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Full Length Research Paper

Resource use efficiency in sole sorghum production in three villages of Kaduna State Nigeria

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In explaining the differences in the efficiency of farms, it is necessary to look into the use of resources to show the close links existing between the performance attained from resources on individual farms and efficient allocation of resources between farms of different sizes. This study estimates the productivity of farm resources on small and large scale farms in three villages of Giwa Local Government Area of Kaduna State. Production data were collected using a structure questionnaire from a representative sample of 78 sorghum farmers. The study used the double log production function to determine the relationship between farm resources and the efficiency of resource use. Empirical results showed that seed, fertilizer and labour inputs are statistically significant in explaining the variation in sorghum output in the study area. However the estimates of the ratio of the marginal value productivities (MVP) and marginal factor cost (MFC), point clearly to the non optimal combination of inputs among the farmers, it showed that the farm resources were inefficiently utilized for sole sorghum production by small and large scale farmers, hence, the need for resource adjustment. Implications for regional and national food policies are discussed.

Key words: Sorghum, productivity, resource-use, efficiency.

INTRODUCTION

Available statistics have shown that while Nigeria's overall food demand has been growing at a rate of 3.5% per annum, food production has been growing at a rate just above 2% per annum, thus creating a serious food gap (Shaib et al., 1997). The food problem, which started in the mid 1960s, has continued to deepen several years after independence. Agricultural contribution to the GDP and exports has been low since the 1980s as food imports continued to rise in value from N3.47billion in 1990 to N113.63 billion in 2000. In terms of relative importance, food import as a percentage of total imports rose from 3.5% in 1991 to 11.8% in the year 2000 (CBN, 2000; Nyako, 2006).

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Although opinions differ on the magnitude of Nigeria's food problem, its nature has never been in doubt. At the national level, the main food problems are food supply deficits, poverty and uneven distribution of income in terms of ability to buy food (Ohajianya, 2004). On the economic front, inadequate food has resulted in reduced export earnings, large food imports, low revenue for government, shortage of raw materials for industries and increase inflationary pressure (CBN, 2000).

In essence, agriculture's contribution to the national economy has been dwindling. This is so given that Nigeria has varied and complex constraints militating against the realization of increased agricultural output, among which are low crop yields, use for unimproved crop varieties, inconsistent macro-economic policies and poor input and produce marketing systems. Catastrophes, disease and pests' outbreak have also contributed to this situation (Shaib et al., 1997).

Sorghum is one of the most important staple food crops in Nigeria. Its production surpasses all other crops. In terms of food contribution, sorghum is the major cereal consumed by the majority of the population. About 73% of the total calories from cereals and 52% of the per capita protein intake are contributed by sorghum alone (NAERLS, 1997). The leaves and grains are also used for livestock feeds and the stalks for thatching houses and making fences. The shortfall in cereal production, particularly sorghum production, has been reported in the Nigeria savannah zone, where sorghum is grown on an estimated area of 4.5 million ha with annual production output of about 6 million tonnes (NAERLS, 1997). This poses a problem to all Nigerians, especially those living in the northern part of the country where sorghum is the most widely cultivated and consumed cereal crop.

Sorghum is also a very valuable industrial crop for brewing alcoholic and non-alcoholic drinks as well as in the baking and confectionery industry (Debrah, 1993), this is true in Nigeria. According to NRC (1996), sorghum has greater untapped potentials than any other crop. They even postulated that if the twentieth century was the century of wheat, rice and maize, then the twenty-first century could become the century of sorghum.

Therefore, to increase sorghum productivity, sound macro and micro-economic farm policies are needed. These require a knowledge of aggregate farm level resource availability and differences in the productivities of these resources in different farm sizes. This paper attempts to provide some useful information in policies towards increasing sorghum production. The study therefore examines resource use efficiency pattern in sorghum production on small and large scale farms, to report evidence related to resource use and farm productivity.

THEORETICAL FRAMEWORK AND EMPIRICAL MODELS OF PRODUCTION FUNCTION

The production function analysis gives the physical or technical relationship between inputs and output in any production scheme or process (Farrel, 1957; Olayide and Heady, 1982; Olukosi and Ogungbile, 1989). Mathematically, this function is differentiable. Its differentiability enables the calculation of the rate of return. It is assumed that the technical relationship between variable factors of production and output can be represented by a production function, which is mathematically expressed as;

$$y = f(x_1, x_2, \ldots x_n) \quad (1)$$

where y is the quantity of output and $x_1, x_2 \ldots x_n$ are factors of production. It is presumed that there are n factors, one or all may be varied and any of which may be considered fixed. Since output is measured in physical terms, y is referred to as total physical product. Important physical concepts are the average and marginal physical products. The average physical product APP, measures the average rate at which an input is transformed into a product, while the marginal physical product *MPP* is the change resulting from a unit increment or unit change in variable input. It measures the amount that total output increases or decreases as input increases. The *APP* and *MPP* are differentiable and allows us to vary one factor while the others are held constant and it gives an insight into the efficiency of resource use. The marginal productivity functions are

$$MPP_1 = \frac{\partial TPP}{\partial x_1} = \frac{\partial y}{\partial x_1} = \frac{\partial f(x_1, x_2, \ldots x_n)}{\partial x_1} = f_1 \quad (2)$$

$$MPP_2 = \frac{\partial TPP}{\partial x_2} = \frac{\partial y}{\partial x_2} = \frac{\partial f(x_1, x_2, \ldots x_n)}{\partial x_2} = f_2 \quad (3)$$

and

$$MPP_n = \frac{\partial TPP}{\partial x_n} = \frac{\partial y}{\partial x_n} = \frac{\partial f(x_1, x_2, \ldots x_n)}{\partial x_n} = f_n \quad (4)$$

Model specification

This study considers only three explanatory variables in modelling the production function for sorghum production. Based on a prior knowledge, the three inputs considered to be important in explaining variation in output of sorghum in the study area are quantity of seeds, fertilizer and labour inputs. The variables considered are;

Quantity of seeds (X_{sd})

This refers to the quantity of seed planted. This was included in the model to determine its influence on sorghum yield it was measured in kilograms.

Quantity of fertilizer (X_{ft})

This referred to the quantity of fertilizer materials used. While some farmers had little or no fertilizer to apply to their crop, others can apply more than the recommended level per hectare. It was therefore included to know the extent to which the variations affect the total output from farms. It was measured in kilogram (kg).

Quantity of labour (X_{lb})

This is the amount of physical efforts used in the production process. It is made up of both family and hired labour. It was included to determine the level of labour utilization so as to ascertain if labour is being over utilized or underutilized. This is important in the light of common assumption in economic literature that labour in developing countries has low or near zero margin product. Labour input was measured in man-hours.

Stochastic/error term (U)

The inclusion of error term was to account for other factors which may not have been captured by the model.

Table 1. Distribution of Farmers Based on Farm Size.

Farm strata	No. of farmers	Average farm size (Ha)	Standard deviation
Small scale	50	1.6	1.3
Large scale	28	8.8	5.1

Source: Field survey

The production function is implicitly expressed as

$$y_{so} = f(x_{sd}, x_{ft}, x_{lb}, u)$$

where,

y_{so} = Yield of sorghum (kg)

x_{sd} = Quantity of seed (kg)

x_{ft} = Quantity of fertilizer (kg)

x_{lb} = Quantity of labour (man-hour)

u = Stochastic/error term

Study area and sampling/data collection

This study used production data collected from three villages of Giwa Local Government Area of Kaduna State, Nigeria; Giwa, Shika and Yakawada. The three villages are Giwa, Shika and Yakawada which are homogeneous. The farmers here are peasant, they have no access to credit and share the same traditional production technology for sorghum. They were purposefully chosen from the list of villages obtained from the Agricultural Development Program zonal office in the state. The data is based on year 2003 production activities.

Giwa local government area of Kaduna state is located in the northern guinea savannah and on the plains of northern Kaduna. It lies between latitude 11.20 -11.52°N and longitude 7.0 - 7.5°E. The area is characterized by alternating dry and wet season with a mean annual rainfall that varies from 1,000mm to 1,300mm and temperature of between 27 and 32°C. The major source of livelihood in this area is farming, engaging about 70% of the rural population. Farming is traditional in nature with emphasis on the cultivation of crops such as sorghum, maize, millet, groundnuts and cowpeas and keeping of livestock.

For this study, primary data was used. A reconnaissance survey was first conducted with the assistance of the extension staff of the Agriculture Department of the Local Government Area to identify farmers who grow sole sorghum, that is farmers that grow sorghum alone on their farm, not in intercrop mixture. The list of the farmers so obtained served as the sample frame. From the sample frame, the farmers were classified into two classes, those who cultivate less than 5 ha were regarded as small scale farmers and those who cultivated 5 ha and above were regarded as large scale farmers, for the purpose of this study only. Random sampling technique was adopted to select 10% of the farmers from each class. A total of 78 farmers were thus used for the study, 50 farmers were selected from the small scale stratum and 28 farmers from the large scale stratum out of the 780 farmers on the sample frame**.**

The average sorghum farm in the study area was 4.2 ha. However on the basis of the classification above, the average on small scale farm is 1.6 ha while it is 8.8 ha on the large scale farm, which more than double the average total farm holdings. The range was 3 and 7 ha for small and large scale farms respectively.

Table 1 showed that there was unevenness in farm size not only among the different classes of farms but also within the different classes as reflected by the standard deviations of the means. Thus, while the small farmers who represent about 64% of the whole farmers sampled cultivated only about 25% of the total sorghum farm in the area, the large scale farmers who represented about 36% of the farmers cultivated 75% of the total farm land. The unevenness observed between the groups could be attributed to the mode of land acquisition, which is mostly by inheritance. With increasing population, the size of holdings becomes smaller while big farms also become smaller, the rate of change depends mostly on the family size.

RESULTS AND DISCUSSION

A sorghum production function was estimated using the Ordinary Least Square technique. The double-log, semi-log, quadratic and linear functional forms were tried in the analysis. Based on the size of the adjusted coefficient of multiple determinations, the number of significant variables and their signs, the double-log function was selected and used in further analysis.

The empirical result of the ordinary least square regression (OLS) of the double-log equation is presented in Table 2.The coefficient of multiple determinations R^2 for double-log function was 0.765 for the small-scale farm, 0.835 for the large-scale farm and 0.901 for the pooled data. This implies that 76.5, 83.5 and 90.1% of the variation in the output of the small-scale farm, large-scale farms and for the pooled data respectively are explained by the explanatory variables included in the model.The coefficient of fertilizer and labour in the small scale farm were significant at 1% confidence level, while for the large farms, seed and labour inputs were the significant variables explaining variation in farm output. For the pooled data, all the three included variables were significant at 1 percent in explaining variation in output.

The double-log function showed that seed, fertilizer and labour has elasticity of 0.066, 0.548 and 0.418 respectively on the small scale farm, while on the large scale farm it has 0.182, 0.732 and 0.679 respectively. This means that for 10% increase in the use of seed from its present average level of 15.25 to 16.78 kg, sorghum output, *ceteris paribus,* will increase by 0.66% that is by 4.95 kg, 10% increase in the use of fertilizer from its present average level of 175 kg to 192.5 kg will increase sorghum output, *ceteris paribus,* by 5.48 % that is by 41 kg and 10% increase in the use of labour from its present average level of 335 man-hour to 368.5 man-hours will

increase sorghum output, *ceteris paribus,* by 4.18% that is by 31 kg on the small scale farm. While on the large scale farm, it means for 10 percent increase in the use of seed from its present average level 10.7 to 11.77 kg, sorghum output, *ceteris paribus,* will increase by 1.8% that is by 27 kg, 10% increase in the use of fertilizer from its present average level of 250 kg/ha to 252.5 kg will increase sorghum output, *ceteris paribus,* by 7.3% that is by 10 kg and 1% increase in the use of labour from its present average level of 291 to 294 man-hour will increase sorghum output, *ceteris paribus,* by 0.679% that isby 10.20kg.

The Marginal Physical Product (MPP) that is the addition to total product resulting from a unit increase in the use of the variable input of each resource was determined using the formula;

$$MPP = b_i \frac{\bar{y}}{\bar{x}_i}$$

where;

MPP = The marginal physical product of x_i (i = seed, fertilizer, labour)

b_i = Regression coefficient

$\bar{y}$ = Geometric mean of y

$\bar{x}_i$ = Geometric mean of x_i

The marginal value product (MVP) that is, the value of the extra output obtained as a result of an increase in input used by one unit, was also estimated as a product of MPP and the unit price of output (that is price of a kilogram of sorghum). The marginal value product (MVP) is obtained as a ratio of the average revenue per hectare to the average output per hectare from sorghum production; it is equivalent to the farm gate price. The marginal value product (MVP) is presented in Table 3.

The magnitude of the marginal value product was compared to marginal factor cost (that is MVP/ MFC ratio) and this indicates the scope of resource adjustment necessary to attain economic optimum. A ratio greater than one implies that the output could be raised by using more of a given resource. A ratio less than one imply the return to additional input is negative and output could be raised by using less of a given resource. A situation where the MVP equals the MFC or price per unit input implied an economic optimum.

The marginal factor cost (MFC) that is the unit price for the variable inputs used in sorghum production in the study area, are found to be ₦32, ₦37 and ₦45 for seed, fertilizer and labour respectively. The efficiency ratio of resource use in sorghum production is presented in Table 4.

Seed input is being employed below economic optimum level. Therefore, it is rational to increase the quantity of seed used on the large scale farm, as indicated by its efficiency ratio until the MVP equals its price, implying that the large scale farmers would increase profit by using more seeds. While the use of seed on the small scale farm is closer to the optimum level.

Fertilizer is also being used below economic optimum level as indicated by the efficiency ratios on both the small and large scale farms. This indicates that with other inputs held constant, increasing fertilizer by one kilogram would increase total value product by ₦74.88 and ₦140.48 on small and large scale farms respectively. This showed it is economical to increase the use of fertilizer on both farm sizes until the MVP equals its price, implying farmers would make more profit by using more fertilizer.

Labour on the small scale farm was employed above the economic optimum level, implying that labour is been over utilized as indicated by its efficiency ratio of 0.66. This can be attributed to the surplus family labour available to the small scale farmers. So reducing labour input by one man-hour will increase total value product by ₦29.76. This means small scale farmers will increase profit by reducing labour input. However, on the large scale farms labour was employed below economic optimum level, farmers here were not employing excessive labour in the production of sorghum, it is economical therefore, to increase labour input on large scale farm. Increasing labour by one man-hour would increase total value product by ₦112.

The estimates of the ratio of the marginal value productivities (MVP) and marginal factor cost (MFC), point clearly to the non optimal combination of inputs among the farmers and hence, the need for resource adjustment.

CONCLUSION AND IMPLICATIONS

From the findings of the study, it can be concluded that farm resources were not efficiently utilized for sole sorghum production in Giwa Local Government Area of Kaduna State, Nigeria. Improvement in the level of farm production and farm size holding requires proper understanding of the technical and socio-economic constraints facing the farmers; especially in the area of resource use and allocation. These farmers allocated their resources and chose enterprises based on their experience without scientific approach.

To increase aggregate sorghum production in the study area and to meet national domestic supply, there is need for resource use adjustments and the need to give the farmers opportunity to make rational decisions. This study provides the following recommendations:

Farmers (especially the small scale farmers) should be enlightened through extension services to make use of production factors by spreading their use across enterprises with different profiles. This will increase aggregate productivity and reduce domestic household consumption.

Table 2. Estimates of the double log function.

Regression no.	Farm size	No. of observation	Constant	Log x_{sd} seed	Log x_{ft} fertilizer	Log x_{lb} labour	R^2	Adj R^2
1	Small	50	-5.205 (110.49)	3.835 (5.099)	2.21*** (0.316)	0.804*** (0.160)	0.765	0.750
2	Large	28	-349.42 (249.43)	79.31*** (10.62)	0.739 (0.741)	0.385** (0.178)	0.835	0.814
3	Pooled	78	575.51 (88.56)	35.259*** (6.163)	2.689*** (0.373)	0.793*** (0.107)	0.901	0.897

Figures in parentheses are standard errors of the coefficients. *** = significant at 1%; ** = significant at 5%; * significant at 10%

Table 3. The marginal physical product and marginal value product of inputs.

Farm Size	Seed		Fertilizer		Labour	
	MPP (kg)	MVP (N)	MPP (kg)	MVP (N)	MPP (kg)	MVP (N)
Small	2.32	104	2.34	74.88	0.93	29.76
Large	25.5	816	4.39	140.48	3.50	112
Pooled	13.2	422.4	2.65	84.80	1.41	45.12

Table 4. Efficiency ratio of inputs used for sorghum production

Farm Size	Item estimated	Seed	Fertilizer	Labour
Small scale farm	MVP (N)	104	74.88	29.76
	MFC (N)	32	37	45
	MVP/MFC	3.25	2.02	0.66
	MVP (N)	816	140.48	112
Large scale farm	MFC/MFC	32	37	45
	MVP (N)	25.5	3.79	2.4
	MVP (N)	422.4	84.80	45.12
Pooled data	MFC (N)	32	37	45
	MVP/MFC	13.2	2.29	1.00

Source: Field survey

household consumption.

Most of the resources such as seed and fertilizer were under-utilized. This was attributed to limited capital, high cost and inadequate input supply. There is need therefore to provide financial support through small credit schemes to help farmers to expand their production.

Labour was the most predominant cost item on both farm sizes. There is therefore need for research to develop low cost technologies that will reduce the level of labour input for various farm operations.

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