is then reformulated as follows:

$$\ln(\frac{q}{q'}) = \alpha_0 + \alpha_1 \ln(\frac{x_1}{x_1'}) + \alpha_2 \ln(\frac{x_2}{x_2'}) + \alpha_3 \ln(\frac{x_3}{x_3'}) + \frac{1}{2}\left(-\delta_{11}\delta_{11} + \alpha_1 - \alpha_1\alpha_1\right)\ln(\frac{x_1}{x_1'})^2 + \frac{1}{2}\left(-\delta_{12}\delta_{12} - \delta_{22}\delta_{22} + \alpha_2 - \alpha_2\alpha_2\right)\ln(\frac{x_2}{x_2'})^2$$
$$+ \frac{1}{2}\left(-\delta_{13}\delta_{13} - \delta_{23}\delta_{23} - \delta_{33}\delta_{33} + \alpha_3 - \alpha_3\alpha_3\right)\ln(\frac{x_3}{x_3'})^2 + \frac{1}{2}\left(-\delta_{12}\delta_{11} - \alpha_1\alpha_2\right)\ln(\frac{x_1}{x_1'})\ln(\frac{x_2}{x_2'}) + \frac{1}{2}\left(-\delta_{13}\delta_{11} - \alpha_1\alpha_3\right)\ln(\frac{x_1}{x_1'})\ln(\frac{x_3}{x_3'})$$
$$+ \frac{1}{2}\left(-\delta_{13}\delta_{12} - \delta_{23}\delta_{22} - \alpha_2\alpha_3\right)\ln(\frac{x_2}{x_2'})\ln(\frac{x_3}{x_3'}) + \sum_{k=1}^{m}\gamma_k z_k + \varepsilon_i$$
[3]

However, the elements of Δ are nonlinear functions of the decomposed matrix, and consequently the resulting normalized translog model becomes nonlinear in parameters. Hence, linear estimation algorithms are ruled out even if the original function is linear in parameters. By this "local" procedure a satisfaction of consistency at most or even all data points in the sample can be reached. The transformation in [3] moves the observations towards the approximation point and thus increases the likelihood of getting theoretically consistent results at

[1] Hence, the underlying function is quasi-concave and an interior extreme point will be a global maximum. The Hessian matrix is positive semi-definite at every unconstrained local minimum.

least for a range of observations (see RYAN and WALES, 2000). However, by imposing global consistency on the translog functional form the parameter matrix is restricted leading to seriously biased elasticity estimates. Hence, the translog function would lose its flexibility. By a second analytical step we finally (a posteriori) check the theoretical consistency of our estimated model. The optimal level of x_i is obtained by setting the marginal productivity (i.e. the first order condition) equal to the input/output price ratio. Using the predicted yield response at the optimum level of x_i, predicted profit levels are compared between the two soil fertility management practices. The predicted profit equation is given as:

$$\pi = p.q - \sum_{i=1}^{j} cx_{ij} \qquad [4]$$

where p and c are output and input prices. Assuming that all farmers face the same output and input prices, then profit will solely depend on the yield response function given by the marginal productivity of the input. Thus:

$$\frac{\partial \pi}{\partial x_i} = \bar{p} * \frac{\partial q}{\partial x_i} - \bar{c} \qquad [5]$$

Therefore, substituting the optimal level of x_i into equation [4], and solving for q, keeping all the other variables at the mean, results in the optimal yield, which is then used in calculating the level of profit.

5 Data

The data used for analysis in this study were based on a farm household survey administered to a stratified sample of 376 farmers. These farmers were randomly drawn from those that have been participating, more or less consistently, in the soil fertility management efforts involving public research institutions, donor organizations and NGOs for at least the last 5 seasons. From these farmers, maize technology information related to variety grown, rate of input application, other soil fertility options applied as well as the general husbandry practices applied to the crop were collected and used in the analysis. The sample used for the analysis comprises of 253 plots on which hybrid maize was grown as the main crop.

To validate the performance of various soil fertility management practices, we compared the farmers' yields with those obtained from two on-farm trails (trial by the Maize Productivity Task Force in 1997/98 season and the Nationwide Best-bet Trial by the Malawian Extension Service in 1998/99). The objective was to compare the maize yield responses of fertilized and unfertilized legume cropping systems. In total six treatments were included in the experiment: (i) green legume rotation involving either soybean or groundnuts; (ii) Mucuna pruriens rotation; (iii) maize pigeon pea intercrop; (iv) fertilized maize; (v) unfertilized maize; and (iv) local maize (fertilized and unfertilized) as the control. Apart from the key inputs such as fertilizer, seed and labour, the specification of the productivity model includes also a number of important control variables that substantially affect yields, especially in the smallholder farming systems. These include rainfall and its variation, crop husbandry practices such as weeding frequency and date of planting as well as the critical policy variables i.e. frequency of extension visits, access to seasonal agricultural credit, access to product and factor markets and agro-ecological dummies. We also incorporate a soil fertility management dummy (either fertilizer only or integrated soil fertility management (ISFM) involving fertilizer and grain legume intercrops for biological nitrogen fixation). The descriptive statistics for all the variables that were included in the productivity model are presented in Table 1.

Table 1: Descriptive Statistics

Variable	Description	Mean	Std.
YIELD	Hybrid maize yield (kg/ha)	914.9	886.6
FERTILIZER	Fertilizer intensity (kg/ha)	30.9	38.3
LABOUR	Labour intensity (mandays/ha/month)	67.3	34.8
SEED	Seed intensity (kg/ha)	25.7	15.6
SFM	Soil fertility management (1 = ISFM;0 = fert)	0.6	0.5
WEEDING	Frequency of weeding	1.4	0.8
PLANTING	Date of planting (1 = early; 0 = later than first rains)	1.7	0.5
RAIN	Rainfall in mm	899.1	59.0
EXT_FREQ	Frequency of extension visits per month	0.8	1.0
CREDIT	Access to credit (1 = yes; 0 = no)	0.4	0.5
MACCESS	Market access (1 = accessible; 0 = remote)	0.4	0.5

Source: Own survey, 2003

6 Discussion of the Results

The estimation results are shown in Table 2. Given the cross-sectional data set and the imposed regularity constraints the overall model fit is significant at the 1 %-level ($P < 0.000$). Nearly 87 % of all observations are consistent with the regularity conditions of monotonicity, diminishing marginal returns and quasi-concavity respectively (the numerical estimation and regularity results are not shown here but can be obtained from the authors). The subsequent discussion is based on the theoretically consistent range of observations in the sample. Except for seed, all input parameters show the expected sign. Among the inputs, fertilizer, its quadratic and seed interaction terms are highly significant. The parameter on soil fertility management is highly significant implying that the use of integrated soil fertility practices significantly influences maize yield. Although the parameters for rainfall, weeding frequency and planting dates show the expected signs, they are all insignificant. Among the policy variables, extension frequency is positively and significantly ($P < 0.05$) related to maize productivity, while market and seasonal agricultural credit access are positively related to maize productivity, but are both insignificant. While we would expect significant influences of rainfall and its variation on maize yield, given the rainfed systems, the insignificance may be attributed to two reasons: First, hybrid varieties e.g. MH18 are bred specifically for drought resistance among other aspects and in Malawi most of these are particularly recommended for areas that are prone to intermittent droughts. Secondly, we attribute the insignificance to the way the rainfall data were collected. Rainfall figures are collected at an Extension Planning Area (EPA) level and thus do not reflect the actual variations experienced by different farms within an EPA. The husbandry practices are all positively related to yield for both varieties but are not significant.

The elasticities presented in Table 2 indicate that, keeping all factors constant, a unit increase in seed, fertilizer and labour will result in a 0.43 %, 0.42 % and 0.11 % increase in maize yield respectively. Hence smallholder farmers are not producing at their optimal point with respect to the usage of variable inputs: The relative input usages could be radially increased to increase the maize output. The use of integrated soil fertility management improves the yield of maize by 4.2 % on average, compared to the use of inorganic fertilizer only. The elasticity of maize yield with respect to the amount of rainfall further indicates a relatively importance of climatic factors. The unit input effect of the other control and policy variables on maize yield is finally quite low.

Table 2: Mean Output Elasticities

Variable	Elasticity $\left(\partial \ln\left(\frac{q}{q'}\right) / \partial \ln\left(\frac{x_i}{x_i'}\right)\right)$
Labour***	0.106 (0.0077)
Fertilizer***	0.420 (0.0613)
Seed***	0.428 (0.1621)
Soil fertility management♣	0.042
Rainfall	0.245
Weeding Frequency	0.005
Planting date	0.034
Market access	0.007
Extension Frequency	0.013
Credit access	0.007

*** P < 0.000; **P < 0.05; *P < 0.10: ♣: invariant over observations as linear added control variables for SFM to Credit access

Source: Own Calculations

In Table 3, we compare the returns to scale associated with smallholder maize production using alternative soil fertility management options. The results indicate that smallholder farmers exhibit considerable returns to scale, consistent with other previous studies (KAMANGA et al., 2000). Most smallholder farmers operate in a region of the production function where marginal productivity of inputs is increasing (stage I in figure 2). However, returns to scale for farmers using integrated soil fertility management practices are significantly higher (P < 0.000) than for farmers using only inorganic fertilizer. The relatively higher returns to scale for integrated soil fertility management options imply that there is still scope for smallholder farmers to improve maize productivity by an increase of their production: ISFM options improve the soil fertility and hence enhance the efficiency of inputs.

Table 3: Returns to Scale by Soil Fertility Management Option

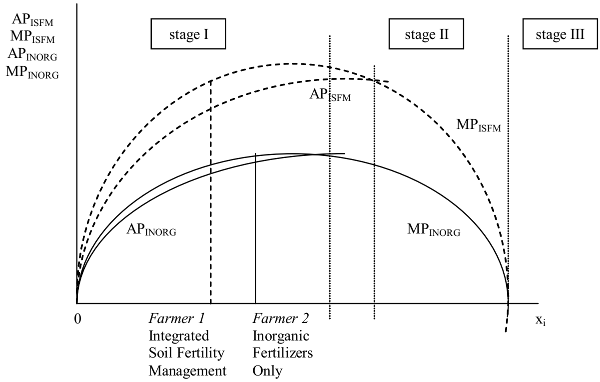
Soil fertility management option	RTS	RTS Range	
		Min.	Max.
Inorganic fertilizers only	1.12 (0.07)	0.98	1.35
Integrated soil fertility management	1.50 (0.12)	1.09	1.71
Total sample	1.31 (0.22)	0.98	1.71

Returns to scale (RTS) difference between soil fertility management options is significant at (*P < 0.000*); Figures in parentheses are standard errors.

Source: Own Calculations

These results imply that assuming constant maize/fertilizer price ratios, the optimal yield response for inorganic fertilizer (as well as other inputs) is higher in the case of integrated soil fertility management, due to the significance of the SFM parameter. Thus, with farmers facing more or less the same maize price and input cost, the profitability of smallholder maize production is likely to be higher when farmers integrate inorganic fertilizers with grain legumes. This is illustrated by figure 1:

Figure 1: Average and Marginal Products



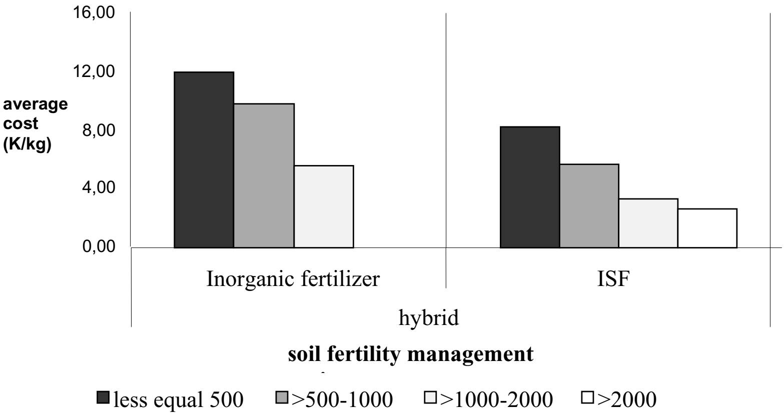
Source: Own illustration

Farmer 1 as the average farmer using integrated soil fertility management enjoys a higher marginal product (MP_{ISFM}) as well as average product (AP_{ISFM}) than farmer 2 as the average farmer applying inorganic fertilizers only (MP_{INORG}, AP_{INORG}). As depicted by figure 1 both smallholder farmers experience increasing returns to scale and hence could enhance the production of maize, however, the average returns to scale for farmer 1 are relatively higher than those for farmer 2 (space in between the MP and AP curve). Although the yield effect implied by the elasticity of SFM is somehow low (at 4.2 % on average), given the low yields experienced by smallholder farmers, if we account for other bonus crops such as grain legumes (groundnuts, soya and pigeon peas), the overall additional yield effect of ISFM is quite substantial. In fact it is likely to be higher among farmers which are unable to afford optimal quantities of inorganic fertilizer, but still have access to hybrid maize seed. These results corroborate those of past studies in many ways. Most studies indicate that in general, ISFM options are more remunerative where purchased fertilizer alone remains unattractive or highly risky, as is the case with the maize-based smallholder farming systems in Malawi (see e.g. TOMLOW et al., 2001 for Malawi; MEKURIA and WADDINGTON, 2002; MEKURIA and SIBIZA, 2003; as well as WHITEBREAD et al., 2004 for Zimbabwe; PLACE et al., 2002 for Kenya; MWALE et al., 2003 for Zambia).

Applying the assumption that all farmers face the same input and maize price ratios, these results imply that on average, use of ISFM in maize production improves profitability compared to use of inorganic fertilizer only. The average profitability indicators also support these results as shown in Table 4. The gross margin per unit of fertilizer and labour is higher when farmers use ISFM. As a result, using average as well as marginal rate of return, the results indicate that it is more profitable for farmers to produce maize under ISFM than using inorganic fertilizer only as shown in Figure 2.

These results agree with those obtained using on-farm trials data which indicate higher yields in green legume rotation systems compared to maize applied with inorganic fertilizer only. Mucuna rotation gives the highest optimal yield compared to maize applied with inorganic fertilizer only. Similarly the optimal yield for groundnut/soybean rotation and maize pigeon pea intercrop is higher than that of maize with inorganic fertilizer only.

Figure 2: Average Cost of Maize Production



Source: Own illustration

Table 4: Descriptive Statistics - The Economics of Maize Production

	Hybrid maize	
	Inorganic fertilizer only (N = 110)	Integrated SFM (N = 143)
Gross revenue (Kwacha per ha)	9488.80	13124.09
Labour cost (Kwacha per ha)	1816.02	1478.91
Fertilizer cost (Kwacha per ha)	1520.34	1994.42
Gross margin (Kwacha per ha)	6107.44	9650.76
Gross margin per Kg of fertilizer	368.41	530.26
Gross margin per manday	99.91	191.03
Average variable cost per kg of maize	4.80	3.60
Value/Cost ratio (VCR)	2.81	3.78
Marginal Rate of Return (%)	181	278

Hybrid maize includes MH17 and MH18, Kwacha is the local currency, Fertilizers include a combination of 23:21:0+4s and CAN, Integrated soil fertility management (SFM) involves the application of inorganic fertilizers and incorporation of grain legumes i.e. groundnuts (*Arachis hypogea*) or pigeon peas (*Cajanas cajan*) in an intercrop system

Source: Own Calculations

7 Conclusions and Policy Implications

The study clearly shows that maize productivity under ISFM is higher than when farmers use inorganic fertilizer only. Gross margin per unit of inputs is also higher, assuming farmers face the same maize prices and input costs. These results are likely to be more meaningful among smallholder farmers that can hardly afford optimal levels of inorganic fertilizer, and those in very risky environments. These results in someway also assist to dispel scepticism associated with the benefits of integrated soil fertility management options, especially among farmers who have been crowded out of the agricultural inputs market for reasons of affordability. In terms of policy implications, ISFM provides scope for improving maize productivity especially where use of inorganic fertilizer is highly unaffordable and risky. Thus there is need for policy interventions to promote smallholder uptake of ISFM options. However, it is important to note that the scope for ISFM to resuscitate the productivity of the maize-based smallholder farmers depends on consistent integration of grain legumes with inorganic fertilizers and access to improved maize varieties. The performance of grain legumes in fixing nitrogen is greatly compromised under low soil fertility conditions. Thus ISFM establishment in smallholder farming systems can be facilitated through cross-compliance interventions through among others, seasonal credit provision to enable farmers to afford inorganic fertilizers and improved maize and legume seeds. Similarly, an improvement in rural output and input markets, including the grain legume market would act as an additional incentive that will motivate farmers to grow grain legumes together with maize. Public extension still remains the main caveat for reaching smallholder farmers with technologies developed by researchers. Where the capacity for public extension is overstretched e.g. due to HIV/AIDS scourge, there is need for policy to create favourable conditions for the involvement of non-governmental organizations that have been instrumental in reaching smallholder farmers.

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