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Full Length Research Paper

Technical efficiency among the bulrush millet producers in Kenya

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South Rift Valley, which has some of the highest poverty levels in Kenya would greatly benefit from increased production of bulrush millet as it will both improve the diet and contribute to household income. Though south Rift Valley is suitable for growing of bulrush millet, its production levels remain low, and farmers continue to achieve much lower yields than the potential. This suggests that farmers are losing out on output due to production inefficiencies. A study to determine the technical efficiency among smallholder farmers in Narok, Bomet and Kericho counties of Kenya was carried out in 2010. 211 randomly sampled bulrush millet-growing households were surveyed. The Cobb-Douglas stochastic production function was used to measure the technical efficiency. The bulrush millet production efficiency varied widely among farmers, with Bomet varying from 11 to 83%, Kericho, 16 to 89% and Narok, 17 to 88% and averages of 72% for Bomet and 44% for Kericho and Narok. This implies that given the level of technology and inputs, the output could be increased by 28 to 56% through better use of available resources thus farmers should be trained to enhance their capacity to efficiently use the available resources.

Key words: Bulrush millet, stochastic production frontier, technical efficiency.

INTRODUCTION

Demand for bulrush millet is high and its popularity is spreading all over Kenya and hence, opening up a large market. However, the yield of bulrush millet in Kenya particularly south of the Rift Valley region is low and there exists a significant yield gap between farmer's production levels and research potential yields of 3 to 4 tonnes ha^{-1} (Ogecha, 2010; Salasya et al., 2009). The average yields of sorghum obtained in this review for the period 1991 to 2010 (south Rift Valley) was about 0.7 tonnes ha^{-1}. An increase in bulrush millet demand may be met through expansion of the available crop land but this is not possible in the densely populated highlands. Thus, the only option open is to increase productivity through efficient use of existing resources and technologies. Improving efficiency lowers production and marketing costs, thus enhancing competitiveness of bulrush millet and provides incentives for expanding production, consumption, processing and trade (Crissman et al., 2006).

Many researchers have tried to justify why efficiency is important in developing countries' agriculture. Obwana (2006) stated that productivity increases do not depend on adoption rates of new technologies but effective use of available technologies. Thus, real productivity problems emanate from social and economic characteristics of the farmers. To achieve higher productivity, technological innovation is a necessary but not sufficient condition; efficient use of old technology is necessary. In developing countries, new technologies have partially succeeded in improving productivity (Xu and Jeffrey, 1998) due to institutional and cultural constraints. If farmers are not efficiently using existing technologies, then ways of improving efficiency will be more cost effective in the short run than introducing another technology (Shapiro, 1983). Unless the potential of existing technology is known and completely exploited, the benefits from new one may not be realized in the short run (Feder et al., 1985). Thus, the objective of the study was to determine technical efficiency levels among bulrush millet smallholder in Kenya given their production technologies.

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Table 1. Mean and standard deviation of variables entered in the production function.

Per county variable	Narok	Bomet	Kericho
Sex (Female=1, Male=0)	0.67 (0.47)	0.47 (0.52)	0.50 (0.50)
Age (years)	43.6 (20.21)	40.7 (13.02)	40.6 (16.2)
Schooling (years)	14 (2)	12 (2)	12 (2)
Employment (Yes=1, No=0)	0.24 (0.43)	0.19 (0.39)	0.14 (0.35)
Own land (acres)	2.27 (0.98)	3.36 (2.3)	6.96 (19.6)
Seasons (Numbers)	2 (1)	2 (1)	2 (1)
Farm loan (Yes=1, No=0)	0.09 (0.29)	0.08 (0.27)	0.01 (0.11)
Yield per acre in kg	107 (2,279)	4,284 (2,994)	3,367 (1,922)
Materials value in (KES/acre)	558.30(1,015)	6,958 (10,600)	6,087 (6,056)
Seed rate (kg)	800	800	800
Labour rate (KSh /mandays)	120(0)	100(0)	110 (0)
Labour (mandays/acre)	57 (37)	66 (36)	76 (66)
Number of observations (N)	55	79	77

Standard deviation in brackets; KES= Kenya shillings; Kg= Kilogrammes

MATERIALS AND METHODS

The study was undertaken in Kericho, Bomet and Narok counties which lie within Kenya's higher potential agricultural areas, as measured by rainfall and soil types (Jaetzold et al., 1983). The three areas were purposively selected due to their importance as the major bulrush millet growing counties in Kenya (RoK, 2010). The study used a cross-sectional data of 211 farm households randomly collected using a pre-tested structured questionnaire from purposively selected bulrush millet growing divisions in the three counties. The sample frame or population of households growing bulrush millet in the three counties was calculated from the Kenya Integrated Households Budget Survey of 2009/2010 (MoA, 2010). The percentage households who grew bulrush millet in the three counties were 96.6% (Kericho), 33.6% (Bomet) and 70.5% in Narok (RoK, 2010). Bulrush millet output estimates in 2010 were 167,710 tonnes (Bomet), 107,241 tonnes (Kericho) and 25,179 tonnes (Narok) from an average area of 18,322 ha (Bomet), 13,986 ha (Kericho) and 8,023 ha (Narok). This translated to low bulrush millet productivity of 9.2, 7.6 and 3.1 tonnes/ha in Bomet, Kericho and Narok respectively which could be attributed to inefficiency (MoA, 2010). Technical efficiency was measured using stochastic frontier production approach (Aigner et al., 1977; Meeusen and van den Broeck, 1977; Battese and Corra, 1977). This approach assumes that the stochastic frontier production function contains an error term that consists of two elements: a symmetric and a one-sided component. The stochastic frontier production function assumes the presence of technical inefficiency of production. It can be presented as:

$$y_i = f(x_i ; \beta).e^{\varepsilon} \qquad y \leq 0. \qquad (1)$$

Where; y_i = the bulrush millet output; y_i = output is a function f (.) the variables in the brackets (.) in this case; x_i = vectors of inputs; β = the parameters to be estimated; $f(x_i ; \beta)_i$ = the deterministic part; β = a vector of parameters to be estimated; e^{ε} = stochastic part of the production ceiling or the frontier; ε =is the random error term.

The total error term ε in (1) could be decomposed into two error components as:

$$\varepsilon = v_i + u_i \qquad u_i(u_i \geq 0). \qquad (2)$$

To measure technical efficiency, specification of compose error distribution is necessary. Modelling and parameterization of the error is explicitly explained in Jondrow et al. (1982) and Kumbhakar and Lovell (2000). Therefore:

$$TE_i = \frac{y_i}{f(x_i;\beta).exp\{v_i\}}, = exp\{-u_i\} \qquad (u_i \geq 0). \qquad (3)$$

defines technical efficiency as the ratio of observed output to maximum feasible output, given the random factors experienced by bulrush millet farmer $exp\{v_i\}$. Equation 3 implies that y_i achieves its maximum feasible value of $[f(x_i;\beta).exp\{v_i\}]$ if and only if $TE_i = 1$ that is if there is no inefficiency and, $u_i = 0$.

The linearised Cobb-Douglas production function of Equation 1 was specified as in Equation 4 and used maximum likelihood estimation to determine technical efficiency following Battese and Coelli (1995) Data analysis was done using FRONTIER 4.1 (Coelli, 1996).

$$ln\, y_{ij} = \beta_0 + \beta_1 lnL_{ij} + \beta_2 lnM_{ij} + \beta_3 lnS_{ij} + \varepsilon_i \qquad (4)$$

In Equation 4, L M and S are the physical inputs; labour, material and seed bulrush millet used in bulrush millet production respectively and the other parameters are as defined in Equation 1. To determine efficiency effects, the basic null hypothesis test is that a farmer is fully efficient, $H_0: Y = 0$ and the alternative hypothesis is that the farmer is not efficient, $H_1: Y \neq 0$. The statistical test of hypotheses for the parameters of the frontier model was conducted using generalized likelihood–ratio (LR) and determination of the same was done using Table 1 in Kodde and Palm (1986).

RESULTS AND DISCUSSIONS

The mean and standard deviation of both physical and

Table 2. Stochastic Cobb-Douglas production function.

Ordinary least square (OLS) estimate	Bomet	Narok	Kericho
Constant	0.31 (0.89)	1.25 (3.60)***	2.17 (5.05)**
log (material/Acre)	0.38 (3.34)***	0.66 (3.34)**	0.06 (0.29)
log (labour/acre)	1.04(3.59)***	0.16 (2.12)*	0.32 (3.51)**
Log (seed/acre)	-0.18(-0.66)	-0.12 (-0.48)	0.31 (3.18)
sigma-squared	0.288	0.08	0.11
Log likelihood function	-60.92	-10.89	-21.06
The maximum likelihood estimates(MLE)			
Constant	1.48 (3.29)**	2.22 (0.18)	2.50 (8.90)**
log (material/Acre)	0.26 (3.28)***	0.57(3.50)***	0.087 (0.50)
log (labour/acre)	0.72 (2.09)*	0.15 (0.53)	0.44 (4.94)***
Log (seed/acre)	0.067 (0.252)	-0.003 (-0.006)	0.20 (0.72)
Diagnostic statistics			
Sigma-squared	1.63 (2.01)*	0.07 (3.50)***	0.08 (6.27)***
Gamma	0.95 (47.35)***	0.99 (291.0)***	0.99 (39863)***
log likelihood function	-46.65	-2.64	-10.93
LR test (one-sided error)	28.54	16.50	20.24

***P ≤1% significant at 1% level, ** P ≤ 5% ,*P ≤10 % significant at 10% level; values outside the bracket are the coefficients; values in the bracket are t-statistics.

socioeconomics variables used in modelling production function are as shown in Table 1. The effects of socioeconomic factors are not discussed in this paper.

Degree of efficiency among bulrush millet growers, the production functions' coefficients (Betas), inefficiency effect variables (sigma) and Likelihood Ratio (LR) test or diagnostic statistics is shown in Table 2.

The intercept values of the MLE are greater than OLS estimates as shown in Table 2; hence, they do not provide the same estimates. Though the C-D production function exhibits unitary elasticity of factors of production, parameters of the model in the two counties exhibit decreasing return to scale (0.73, Kericho and 0.72, Narok). This is an observable fact which could be due to the real nature of the farmers' production behaviour which might not be constant across farms.

All the input factors except seed in Narok have positive elasticity values and therefore raise production levels through higher use. Statistical tests of the estimated parameters were necessary to know if variation in bulrush millet output was due to inefficiency (Table 3). The statistics test using LR was done and the decision criterion arrived at by using Table 1 in Kodde and Palm (1986). The null hypothesis (H_0) that there were no technical efficiency effect in bulrush millet production, $H_0: \gamma = 0$, was rejected with farmers' data for all the counties and alternative hypothesis that there was technical inefficiency effect in bulrush millet production, $H_1: \gamma \neq 1$, was accepted. The estimated total variation from the frontier $\partial^2 = \partial_u^2 + \partial_v^2$ and variations due to inefficiency $\gamma = \partial_u^2 + \partial_v^2$ terms (Table 2) are positive and significantly different from zero at 5% in all counties. This is an indication that the observed output significantly differed from the frontier output. That is, factors, which are within the control of the farmer, are the cause of these variations. It also indicates a good fit and correctness of the specified half normal distribution assumption of the composite error term (Amaza and Olayemi, 2002). The values of gamma (γ) are 0.95, 0.99 and 0.99 for Kericho, Bomet and Narok respectively. The results are highly significant at 1% level. This implies that 95% (Kericho), 99% (Bomet) and 99 % (Narok) variations in the output of bulrush millet were due to inefficiency. The three county's results depict that the systemic influences that are unexplained by the production function are the dominant source of inefficiency. It also shows that variations in inputs productivity among bulrush millet farmers are also due to differences in technical efficiency in the counties (Ajibefun et al., 2006).

CONCLUSION AND RECOMMENDATIONS

The hypothesis that there is no technical inefficiency effects and that explanatory variables had no effect on efficiency is strongly rejected for the three counties data. Thus, high bulrush millet output (over 95%) variation is due to technical inefficiency. This inefficiency is attributed to inadequate use of inputs common to small scale bulrush millet farmers. The implication of the study is that

Table 3. Hypothesis test on the above models.

Hypothesis	LLF	λ_{λ} / $(LR - Test)$	Degree of freedom	$\chi^2 5\%\ value$	Decision
Kericho model (OLS)	-21.05				
$H_0: \gamma - 0$	-10.93	20.24	3	7.045	Reject H_0
$H_0: \beta_1 \ldots\ldots \beta_3 = 0$	-10.93	20.24	3	7.045	Reject H_0
$H_0: u$	-10.93	20.24	1	2.706	Reject H_0
Bomet model (OLS)	-60.92				
$H_0: \beta_1 \ldots\ldots \beta_3 = 0$	-46.65	28.54	3	7.045	Reject H_0
$H_0: \gamma = 0$	-46.65	28.54	3	7.045	Reject H_0
$H_0: u$	-46.65	28.54	1	2.706	Reject H_0
Narok model (OLS)	-10.89				
$H_0: \beta_1 \ldots\ldots \beta_3 = 0$	-2.64	16.50	3	7.045	Reject H_0
$H_0: \gamma = 0$	-2.64	16.50	3	7.045	Reject H_0
$H_0: u$	-2.64	16.50	1	2.076	Reject H_0

technical efficiency in bulrush millet production in Kenya could be increased by 28 to 56% through better use of available resources, given the current state of technology. Policy strategy aimed at improving technical efficiency in the short run should emphasize on an effective and efficient use of the current technology transfer instruments which enhance capacity of the farmer to efficiently use the physical inputs (labour, materials and seeds in this case). Bulrush millet farmers need to utilize the available technology efficiently to reduce losses or alternatively gain from it by minimizing inputs use while maintaining output levels, ceteris paribus.

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