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Research Article
Resource optimization in sorghum production in Niger state, Nigeria

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Abstract

This study determines the resource use efficiency in sorghum production in Niger State, Nigeria. Multi stage sampling technique was employed to elicit information from 100 sorghum framers through administration of pre-tested questionnaire. Data collection was for 2014 cropping season. Production function analyses which incorporate the conventional neoclassical test of economic and technical efficiencies were used as the analytical technique. Findings revealed that the farmers were inefficient in the use of all the resources. Generally, inputs such as hired labour, seed, farm size and fertilizer were under-utilized, while family labour was over-utilized. The results indicate that there is need to make inputs such as fertilizer and improved seeds affordable and accessible to the farmers so as to improve efficiency. Also policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in sorghum production in the area should be formulated.

Introduction

Fifty years ago, Nigeria produced all the food it needed but then something happened. Oil was discovered, the country became embroiled in a bitter civil war, and a high fertility rate triggered population explosion that raises the population from 45 million to 173 million today. Somewhere along the way, agriculture was relegated to a secondary activity. Faced with an appalling legacy of military rule, widespread corruption and gross mismanagement of the economy, all that is about to change given the political willingness of current Nigerian government been determined to embark on a new development course that places agriculture at the heart of domestic growth. In one sense, Nigeria is preparing to become a post-oil society and is cultivating as many different economic sectors as possible to smooth that transition (NEDBANK Capital, 2013). Agriculture still remains an important sector of the economy with high potentials for employment generation, food security and poverty reduction. However, these potentials has remained largely untapped which has led to the dwindling performance of the agricultural sector both domestically and in the international trade over years. Its competitors maintained their dominance due to strong marketing organizations that linked the farmers to markets and provided support in the form of improved planting material, fertilizer, credit and rural infrastructure (FMARD, 2013).

According to RPCA (2013) cereal production in the Sahel and West Africa is 57.01 million tonnes. This is equivalent to the production seen in 2012-13, but it is 11% higher than the average of the last five years. For the Sahel, production is 19.596 million tonnes, which is equivalent to the average of the past five years but down 12% compared to production in 2012-13, when production was strong. For Gulf of Guinea countries, cereal production is estimated to be 37.414 million tonnes, which represents an increase of 8% compared to 2012-13 and a 17% increase compared to the average of the past five years. However, per capita production in the region is the same as the average of the past five years.

Sorghum is a genus of numerous species of grasses, one of which is raised for grain and many of which are used as fodder plants either cultivated or as part of pasture. The plants are cultivated in warmer climates worldwide. Species are native to tropical and subtropical regions of all continents in addition to the South West Pacific and Australasia. One species, Sorghum bicolor, is an important world crop, used for food (as grain and in sorghum syrup or "sorghum molasses"), fodder, the production of alcoholic beverages, as well as biofuels (Miller Magazine, 2014). Sorghum production in 2012/13 was forecasted at 6.9 million tons, up from 6.8 million tons in 2011/12. Crop yield has increased because of the growing acceptance by farmers of improved varieties developed by local research institutes. These include two sorghum varieties bred by the International Crops Research Institute for Semi-Arid Tropics (INCRISAT) which are higher yielding and earlier maturing (FEPSAN, 2012).

Nigeria is the largest sorghum producer in West Africa, accounting for about 71 percent of the total regional sorghum output, 30-40 percent of total African production, and is the third largest world producer after the United States and India. About 90 percent of sorghum produced by United States and India is utilized for animal feed production, leaving Nigeria as the world's leading food grain sorghum producer (GAIN, 2014). Sorghum ranks third after corn and millet in term of cereal production in Nigeria and is the primary food crop across northern Nigeria (CGIAR, 2013). Sorghum millet and maize are widely consumed by most households, especially in the North, and are used by various industries (FMARD, 2012; FEWSNET, 2014), but demand from industry is the main drive behind increases in sorghum production. Sorghum is used extensively in brewing and industrial demand for sorghum for beer production is rising steadily, as beer demand rises (GAIN, 2013). Sorghum is very important in human diet with becoming one of the most important cereals used in World Food Program such as Food aid and school feeding program. It is projected that by the end of 2012, sorghum requirement for fortified food for Home Grown School Feeding (HGSF) Program would be to the tune of 51,000MT. This figure would however increased by 500% by 2015.The demand for sorghum for both HGSF and WFP will however be met by ramping up production and processing capacity in the North East and North West, ensuring minimal (5-10%) loss of grain during processing (FAO, 2012). As at now, 90,000 jobs are being created in primary production of sorghum and 18,000 across the value chain. By 2015, despite the relatively low labour requirements of sorghum of 88 man days per hectare, it is expected that an estimated 131,000 employment opportunities would be generated in primary production. Sorghum value chain being relatively labour intensive, it is projected that 20% of the jobs created in primary production would be generated across sorghum value chain by 2015. The value chain includes, input supply, service delivery, aggregation of output and processing. (FMARD,2012).

Low productivity in Nigeria over years compared to leading countries like Malaysia, Thailand, Indonesia, and Brazil has been largely due low fertilizer and improved seed utilization, inadequate government expenditure and the inability to compete with others. At the national level, productivity growth raises living standards because more real income improves people's ability to purchase goods and services, enjoy leisure, improve housing and education and contribute to social and environmental programs. Productivity growth is important to the firm because it means that the firm can meet its (perhaps growing) obligations to customers, suppliers, workers, shareholders, and governments (taxes and regulation), and still remain competitive or even improve its competitiveness in the market place (FEWSNET, 2014). Furthermore, it was submitted that a consensus seems to have emerged to the effect that productivity growth in the agricultural sector is essential if agricultural output is to grow at a sufficient rapid rate to meet the demand for food and raw material that typically accompanied urbanization and industrialization. Failure to achieve rapid growth in agricultural productivity can result either in drain of foreign exchange or a shift in internal terms of trade against industry and thus seriously impede the growth of industrial production. Yield per hectare is the driver of agricultural competitiveness (FMARD, 2014).

As part of the Federal Government of Nigeria's effort to revamp the agriculture sector, ensure food security, diversify the economy and enhance foreign exchange earnings, the FMARD embarked on a Transformation Agenda with a focus on the development of agricultural value chains, including the provision and availability of improved inputs (seeds and fertilizer), increased productivity and production, as well as the establishment of staple crop processing zones. It also addresses reduction in post-harvest losses, improving linkages with industry with respect to backward integration, as well as access to financial services and markets. The Transformation Agenda targets rural communities particularly women, youth and farmers associations as well as improving rural institution and infrastructure (FMARD, 2012).The Vision in the transformation strategy is to achieve a hunger-free Nigeria through an agricultural sector that drives income growth, accelerates achievement of food and nutritional security, generates employment and transforms Nigeria into a leading player in global food markets to grow wealth for millions of farmers" (FMARD, 2013). Today, sorghum and millet are two of the most basic foods for the poor and rural people in the dry regions that are poor in terms of other grains. When the production regions of these products are reviewed, it is seen that Africa, Central America and South Asia are at the front. Used in various fields such as human food, feed and biofuel; these products are an important food source for the African countries that are especially poor in terms of other grain products (GRAIN AFRICA, 2014).

Given these above scenarios, this call for an appraisal of efficiency resources under small scale sorghum production. The implication is that there is scope for additional increase of output from existing hectares of sorghum, if resources are properly harnessed and efficiently allocated (Zalkuwi *et al*., 2014). It is against this background that the study intend to examine resource use efficiency in sorghum production in Niger State, Nigeria to bridge the gap in existing knowledge on resource use efficiency research in the study area. The choice of Niger state is premised on the fact the state accounts for the largest arable cultivatable landmass in the country which will give the state a head advantage over other sorghum producing states, there is little or no documented evidence of studies related to efficiency in sorghum production, given that similar studies on resource utilization in sorghum production have been conducted in most sorghum producing states in Nigeria (Aduba *et al*., 2013; Sani *et al*., 2013; Zalkuwi *et al*., 2013;). Furthermore, the economic importance of sorghum and its significance in the economic development of the nation, therefore, call for a sustain research work on all aspect of sorghum production. Therefore, this study ought to examine the resource utilization in small-scale sorghum production in Niger state, Nigeria.

Production function in efficiency studies

Agricultural productivity can be defined as the index of the ratio of the value of total farm output to the value of the total inputs used in the farm production. Production efficiency means the attainment of production goals without waste. Efficiency is an important factor of productivity growth specifically in developing economies where resources are meager and opportunities for developing and adopting better technologies are limited. Farell (1957) derived the three components of efficiency recognized in the economic literature. They include: (i) Allocative efficiency, and (ii) Economic efficiency. A firm is said to be technically efficient if it produces as much output as possible from a given set of inputs or if it uses the smallest possible amount of inputs for a given level of output and input mix. The allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. The product of these two efficiencies is economic efficiency, which could be defined as the ability of the firm to produce a well-specified output at minimum cost.

The modeling and estimation of production efficiency of a farm relative to other farms or the 'best' practice in an industry has become an important area of economic study. Productivity is generally measured in terms of the efficiency with which factor inputs, such as land, labour, fertilizer, herbicides, tools seeds and equipment etc are converted to output within the production process. According to Sadiq and Yakasai (2012), productivity measures are of two types, partial productivity and total factor productivity (TFP). Partial productivity is measured as the ratio of output to one input. Total factor productivity is the ratio of output to all inputs mixed.

Generally, two approaches are used in measuring TFP. These referred to growth accounting or index number approach and the econometric or parametric method. The econometric method is based on an econometric estimation of the production function or the underlying cost or profit function. In this study, the production function is used to measure the productivity. From the production function, the conventional neoclassical test of economic efficiency was derived. The rule of this test is that the shape of the production function (MPP) should be equal to the inverse ratio of input price to output price at the profit maximization point. This is given as:

$$MPPXi = Pxi/Py$$

Where:

Pxi=the price per unit of resource input used
Py= the output price
MPP = the marginal physical product of resource input used

$$MPP \times Py = MVP$$

$$MVP/MFC = r$$

Where:
MVP = ma
rginal value product
MFC = marginal factor cost/ unit cost
K = numerical constant
In an attempt to substitute the efficiency hypothesis, focus is centered on the estimated value of r and its closeness to unity (1). Efficiency is attained if: MVP = MFC.

Methodology

Study Area

This study was based on the farm level data on small scale maize farmers in Niger State, Nigeria. Niger State is in the North-central part of Nigeria and lies in between longitude 3^0 30^1 and 7^0 20^1 east of the Greenwich Meridian and latitude 8^0 20^1 and 11^0 30^1 north of the equator .The land area is about 80,000 square Kilometre with varying physical features like hills, lowland and rivers. The state enjoys luxuriant vegetation with vast Northern guinea savannah found in the north while the fringe (southern guinea savannah) in the southern part of the state. The people are predominantly peasant farmers cultivating mainly food crops such as yam, cassava, maize and rice for family consumption, and markets.

Sampling technique and Data Collection

The data for the study was drawn from primary source with the aid of pre-tested questionnaire coupled with interview schedule. The questionnaires were administered on 100 maize famers selected through multistage sampling procedure.

The first stage involved the purposive selection of one Agricultural zone out of the three Agricultural zones in the state, namely, Kontagora for its prominence in sorghum production. In the second stage, two local government areas, namely Kontagora and Rijau were purposively selected due to preponderance of small scale sorghum producers. The third stage involved random selection of five villages from each LGAs. Lastly, 50 respondents were drawn from each of the villages, thus, given a total sample size of 80 respondents'.

Method of Data Analysis

The analytical procedure employed was production function analysis. This was used to obtain the parameters for the measurement of resource use efficiency of the rice farmers. Four functional forms were tried and the lead equation was selected based on economic, econometric and statistical criteria including signs and magnitudes of the coefficients, the magnitude of R^2, T-statistics, F-statistic s (Goni *et al*., 2007). The function experimented with were linear, semi-log, exponential and double-log.

Model specification:

The implicit function can be presented by the following equation:

Y=f(X1,X2,X3,X4,X4,X5,X6) …………………………... (1)

Where;

Y = Output of Maize (kg)
X_1 = Family labour used (in manday)
X_2 = Hired labour used (in manday)
X_3 = Quantity of seed (kg)
X_4 = Fertilizer used (kg)
X_5 = Farm size (in hectares) (kg)
X_6 = Depreciation on capital inputs (in naira)

The following functional forms were evaluated

(a) Linear function
(b)

$Y = b_0 + b_1 X_1 + b_2 X_2 \text{........} + b_n X_n + e_i$ ……………………….(2)

MPP= b

Elasticity = b * X/ Y

(b) Semi–log function

$Y = \log b_0 + b_1 \log X_1 + b_2 \log X_2 \text{..............} + b_n \log X_n + e_i$ ………… (3)

MPP = b/ X

Elasticity = b/Y

(c) The Cobb Douglas (double log) function

$Log\ Y = \log b_0 + b_1 \log X_1 + b_2 \log X_2 \text{...........} + b_n \log X_n + e_i$ ……… (4)

MPP = b* Y/X

Elasticity = b

(d) Exponential function

$Log\ Y = = b_0 + b_1 X_1 + b_2 X_2 \text{.............} + b_n X_n + e_i$ ………………….. (5)

MPP = b*X

Elasticity = b*Y

Note:

b_0 = Intercept

b_1-b_n = Regression co-efficients

Determining technical efficiency of resource use

The elasticity of production which is the percentage change in output as a ratio of a percentage change in input was used to calculate the rate of return to scale which is a measure of a firm's success in producing maximum output from a set of input (Farrel, 1957).

EP=MPP/APP ……………………….. (6)

Where:

EP = elasticity of production
MPP = marginal physical product
APP = average physical product
If
EP =1: constant return to scale
EP < 1: decreasing return to scale
EP > 1: increasing return to scale

Determining Economic Efficiency of Resource use

The following ratio was used to estimate the relative efficiency of resource use (r)

r = MVP/MFC ………………. (7)

Where:

MFC = unit cost of a particular resource
MVP = value added to rice output due to the use of an additional unit of input, calculated by multiplying the MPP by the price of output. i.e. MPPxi x Py

Decision rule

If r = 1, resource is efficiently utilized,
if r > 1, resource is underutilized, while,
if r < 1, resource is over utilized.
Economic optimum takes place where MVP = MFC. If r is not equal to 1, it suggests that resources are not efficiently utilized. Adjustments could be therefore, be made in the quantity of inputs used and costs in the production process to restore r = 1 and the model is given as follows:

Divergence percent = (1-1/ri) x100 or [(ri-1)/ri] x100

Results and Discussion

Input-Output relationship in sorghum production

The effect of production inputs on sorghum output was determined with the aid of production function analysis. On the basis of *a priori* expectation, sample coefficient of determination (R^2), population coefficient of determination (F-statistics), statistical significance of the coefficients (t-statistics), test of normality, heteroscedasticity and multicollinearity the Linear functional form was chosen as the best fit for the model (Table 1a). Table 1 reveals that all inputs included in the model were positively related to the sorghum output except family labour which carries negative sign. The value of the R^2 indicates that 91.6% of the variations in sorghum output were explained by the independent variables included in the model. Furthermore, all the variables included in the model significantly influenced the output level at 1 percent, except depreciation on capital items which is not significant.

Moreover, since the coefficient of the linear equation is the MPP, its ratio to APP gives the elasticity, therefore, the following can be inferred: a unit increase in the level of hired labour, improved seed, fertilizer and farm size will lead to 0.77, 0.35, 0.17 and 0.49 percent changes in sorghum output respectively, while a unit increase in family labour will leads to -0.83 changes in output level. In the former, an unit increase implies increment in the output level, while the later implies a decrease in the output level which means it is has attained its third stage in the production process. Depreciation on capital items is not significant, as such need no further discussion. The negative sign of family labour is not a surprising outcome given that it is cheap/free and in abundance. The notion is that farm production and productivity is synonymous to size of the household in a characterized traditional agricultural setting which is peculiar to Africa. This findings is conforms with the finding of Sani *et al*.(2013) except for seed which differs. The value of the function coefficient which is 1.63 indicates increasing returns to scale (Table 1b). This suggests that farmers in the study area can increase their sorghum output by using more of hired labour, improved seeds, fertilizer and land, and less of family labour.

Table 1a: Regression results for Sorghum production in Niger state, Nigeria

Variable	Linear(+)	t-value	Semi-log	t-value	Exponential	t-value	Double log	t-value
Constant	205.23 (156.21)	1.31^{NS}	-732.06 (718.55)	1.02^{NS}	6.25 (0.17)	37.96 ***	5.29 (0.43)	12.33***
Family labour	-9.31 (4.649)	-2.00***	-9.48 (8.5)	1.12^{NS}	-0.005 (0.004)	-1.25^{NS}	-0.033 (0.022)	-1.5^{NS}
Hired labour	19.13 (6.89)	2.78***	-65.76 (59.7)	1.10^{NS}	-0.007 (0.006)	-1.20^{NS}	0.08 (0.06)	0.03^{NS}
Seed	82.78 (27.54)	3.01***	594.55 (203.67)	2.92***	0.049 (0.029)	1.70*	0.35 (0.12)	2.88 ***
Fertilizer	2.49 (1.15)	2..16***	115.88 (80.75)	1.43^{NS}	0.002 (0.001)	1.37^{NS}	0.11 (0.05)	2.35 ***
Farm size	311.17 (59.41)	5.24***	651.74 (163.73)	1.21^{NS}	0.23 (0.06)	0.366^{NS}	0.52 (0.098)	5.36 ***
Depreciation	0.3 (0.2)	1.5^{NS}	58.64 (48.64)	3.89***	7.7780-6 (0.000)	3.61***	0.06 (0.04)	1.59^{NS}
R^2 value	0.916		0.881		0.822		0.918	
R^2 Adjusted	0.906		0.867		0.802		0.910	
F-statistics	93.998***		62.75***		40.114***		116.59***	

Source: Field survey, 2014

Table 1b: Elasticity estimates of linear regression

Variables	Estimates
Family labour	-0.88
Hired labour	0.77
Seed	0.35
Fertilizer	0.17
Farm size	0.68
Depreciation	0.49
Return to scale	1.63

Field survey, 2014

Estimates of resources use efficiency

Table 2 reveals measure of technical efficiency of resource use such as Average Physical Product (APP), Marginal Physical Product (MPP), and Marginal Value Product (MVP) and Marginal Factor Cost (MFC) were derived. The values of the MPP show that the farmers were more efficient in the use of land than the other resources. This suggests that if additional hectares were available, it would lead to an increase in sorghum yield by 311.168 kg among the farmers. This implies that the farmers are more technically efficient in the use of land. Of all the resources used, fertilizer had the least MPP (2.49 kg). This shows inefficiency in the use of available fertilizer. Given the level of technology and prices of both inputs and outputs, efficiency of resource use was further ascertained by equating the MVP to the productive MFC/UFC of resources. A resource is said to be optimally allocated if there is no significant difference between the MVP and MFC i.e. if the ratio of MVP to MFC =1 (unit). Table 2 further reveals that the ratios of the MVP to the MFC were greater than unity (1) for all the input except family labour. This implies that hired labour, improved seed, fertilizer and farm size were under-utilized, while family labour was over utilized. This implies that sorghum output was likely to increase and hence revenue if more of such inputs (hired labour, improved seed, fertilizer and farm size) had been utilized. The adjustment in the MVPs for optimal resource use in Table 2 indicates that for optimum allocation of resources more than 19% increase in hired labour was required, while approximately 94% increase in seed was needed. Similarly, over 65% increase in fertilizer was needed, while more than 75% increase in land was required. Labour was over utilized, and required more than 23% reduction for optimal use in sorghum production.

Table 2: Values of estimates of Efficiency parameters

Resource	Mean	APP	MPP	MVP	MFC	MVP/MFC	Divergence %
Family labour	121	11.13	-9.32	605.61	750	-0.81	23.46
Hired labour	54	24.94	19.13	1243.45	1000	1.24	19.35
Seed	5.75	234.26	82.78	5380.77	322.88	16.66	94
Fertilizer	94.13	14.31	2.49	161.72	55	2.94	65.99
Farm size	2.11	638.39	311.17	20225.92	5000	4.05	75.31

Source: Field survey, 2014

Conclusion and Recommendations

Findings from this study revealed that sorghum farmers were allocatively inefficient in the use of farm resources. The inefficiency of the farmers may be directly or indirectly linked to the high cost of improved seeds, fertilizers cost and rent cost. The implication of the study is that allocative efficiency in sorghum production in the study area could be increased through better use of improved seeds, fertilizer, land and subsidies on the aforementioned inputs. The improvement in the efficiency among the farmers is the responsibility of the individual farmers, government and research institutions. There should be improvement in extension services delivery, adequate provision of improved rural infrastructures and enabling policies (such as making available all agricultural inputs required at the right time and affordable prices) among others, are also required in order to enhance efficiency. In addition, there should be policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in rice production.

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