Efficiency in Fertilizer use among Smallholder Farmers in Mbinga District

F.G.H. Hawassi, N.S.Y. Mdoe and F.M. Turuka

Department of Agricultural Economics and Agribusiness
Sokoine University of Agriculture

Abstract

This paper compares the efficiency of fertilizer use among smallholder farmers in two agro-ecological zones of Mbinga district for the period before and after the removal fertilizer subsidies. Two Cobb-Douglas production functions, one for each agro-ecological zone, were estimated and the derived marginal products (MPs) of the fertilizer input were used to determine the efficiency of fertilizer use among smallholder farmers in the two zones. Results of the estimated production functions indicate that capital expenses other than fertilizer, fertilizer intensity and full-time family labour significantly influence maize production in both the intermediate and wet-highland zones. There is ample evidence that complete removal of fertilizer subsidy has significantly reduced maize output in the study area. Efficiency analysis results reveal deviations from optimal use of fertilizer before and after complete subsidy removal, implying that smallholder farmers in both agro-ecological zones were using fertilizer inefficiently before and after complete removal of fertilizer subsidy. The results generally suggest that development practioners might fruitfully put more emphasis on raising smallholder farmers close to efficiency levels through extension and education programs, which are aimed at improving the use of available fertilizer.

Key Words: *Fertilizer, efficiency, smallholder farmer, development policies, subsidy*

1 Introduction

Decisions about development strategies are in part guided by policy maker's conceptions of farm-level performance. An important aspect of performance that can be investigated to guide policy makers, is efficiency in resource use among smallholder farmers, to determine what adjustments might be made to increase agricultural output. The issue of efficiency in resource use in smallholder agriculture has been the focus of several studies (Leibenstein 1977, Shapiro and Mueller 1977, Junankar 1980, Mtoi 1984, Quiggin and Bui-lan 1984, Olagoke 1990, Mwenda 1993, Turuka 1995, Hawassi 1997). Most of the empirical works can be viewed as testing the hypothesis that smallholder agriculture is highly efficient given the available inputs and technologies. Acceptance of this hypothesis by policy makers may lead to increasing emphasis on new investments and technologies rather than extension and education efforts aimed at improving resource use efficiency. If the efficiency hypothesis does not infact apply to most of the smallholder farmers, development practitioners and policy makers may be overlooking opportunities for relatively inexpensive gains in production. If there are significant opportunities to increase productivity through more efficient use of resources at smallholder farmers' disposal, a stronger case can be made for institutional support in input delivery, infrastructure, for example. An increase in productivity of smallholder agriculture can be achieved through adoption of improved technology. The most important of these technologies come in the form of chemical fertilizers, improved varieties, pesticides, irrigation, the adoption of improved seed farming practices and the use of animal or mechanical power to reduce or eliminate the drudgery of human labour in traditional agriculture (Lopez-Pereira et al. 1990). Of all the farm inputs, fertilizer by far remains the most important input in crop yield maximization (FAO 1981). The role of fertilizer in increasing crop yield and hence agricultural production is generally the highest followed by improved seeds and improved agricultural practices in soils of moderate fertility (Dapaah and Ontikorang 1990). Not only does fertilizer increase crop yields, but also it improves the quality of agricultural produce.

Despite the significance of fertilizers in obtaining higher crop yields, fertilizer use per unit area in Tanzania is low, ranging between 4 and 9 kg/ha of cropped land (Mahundaza et al. 1992). This was the situation before complete removal of fertilizer subsidies in the 1994/95 cropping season. The government phased-out subsidy in fertilizer from 78% in 1990/91 to 0% in 1994/95 cropping season. Fertilizer prices increased drastically as a result of complete removal of the fertilizer subsidy. For example the price of Urea increased from TShs. 595 (when it was 78% subsidized) to about TShs. 11,000 in 1996/97 per 50 kg bag (after complete removal of the subsidy). An increase in fertilizer prices as a result of fertilizer subsidy removal is expected to reduce fertilizer use by smallholder farmers. Moreover an increase in the fertilizer price relative to crop prices is likely to change the level at which efficiency in smallholder production is attained. Assuming a competitive market environment, optimal efficiency in the production process is achieved if the value of marginal product of fertilizer input equals the marginal factor cost of the fertilizer input.

This paper is geared towards the assessment of the efficiency of fertilizer use among smallholder farmers in Mbinga district for the period before and after the removal fertilizer subsidies. The second section of the paper presents the theoretical framework of the study and data used for the analysis. Section three is concerned with the use of fertilizer in two agro-ecological zones of Mbinga district. The fourth section discusses the results of the estimated maize production functions. Section five presents empirical evidence of differences in efficiency of fertilizer use between farmers in the two agro-ecological zones of Mbinga district and smallholder farmers in the neighbouring district of Songea. The last section presents the conclusions and implications for development policies.

2 Methodology

2.1 Theoretical framework

The notion of efficiency is usually associated with production frontiers. This paper uses non-frontier techniques to investigate efficiency in using fertilizer in smallholder agriculture. Lau and Yotopoulous (1971) and Yotopoulous and Lau (1973) introduced the first non-frontier models that provided a way of examining efficiency. The commonly used formulation is the Cobb-Douglas type of production function. The use of the Cobb-douglas production function is preferred, partly due to its convenience in estimation which employs an ordinary least squares technique, and its simplicity in interpretation of the coefficients.

The usual formulation of the Cobb-Douglas production function has the following general form:

$$Q_j = aX_{ij}^{bi}$$

Where i = 1, 2, ... n, m are inputs; j = 1, 2, ... n, n are farms, Q_j = output of the jth farm, X_{ij} = level of the ith input on the jth farm and b_i = parameters (including the intercept b_0) to be estimated.

The empirically estimated Cobb-Douglas production function model is specified as follows:

$$\ln (Q_j) = \ln a + b_{ij} \ln X_{ij} + U_j$$

Where b_i is the estimated coefficient, $\ln x_i$ is the logarithm of the factor x_i used in the production process and U_j is the error term.

In this paper, assessment of efficiency of fertilizer use among smallholder farmers in two agro-ecological zones of Mbinga district (for the period before and after the removal fertilizer subsidies) involved two stages. The first stage was the estimation of two separate maize production functions one from each agro-ecological zone. The following equation represent the emprical model estimated with all the factors hypothesized to influence maize production in the two agro-ecological zones:

$$\text{Log } Q_j = \text{Log } a + b_1 \text{Log} X_1 + b_2 \text{Log} X_2 + b_3 \text{Log} X_3 + b_4 FP + b_5 D_1 + U_j$$

Where, Q_j is quantity of maize produced in kg/ha; a is a constant; X_1 represent cash expenses other than fertilizer (i.e. costs incurred on hired labour, tractor hiring, improved maize seeds and insecticides) in Tshs./ha, X_2 is fertilizer intensity in kg-N/ha, X_3 is full-time family labour expressed as number of persons/ha, FP is a proxy variable representing the use of farm power with A1" if the farmer used either a tractor or oxen plough and A0 otherwise, D_1 is a dummy variable capturing the effect of fertilizer subsidy removal with A1 representing 1995 and 1996 (following subsidy removal) and A0 is otherwise, b_s are coefficients of the variables and U_i is a random error term.

If it is assumed that the error term is randomly distributed the production functions can be estimated using ordinary least squares method. Economic literature suggests that if the ordinary least squares (OLS) method is used to estimate the production functions, the estimated functions are average functions rather than frontier functions (Upton 1979).

Data from sample farmers in the intermediate and wet highland zones were separately used to estimate maize production functions in this first stage.The second stage involved the use of the estimated maize production functions to assess efficiency of fertilizer use. In this stage the estimated maize production functions were used to derive marginal productivities (MP_s) and these were compared with fertilizer: maize price ratios. Theoretically, optimum efficiency is achieved when MP equals fertilizer: maize price ratio.

The MP_s of fertilizer in producing maize in the two agro-ecological zones were determined using the coefficients (b_s) in the estimated production functions. The estimated coefficients (b_s) indicate responsiveness of the maize output to marginal change in the level of resource used in the production process. For a Cobb-Douglas function, this is equivalent to the elasticity of production:

$$\epsilon = (Q_j / X_2)*(X_2/Q_j) = b_2$$

Where ϵ is the elasticity of production, Q_j / X_2 is the change in the maize output resulting from a unit change in fertilizer input, X_2 is the average amount of fertilizer used and Q_j is the average amount of maize output produced. Q_j / X_2 in the above equation is marginal productivity which by definition refers to the change in output following a unit change in the level of input while Q_j/X_2 is the average product. From the above equation,

$$Q_j / X_2 = b_2 * (Q_j / X_2) = MP$$
$$= b2*AP = MP$$

2.2 The study area and data sources

The study was carried out in two agro-ecological zones of Mbinga district during 1996. The two agro-ecological zones, intermediate and wet-highland, were purposely selected out of the three agro-ecological zones (Croon et al. 1984) on the basis of fertilizer consumption levels in the district. The intermediate zone essentially represents tobacco-maize production system while the wet-highlands zone represents coffee-maize production system.

In the intermediate zone, seven villages namely, Amani Makoro, Mkako, Lihale, Kigonsera, Lipumba, Kitanda and Mbangamao were purposely selected on the basis of accessibility to transport. In the wet-highlands zone, eight villages namely, Mhekela, Tukuzi, Myangayanga, Kihangi Makuka, Mateka, Kindimba, Lukarasi and Matiri were also purposely selected on the basis of accessibility to transport. Finally, 10 households were picked randomly from the register of each selected village. This created a sample of 70 households in the intermediate zone and 80 households in the wet-highland zone.

Heads of the selected households were visited and asked to respond to a structured questionnaire seeking information about household size and composition and crop production. Information on marketing, crop prices, use of farm inputs, input prices and main sources of income for 1991/92, 1992/93, 1993/94, 1994/95 and 1995/96 cropping seasons were also collected from households. The data for the different seasons were pooled together during the analysis. The primary data collected from the households were supplemented with secondary data on fertilizer prices, fertilizer supply and demand trends in Mbinga. This information was obtained from the District Agricultural and Livestock Development office in Mbinga, FAO-Fertilizer Programme and Fertilizer Stockists.

3 Results and Discussions

3.1 Fertilizer type and amounts applied to major crops

Sulphate of Ammonia (SA of 21% N), Calcium Ammonium Nitrate (CAN of 26% N) and Urea (46% N) were the main types of fertilizer used in Mbinga. Table 1 summarizes the mean amount of nitrogenous fertilizer used by farmers in the two zones. It is clear from the Table 1 that Urea has the highest contribution to the total quantity of fertilizer used. Putting aside the quantity of fertilizer used, a large proportion of the households in the wet-highlands zone used high analysis fertilizer (Urea) as opposed to their counterparts in the intermediate zone. The type of fertilizer used has an implication. The cost of fertilizer nutrients per unit can be greatly reduced by encouraging farmers to use high analysis rather than low analysis fertilizers.

Analysis of the fertilizer use pattern indicates that large quantities of the fertilizer nutrients used by the sample farmers in the study area are applied on maize, coffee and tobacco in descending order (Table 2). More than 80% of the fertilizer nutrients were applied on maize. This observation is consistent with Turuka (1995) who found that over 70% of the fertilizer available in the Southern Highlands of Tanzania and the country as a whole is used on maize. Also the observation supports the view of most fertilizer use analysts in sub-Saharan Africa that fertilizer consumption has shifted from export or plantation crops to cereals. Maize accounts for the large share of fertilizer consumed in East and Southern Africa (Desai and Gandi 1988, Gerner and Harris 1993, Mudahar 1986, Tshibaka and Baanante 1988).

Table 1 Average amount of fertilizer nutrients (Kg-N) used per Household by fertilizer type, 1992-1996

Fertilizer Type	Zone	1992	1993	1994	1995	1996
SA	Intermediate	45.99	47.62	37.28	37.19	40.18
		(82)	(75)	(69)	(84)	(82)
	Wet-highland	28.71	19.25	17.72	20.47	20.30
		(62)	(49)	(41)	(47)	(47)
	Total	37.90	33.44	28.50	30.13	31.24
		(68)	(60)	(52)	(64)	(63)
CAN	Intermediate	83.50	57.00	56.60	78.00	68.52
		(46)	(46)	(41)	(30)	(38)
	Wet-highland	38.11	32.93	32.02	25.54	33.37
		(42)	(35)	(39)	(33)	(47)
	Total	61.81	45.37	44.30	52.14	51.19
		(43)	(40)	(40)	(31)	(42)
UREA	Intermediate	109.59	116.24	96.06	104.38	115.37
		(41)	(43)	(59)	(41)	(43)
	Wet-highland	69.48	57.96	114.01	69.37	60.15
		(61)	(63)	(63)	(72)	(48)
	Total	90.16	86.97	105.13	86.97	87.16
		(50)	(52)	(60)	(56)	(44)

Note: Figures in brackets represent the percentage of sample household using the respective fertilizer.

Source: Survey Data, 1996

According to Table 2, farmers in the intermediate zone applied a relatively large share of nutrients on maize as opposed to their counterparts in the wet-highland zone. The reverse is true in the case of quantity of fertilizer nutrients applied on coffee. Farmers in the wet-highlands zone applied relatively larger quantities of fertilizer nutrients on coffee than farmers in the intermediate zone.

3.2 Relative maize crop areas applied with fertilizer

Table 3 summarizes the proportion of maize crop area applied with fertilizer. The results in the table show that farmers in the intermediate zone had a large proportion of farm area on which fertilizer was applied as opposed to their counterparts in the wet-highlands zone. Trend-wise, maize crop area applied with fertilizer in the intermediate zone remained almost constant between 1991/92 and 1995/96.

Table 2 Mean quantities of fertilizer nutrient (Kg-N) used by household by crops, 1992-1996

Crop	Zone	1992	1993	1994	1995	1996
Maize	Intermediate	132.07	109.17	98.00	91.99	105.85
		(56)	(57)	(58)	(64)	(63)
	Wet-highland	68.86	62.53	80.99	69.46	52.90
		(52)	(43)	(39)	(43)	(32)
	Total	101.46	85.85	89.50	80.37	79.40
		(108)	(100)	(97)	(107)	(95)
Coffee	Intermediate	34.02	21.50	23.49	39.93	32.34
		(11)	(12)	(10)	(13)	(11)
	Wet-highland	47.23	41.24	51.60	39.79	37.95
		(36)	(29)	(25)	(33)	(24)
	Total	40.62	30.47	37.55	39.78	35.20
		(47)	(41)	(35)	(46)	(35)
Tobacco	Intermediate	30.07	26.73	25.20	19.26	22.43
		(11)	(12)	(10)	(10)	(12)
	Wet-highland	0.0	0.0	0.0	0.0	0.0
	Total	30.07	26.73	25.20	19.26	22.43
		(11)	(12)	(10)	(10)	(12)

Note: Figures in Brackets represent number of sample farmers

Source: Survey data, 1996

3.3 Fertilizer use intensity

Fertilizer use intensity refers to the quantity of fertilizer nutrient used per unit area. Fertilizer use intensity is a better measure of the relative amount of fertilizer used by farmers (Turuka 1995). The use of fertilizer intensity can provide information on the relationship between farm size and fertilizer use as it is still inconclusive whether small farm sizes are associated with more intense fertilizer use or whether the reverse is true. Table 4 summarizes the intensity of fertilizer applied to major crops from 1992 to 1996. It is clear from Table 4 that fertilizer application rates were considerably higher on maize than coffee and tobacco. Generally, fertilizer application rates on maize in the intermediate zone were in line with the rate of at least 70 kg N/ha recommended for Mbinga (Samki and Harrop 1984). Farmers in the wet-highlands zone generally applied slightly below this recommended rate.

Majority (87%) of the sampled farmers in both the intermediate and wet-highlands zones indicated high fertilizer prices after subsidy removal as the main reason for applying fertilizer below the recommended rates. Other constraints in fertilizer use as perceived by the interviewed farmers include lack of credit, low producer prices and non-availability of fertilizer. About only 2% of the sampled farmers considered non-availability of fertilizers as an important determinant of fertilizer use. Many fertilizer use analysts in Africa and elsewhere in the developing world contend that basic problems of availability (that is getting the right fertilizer to the right place at the right time) are at least as important as price- response interactions in determining fertilizer use in sub-Saharan Africa (Fontaine and Sindzingre 1991, Pinstrup-Andersen 1993, Blackie 1995).

Table 5 compares the average fertilizer intensity on maize crop between the period before (1992, 1993 and 1994) and following complete removal of fertilizer subsidy in 1995-1996.

Table 3 Relative maize crop area applied with fertilizer according to zone, 1991/92-1995/96

Season	Zone	Total area under maize (Ha)	Area applied with Fertilizer (Ha)	Percent
1991/92	Intermediate	1.58	1.49	94.30
	Wet-highland	1.20	1.05	87.50
	Total	1.55	1.34	86.50
1992/93	Intermediate	1.57	1.47	93.60
	Wet-highland	1.13	0.88	77.80
	Total	1.51	1.28	84.80
1993/94	Intermediate	1.43	1.39	97.20
	Wet-highland	1.13	0.93	88.30
	Total	1.32	1.26	95.50
1994/95	Intermediate	1.47	1.45	98.60
	Wet-highland	1.13	0.94	83.20
	Total	1.38	1.25	90.60
1995/96	Intermediate	1.50	1.45	96.70
	Wet-highland	1.39	1.04	74.80
	Total	1.44	1.32	91.70

Source: Survey data, 1996

Although the results in Table 5 show a reduction in fertilizer intensity following complete subsidy removal, the difference in the fertilizer intensity between the two periods was statistically insignificant. These findings seem to suggest that fertilizer use on maize is an important practice and that farmers will continue applying more or less same rate despite the increase in fertilizer prices. Alternatively this result could be interpreted to imply that the price increase was such that farmers could still obtain a positive net return.

Table 4 Fertilizer application intensity (Kg N/Ha), 1992-1996

Crop	Zone	1992	1993	1994	1995	1996
Maize	Intermediate	88.6	74.3	70.5	63.4	73.0
	Wet-highland	65.6	55.0	75.3	65.3	50.9
	Total	74.96	66.84	71.29	64.19	59.94
Coffee	Intermediate	14.3	10.8	11.0	14.0	10.3
	Wet-highland	34.5	29.7	27.9	27.7	25.4
	Total	28.04	21.33	19.78	23.65	18.28
Tobacco	Intermediate	16.54	14.43	10.33	7.13	10.77
	Wet-highland		0.0	0.0	0.0	0.0
	Total	16.54	14.43	10.33	7.13	10.77

Source: Survey data, 1996

Table 5 Mean fertilizer intensity (KG-N/ha) before and after complete fertilizer subsidy removal

Zone	1992-1994	1995-1996
Intermediate	76.90	67.90
Wet-highlands	65.30	59.10
Total	70.94	62.12

Source: Survey data, 1996

4 Estimated maize production functions

Tables 6 and 7 present results of the estimated maize production functions for farmers in the intermediate and wet highlands zones respectively, as estimated using ordinary least squares (OLS). The most common problem in studies of this type, multicollinearity, was examined through estimation of Pearson correlation coefficients for all independent variables. In most cases, these were were found to be insignificant, indicating the absence of serious multicollinearity problems.

The results in Table 6 show that other cash expenses (X_1), fertilizer intensity (X_2), dummy (D_1) and full-time family labour (X_3) were statistically significant in explaining maize yield variation in the intermediate zone. The use of farm power (FP) had no significance influence on maize yields achieved by farmers in the intermediate zone. The signs of the coefficients of the variables are positve as expected. The estimated coefficient for cash expenses other than fertilizer (X_1) suggest that a 10% increase in those expenses would increase maize yield by 4.3%. Similarly, 10% increase in fertilzer intensity (X_2) and full-time family labour (X_3) would be associated with increase of

2.1% and 1.4% in maize yield respectively. The coefficent of dummy variable (D_1) which was included in the function to capture the effect of fertilizer subsidy removal was statistically significant (p=0.01). This implies that there is significant difference in maize output in the intermediate zone between the period before and after complete phasing-out of fertilizer subsidy. Complete removal of fertilizer subsidy would be associated with a decrease of 0.146 kg/ha in maize yield levels in the intermediate zone, probably due to decrease in fertilzer use intensity.

Table 6 Estimated maize production function for farmers in the intermediate zone

Dependent variable: Quantity of maize produced in kg/ha

Variable	Coefficient (b_i)	Standard error	t-value	Significance level
Constant	7.0937***	0.0811	87.5090	0.0000
X_1	0.4332***	0.0916	4.7940	0.0000
X_2	0.2142***	0.0052	4.6300	0.0001
X_3	0.1407**	0.0366	2.2030	0.0279
FP	0.0109	0.0333	0.3260	0.7445
D_1	0.1462***	0.0461	3.1720	0.0006

R^2, Adjusted = 0.5956
F-value = 15.2932***
n = 350 (data for different years pooled together)
** = Significant at p = 0.05
*** = Significant at p = 0.01

Source: Survey data, 1996

As in the case for the intermediate zone, results in Table 7 show that other cash expenses (X_1), fertilizer intensity (X_2), full-time family labour (X_3) and dummy (D_1) were statistically significant in explaining maize yield variation in the wet highland zone. The coefficient for the use of farm power (FP) was positive as expected but statistically not significant (p=0.05), indicating that use of farm power had no significance influence on maize yield in the wet-highland zone. The insignificant influence of farm power on maize output in this zone could be probably explained by the fact that it is difficult to practice mechanization in these highlands. Like in the case of intermediate zone, the coefficients of the variables are positive as expected. The magnitude of the coefficient of other cash expenses (X_1) indicate that a 10% increase in cash expenses other than fertilizer would increase maize yield by 4.5%. Similary, other factors being constant, a 10% increase in fertilizer intensity (X_2) and full-time family labour (X_3) would increase maize yield in the wet-highland zone by 3.8% and 1.8% respectively. Similarly the coefficient of the dummy (D_1) variable was found to be statistically significant (p=0.01) in explaining maize yield difference in the intermediate zone between the period before and after complete phasing-out of fertilizer subsidy. The magnitude of the cofficient of dummy (D_1) variable suggests that complete fertilizer subsidy removal would decrease maize yields achieved by farmers in the wet highland zone by 0.15 kg/ha.

Table 7 Estimated maize production function for farmers in the wet-highland zone

Dependent variable: Quantity of maize produced in kg/ha

Variable	Coefficient (bi)	Standard error	t-value	Significance level
Constant	7.0789***	0.0841	84.1660	0.0000
X1	0.4526***	0.0954	4.8400	0.0000
X2	0.3751***	0.0535	4.1890	0.0001
X3	0.1773**	0.0387	1.9970	0.0462
FP	0.0071	0.0349	0.2040	0.8387
D1	0.1532***	0.0481	3.1850	0.0004

R2, Adjusted = 0.5279
F-value = 14.3735***
n = 400
** = Significant at p = 0.05
*** = Significant at p = 0.01

Source: Survey data, 1996

5 Fertilizer use efficiency among smallholder farmers in Mbinga

The ordinary least squares (OLS) method was used estimate the coefficient of the fertilizer input in the Cobb-Douglas production function described in section 2 of this paper. As pointed out in section 2, the coefficient b_2 in the linearized Cobb-Douglas mode represent elasticity of fertilizer use. Marginal product (MP) of fertilizer in the intermediate and wet-highlands zones were derived from the relationship $\in = (Q_j / X_2) * (X_2 / Q_j) = b_2$, where is the elasticity of production, Q_j / X_2 is the marginal product (change in the output resulting from a unit change in fertilizer use), X_2 is the amount of fertilizer used and Q_j is the amount of maize produced.

Table 8 shows the calculated marginal products and the ratio of fertilizer-maize prices in the intermediate and wet-highlands zones in Mbinga district for the periods before and after complete removal of fertilizer subsidy. As can be seen from Table 8, the price ratios were higher than the marginal product of fertilizer in both the intermediate and wet highlands zones before and after complete subsidy removal. In a competitive market situation, optimal allocative efficiency is achieved if fertilizer: maize price ratio equals marginal product of the fertilizer input. In terms of allocative efficiency, therefore, smallholder farmers in both zones are using fertilizer inefficiently before and after complete removal of fertilizer subsidy.

The relatively higher fertiliser: maize price ratios as compared to marginal productivity of fertilizer suggest the following: (i) price of maize received by farmers are relatively lower, (ii) fertilizer price paid by farmers are relatively higher, (iii) either farmers are producing at a stage where marginal product is increasing or decreasing, which is lower than the fertiliser: maize price ratio. These results suggest that if the farmers are technically efficient, the situation can be improved by either increasing maize price or reducing fertilizer price. On the other hand, if farmers are technically inefficient, they should improve on fertilizer application, including proper timing and application. Thus, if farmer's objective is to maximize profit and that they are technically efficient, these results suggest that it is not profitable to use fertilizer at the current fertilizer and maize prices given the responsiveness of maize yield to fertilizer input.

Table 8 Fertilizer-maize price ratios and marginal products of fertilizer in two agro-ecological zones of Mbinga district

	Intermediate zone		Wet-highlands zone	
	1992-1994	1995-1996	1992-1994	1995-1996
Price ratio	5.35	6.78	5.65	8.40
Marginal product	4.69	4.94	3.73	8.34

Source: Survey data, 1996

However, the observed inefficiency may not be attributed to only farmer inefficiency. The physical failure in the measurement of inputs or the failure to capture them in the estimated production function may also be the cause of the observed inefficiency. Inefficiency may disappear if measurement of the inputs used in the production process is properly done. In the context of this study, one area where an inadequate measurement of inputs may have occurred is related to the measurement of labour input. Also all land used was assumed to be of the same quality which may not be a realistic assumption. In addition, no information was collected on the crops grown along with maize partly because the crops were either unimportant or it was difficult to ascertain the amount harvested and its monetary value.

It is also argued that the measurement of allocative inefficiency depends whether one adopts profit maximization (unconstrained case) or cost minimization functions (constrained case). Ali and Byerlee (1991, p. 20) cite results from van der Veen (1975) in which case the researcher failed to reject the cost minimization (constrained case) hypothesis for most of the farmers but did reject the hypothesis of profit maximization (unconstrained case) for 36 out of 78 farmers in a sample of rice farmers in the Philippines. It has also been argued that the desire of farmers to achieve an intended allocation of resources is often impaired by the fixity of some factors of production in the short run (Russell, Young, 1983).

6 Conclusions and implication for development policies

6.1 Fertilizer use

A large proportion of farmers in the intermediate zone of Mbinga district used low analysis fertilizers, such as SA as opposed to their counterparts in the wet-highlands zone who used high analysis fertilizers, such as Urea. Thus, the households in the intermediate zone are more likely to be affected by fertilizer price increases due to subsidy removal. One way of offsetting this is to inform farmers, through the agricultural extension services, the advantages of using high analysis fertilizers. The use of high analysis fertilizers will not only lower the per unit price of fertilizer nutrients but also lower transport cost as well as storage requirements.

6.2 Fertilizer use intensity

Most sampled farmers in the study area used fertilizers below recommended rates especially when the fertilizer subsidy was completely removed in 1994/95 farming season. Possible ways of improving the situation include the use of extension messages to inform farmers on the recommended rates, ensuring that the right fertilizers are available to farmers at the right time and encourage establishment of savings and credit unions through which farmers can get fertilizer on credit.

6.3 Fertilizer use efficiency

The findings on fertilizer use efficiency presented above do not support the hypothesis that smallholder farmers are efficient in using fertilizer. On the contrary, the findings reveal deviations from optimal use of fertilizer given the available inputs and technologies. Differential inefficiency was observed in the use of fertilizer between farmers in Mbinga and Songea districts in Ruvuma region. In terms of allocative efficiency, smallholders in Mbinga district used fertilizer inefficiently because of relatively lower marginal productivities of fertilizer compared to fertilizer-maize price ratios for farmers in intermediate and wet-highlands zones. On the contrary smallholder farmers in Songea district were using fertilizer inefficiently because of relatively higher marginal productivity of fertilizer compared to fertilizer-maize price ratio.

Our main conclusion is that development policies might fruitfully place more emphasis on raising smallholder farmers close to efficiency levels through extension and education programs, aimed at improving the use of the available fertilizers and other inputs. This conclusion is not intended to downplay the overwhelming importance of new inputs and technologies for developing smallholder agriculture, in the long-run. Rather, the intention is to point out that there are observed efficiency differentials in smallholder agriculture which may imply the potential for relatively inexpensive, short-run gains in output that do not depend on major new investments or research programmes.

It is also important to note that the optimal level of using fertilizer on maize production is influenced by the price of fertilizer relative to the price of maize. Efforts to ensure better market prices of maize can improve allocative efficiency. Farmers should be encouraged to form farmer organizations to increase their bargaining power both in the input and output markets. Improvement in transport infrastructure, especially roads in the remote villages of Mbinga, is necessary to lower transport costs and improve the marketing system.

7 References

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