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Analysis of technical efficiency among community-based seed producers in the savannas of Borno State, Nigeria

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Received 29 September 2009, accepted 20 March 2010.

Abstract

The study examined the socio-economic characteristics of participating seed farmers in a community-based seed production scheme organized by the project, Promoting Sustainable Agriculture in Borno State (PROSAB). In addition, it determined the technical efficiency of resource use in PROSAB seed farms. Farm level survey data from 396 seed producers who cultivated maize, cowpea, soybean, rice, groundnut and sorghum were obtained using well structured questionnaires. The production parameters were estimated simultaneously with those of the models of inefficiency effects. Using the maximum likelihood estimation technique, asymptotic parameter estimates were evaluated to describe production inputs and efficiency determinants. Based on the results of gross margin analysis, the observed profit margins across the seed types conclusively revealed that every one naira spent in cultivating the seeds, some levels of financial benefits were derived as indicated by the output/input indices. Results further revealed that labour, farm size, seed and fertilizer were the most important inputs across the six crops. Inefficiency model analysis further revealed that the duration of the crop grown and ecological region predominantly affected the seed farm level of technical efficiency in input use. A mean technical efficiency of between 55% and 58% was identified, meaning that seed production under the scheme can still be increase by about 45% and 42% using available technology. The study recommends that, given the significance of seeds that have a shorter duration to maturity, quick maturing varieties of seeds should be promoted among farmers in the study area. Also, timely access to land augmenting input like fertilizer should be ensured.

Key words: Community-based, seed, production, farmers, technical, efficiency, profit, Borno, Nigeria.

Introduction

One of the major constraints facing the crop sub sector in sub-Saharan agriculture is a lack of quality planting materials, especially seeds. Most farmers in the region have little or no access to improved seeds and continue to recycle seeds that have been exhausted after generations of cultivation¹. The crops rarely withstand pest and disease attacks and adverse weather conditions. The resultant effects of dependence on these poor quality seeds have been low yield and persistent food insecurity experienced in the sub-Saharan region^{2,3}.

This has been the case in Borno State, Nigeria with a weak seed supply system and poor access by farmers to improved seeds: Prior to the PROSAB intervention, the only improved seeds that were available to farmers were the hybrids which are not resilient to the constraints in the drought-prone State. Farmers have been recycling grain as seeds, a situation that has adverse effect on the viability of the planted seeds.

The PROSAB community-based seed production scheme was initiated because farmers in the State lacked quality seed at the time of planting. Designing community-based seed production is based on several issues. According to Banziger⁴ these include the choice of crop(s) and variety; source of seeds; training of seed producers; quality control; need for credit to facilitate purchase of inputs such as fertilizer to produce the seeds; cleaning,

packaging, and marketing and sustainability issues. To ensure availability of the improved crop seeds, the project selected and trained producers and assisted them in establishing community-based seed multiplication schemes in 30 communities. The project which began in 2004 has assisted 971 selected farmers through the provision of certified seeds of different crop varieties and inputs, such as fertilizer.

Since 2004, when the first set of seeds producers were trained and empowered, the Project has continuously selected, trained, and empowered more farmers. The scheme is proving successful. There are prospects that some seeds producers would develop into self-sustaining rural enterprises with a large capacity to fill the niche in the supply of quality improved seeds that farmers need within and around their communities.

Community-based seed production requires resources that are limited in supply. The availability of these resources and various combinations determine the quantity of output produced⁵. The cost-revenue relationship of the entire production process is influenced by how technically efficient is the utilization of their resources. This is why the concept of efficiency has remained an important economic study especially in developing agricultural economies, where resources are meagre and opportunities for developing better technologies are dwindling⁶⁻⁸. Efficient use of

resources is a prerequisite for optimum farm production since inefficiency in resource use can distort food availability and security⁹.

Efficient use of farm resources is an important part of agricultural sustainability, which Banziger⁴ underscored as a major issue in the design of a community-based production scheme such as the PROSAB scheme. One way small-scale farmers can achieve sustainability in agricultural production and handle the predominant menace of poverty and unemployment is to raise the productivity of their farms by improving efficiency within the existing resource base and available technology^{5,8}. The thrust of this paper, therefore, is to estimate the farm-level input productivities and efficiency indices among PROSAB farmers, and to evaluate the major determinants of inefficiencies among the farms.

Conceptual framework and literature review: Farrell¹⁰ is known to be the proponent of the modern concept of technical efficiency. His pioneering work provided a simple measure of farm-firm efficiency arising from multiple input uses. Technical efficiency as a major component of farm productivity indicates an ability of a farm to produce maximum output from a set of scarce inputs mix¹¹. Following Farrell, a farm-firm is technically efficient in resource use when it operates on a production possibility curve (PPC). On the other hand, a farm technically inefficient in resource utilization operates below the production frontier. The magnitude of the deviation of an individual farm from the frontier is the measure of the inefficiency^{12,13}. The closer the deviation, the nearer a farm is to the frontier and the more technically efficient it becomes. Hence, the position of an individual farm relative to the PPC could be influenced by factors ranging from the climatic, environment to the attitude and disposition of the farmers, among others¹⁴.

Mathematically, Farrell's production frontier function begins by considering a stochastic production with a multiplication disturbance term of the form

$$Y = f(Xa; \beta) e^{\varepsilon} \quad (1)$$

where Y = output, X = vector of input, β = vector of parameter; e = error term; ε is the stochastic disturbance term consisting of two independent elements "V" and "U". Both U and V are independent of each other. Hence

$$\varepsilon = U+V \quad (2)$$

The symmetric element "V" accounts for random variation in output quantity attributed to factors outside the farmer's control, such as disease and weather, and it is assumed to be normally distributed with zero mean and constant variance. A one-sided component $U \leq 0$ reflects technical inefficiency relative to the stochastic frontier. Thus, $U=0$ is for farm-firm output that lies on the PPC (i.e., they have 100% technical efficiency in input used) and $U<0$ for farm-firm output below the PPC as $N(0, \delta_u^2)$. Thus equation (1) becomes

$$Y = f(Xa; \beta) e^{u+v} \quad (3)$$

A considerable amount exists in the literature on the efficiency

measurement of farm input in developing countries¹⁵. Parikh¹⁶ applied the behavioural and stochastic cost function to measure the efficiency of farm resources in Pakistan. Their result indicated sub-optimal use of manure, fertilizer and labour. Udoh and Akintola⁹ measured the technical efficiency of crop farms in South Eastern Nigeria using a restricted translog production frontier. The empirical result revealed a mean technical efficiency of 77%, indicating about 23% inefficiency in resource use. Ajibefun and Abdulkadri¹² employed the stochastic frontier model and discovered that technical efficiency varied widely across farms participating in the National Directorate of Employment, Ondo State, Nigeria. The efficiency ranged between 21.7 and 87.9% with a mean value of 67%. Etim *et al.*¹⁷ in their work used the stochastic production frontier to estimate the technical efficiency of urban farms in Uyo metropolis. The result showed a mean efficiency value of about 69%, meaning that production could still be increased by 31% using the available technology. In a study of 1086 farmers, Amaza *et al.*² examined the determinants of food crop production and technical efficiency in the Guinea savannas of Borno State, Nigeria. The Maximum Likelihood Estimates (MLE) results reveal that farm size; fertilizer and hired labour are the major factors that are associated with changes in the output of food crops. The effect of land area on output is positive and the coefficient is found to be significant ($p = 0.01$). Fertilizer and hired labour have positive effects on output and their coefficients are significant ($p = 0.01$). Mean farmers' technical efficiency index was found to be 0.68. Farmer-specific efficiency factors, which comprise age, education, credit, extension, and crop diversification, were found to be the significant factors that account for the observed variation in efficiency among them. The implication of the study is that technical efficiency in food crop production could be increased by 32% through better use of available resources, given the current state of technology.

Methodology

Area of study and data source: The study was conducted in Borno State, Nigeria. It covered all the three ecological zones of the PROSAB project areas of the state[†]. A total number of 971 seed producers were under the PROSAB scheme in the state. The seed produced under the scheme include, maize, cowpea, soybean, rice, groundnut and sorghum. Using the criteria of ecological zones and type of seeds, 396 seed producers were randomly selected for the study. Cross sectional, primary data were therefore collected from these 396 seed producer using well structured questionnaires and personal interview under a single survey regime.

Data analysis techniques: Descriptive statistics, Gross margin analysis and the stochastic frontier production (SFP) technique were used as analytical tools. Descriptive statistics examined the socioeconomic characteristics of seed producers. The stochastic frontier production model, which assumed a Cobb-Douglas form, was used to determine resource use efficiency among the seed producers.

Gross margin analysis: A partial budget using gross margin analysis was used to determine the profitability of different seed types. The gross margin is usually referred to as returns over

[†] NGS = Northern Guinea Savanna, SGS = Southern Guinea Savanna, SS = Sudan savanna.

variable cost and it serves as a proxy measure of profitability¹⁸. The gross margin from production activities is the gross value of seed output less all the variable costs incurred on the same seed crop during the production year.

The gross margin was estimated as:

$$GM = \sum_i \pi_i q_i - \sum_j r_j x_j \quad (4)$$

where GM = Gross margin, π_i = Unit price of i^{th} output, q_i = quantity of i^{th} output, r_j = unit cost of the variable input j , x_j = quantity of the variable input j .

The empirical SFP models: Six different SFP models are specified to represent frontier functions for the six seed types cultivated under the PROSAB scheme. However, the general empirical SFP model used in the analysis of data is specified as:

$$\ln(Y_i) = \beta_0 + \beta_{1i} \ln(Lb) + \beta_{2i} \ln(Cp) + \beta_{3i} \ln(Fms) + \beta_{4i} \ln(Sd) + \beta_{5i} \ln(Frt) + \beta_{6i} \ln(Ach) + V_i - U_i \quad i=1, \dots, 6 \quad (5)$$

where Y_i = quantity of i^{th} seed produced per household measured in kg, Lb = labour used to produce i^{th} seed measured in man days, Cp = capital, measured as depreciation value of fixed input used in the farm to produce i^{th} seed, Fms = farm size for i^{th} seed measured in ha, Sd = quantity of i^{th} of seed used, measured in kg, Frt = quantity of fertilizer used to produce i^{th} seed measured in kg, Ach = agrochemical used in producing i^{th} seed measured in litres.

It is assumed that the technical inefficiency effects are independently distributed and v_{ij} arises by truncation (at zero) of the normal distribution with mean, v_{ij} and variance, σ^2 where v_{ij} is defined by equation (5):

$$u_i = \delta_0 + \delta_{1i}(\text{GN}) + \delta_{2i}(\text{Ag}) + \delta_{3i}(\text{Edu}) + \delta_{4i}(\text{Fms}) + \delta_{5i}(\text{Dur}) + \delta_{6i}(\text{Reg}) + e \quad i=1, \dots, 6 \quad (6)$$

where GN = gender of farmer producing i^{th} seed (dummy, 1 for male and 0, otherwise), Ag = age of farmer producing i^{th} seed measured in years, Edu = educational level of farmer producing i^{th} seed measured in years, Fms = farm size for i^{th} seed measured in ha, Dur = duration of i^{th} crop grown (dummy, D= 1 for quick maturing variety and 0 = otherwise), Reg = agroecological region (1 = NGS, 2 = SGS and 3 = SS), e = error term.

The 1-2-3 scale represents a linear gradient since moving from 1 to 2 and to 3 implies moving from the wet to the dry extreme ecological zones.

The β and δ coefficients in equations (4) and (5) were unknown parameter jointly estimated by maximizing the likelihood function^{2,9}. The parameters of the stochastic frontier function were estimated by the method of maximum likelihood, using the computer program FRONTIER Version 4.1¹⁹.

Results and Discussion

The majority of seed producers were male in all the years (Table 1). This result conforms to the cultural norms and predominant religion of the area, where males have more access to and control of productive inputs than females. Average ages in years were about 47 (2004), 43 (2005), and 43 (2006). This implies that the majority of seed producers fell within the active age group. This

perhaps has a positive implication on the availability and productivity of labour in the scheme. Most of the seed producers were literate. About 86% (2004), 76% (2005), and 76% (2006) had one form or another of formal education. The implication of this distribution is that the producers have minimum level of education required to comprehend the training in seed production practices and can easily adopt innovations.

The majority of respondents had a large household size. With an average size (number of persons) of about 13 (2004), 10 (2005), and 10 (2006) the family constituted the major source of labour in the scheme.

Across the three years, crops grown were about 37% maize, 23% cowpea, 19% soybean, 2% rice, 11% groundnut, and 7% sorghum. The average gestation period (days) for maize, cowpea and soybeans are about 82 (2004), 85 (2005) and 90 (2006) respectively. An average seed farm size was about 0.3 ha (2004), 0.42 ha (2005), and 0.34 ha (2006).

Gross margin: As shown in Table 2 producers of the different seed types recorded some levels of profitability. As such, the enterprises of certified seed production have an impressive return to capital and are profitable. However, the profitability levels vary with seed types. The profit margin recorded by maize seed producers was consistently largest for 2005 and 2006; it stood at ₦36, 413.43/ha in 2005 but increased to ₦56, 073.00/ha in 2006. The same increased profit margin pattern was recorded for soybean, groundnut, and sorghum, but for cowpea and rice, profit margins showed declining values between 2005 and 2006.

The observed profit margins across the seed types conclusively revealed that every one naira spent in cultivating the seeds, some levels of financial benefits were derived as indicated by the output/input indices. Specifically, in the case of sorghum, every one naira spent brought to the producers financial benefits of about ₦2.03 (2005) and ₦2.09 (2006). Also, judging from the p-values, which indicate profitability over one planting cycle, each of the seed type production processes was fairly financially sustainable in the two planting seasons. This is because the p-values for each seed types are non-decreasing and satisfy the constraint or side condition of being greater than zero.

Maximum likelihood estimate and inefficiency estimates: The MLE estimation results for the six crops are presented in Table 3. The sigma square coefficients of the six functions are statistically significant and different from zero at 1%. This indicates a good fit and the correctness of the specified distributed assumption of the composite error terms. Also, the variance ratios are significant at 1%. This means that the systematic effect unexplained by the respective production functions constituted sources of random errors. Hence, the occurrence of technical inefficiency among the PROSAB seed producers accounted for average of 60% of variations in the quantity of certified seed produced. The presence of one-sided error component in the specified SFP models is thus confirmed, implying that the ordinary least square estimation would be inadequate representation of the data. The diagnostic results therefore confirm the relevance of the stochastic production frontier and maximum likelihood estimation

The estimated Cobb-Douglas production frontiers showed perfect combination of inputs in producing different certified seeds in the PROSAB scheme. In all the six models, most of the input

Table 1. Socioeconomic characteristics of respondents.

| Characteristics | | 2004 | | 2005 | | 2006 | |
|-----------------|---------------------------------------|------------|------------|-------------|------------|-------------|------------|
| | | Frequency | % | Frequency | % | Frequency | % |
| i | Gender distribution | | | | | | |
| | Male | 40 | 95.2 | 76 | 61.3 | 144 | 62.6 |
| | Female | 2 | 4.8 | 48 | 38.7 | 86 | 37.4 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |
| ii | Age distribution | | | | | | |
| | 20 – 30 years | 6 | 14.3 | 24 | 19.4 | 40 | 17.3 |
| | 31 - 40 years | 12 | 28.6 | 37 | 29.8 | 62 | 27.0 |
| | 41 – 51 years | 9 | 21.4 | 33 | 26.6 | 66 | 28.7 |
| | > 50 years | 15 | 35.7 | 30 | 24.2 | 62 | 27.0 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |
| iii | Educational level (yrs) | | | | | | |
| | No Schooling | 6 | 14.3 | 30 | 24.2 | 54 | 23.5 |
| | Primary School | 5 | 11.9 | 18 | 14.5 | 40 | 17.4 |
| | Quaranic School | 17 | 40.5 | 28 | 22.6 | 52 | 22.6 |
| | Secondary School | 10 | 23.8 | 35 | 28.5 | 61 | 26.5 |
| | Tertiary | 4 | 9.5 | 13 | 10.5 | 23 | 10.0 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |
| iv | Household size (number) | | | | | | |
| | 1-4 | 2 | 4.8 | 15 | 12.1 | 30 | 3.0 |
| | 5-8 | 11 | 26.2 | 36 | 29.0 | 66 | 28.7 |
| | > 8 | 29 | 69.0 | 73 | 58.9 | 134 | 58.3 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |
| v | Primary occupation | | | | | | |
| | Upland farming | 30 | 71.4 | 103 | 83.1 | 189 | 82.2 |
| | <i>Fadama</i> farming | 2 | 4.8 | 4 | 3.2 | 6 | 2.6 |
| | Livestock farming | 2 | 4.8 | 9 | 7.3 | 10 | 4.4 |
| | Artisan | 3 | 7.1 | 2 | 1.6 | 7 | 3.0 |
| | Civil servant | 5 | 11.9 | 6 | 4.8 | 18 | 7.8 |
| | Seed production | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |
| vi | Distribution of seed type | | | | | | |
| | Maize | 36 | 53.7 | 50 | 37.0 | 58 | 31.4 |
| | Cowpea | 9 | 13.4 | 34 | 25.2 | 46 | 24.9 |
| | Soybean | 13 | 19.4 | 27 | 20.0 | 33 | 17.8 |
| | Rice | 1 | 1.5 | 1 | 0.7 | 6 | 3.2 |
| | Groundnut | 1 | 1.5 | 16 | 11.9 | 28 | 15.1 |
| | Sorghum | 7 | 10.5 | 7 | 5.2 | 14 | 7.6 |
| | Total | 67* | 100 | 135* | 100 | 185* | 100 |
| vii | Duration of crops grown (days) | | | | | | |
| | < 60 | 1 | 2.4 | 0 | 0.0 | 0 | 0.0 |
| | 60 – 70 | 7 | 16.7 | 20 | 16.1 | 41 | 17.8 |
| | 71 – 80 | 5 | 11.9 | 18 | 14.5 | 21 | 9.1 |
| | > 8 | 29 | 69.0 | 86 | 69.4 | 168 | 73.1 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |
| viii | Distribution of farm size (ha) | | | | | | |
| | < 0.1 | 8 | 19.0 | 3 | 2.4 | 26 | 11.3 |
| | 0.1- 0.25 | 5 | 11.9 | 43 | 34.7 | 89 | 38.7 |
| | 0.26- 0.05 | 27 | 64.3 | 62 | 50.0 | 97 | 42.2 |
| | > 0.50 | 2 | 4.8 | 16 | 12.9 | 18 | 7.8 |
| | Total | 42 | 100 | 124 | 100 | 230 | 100 |

Source: Field survey, 2006, Note F = frequency. * Multiple responses.

coefficients had the expected signs and magnitudes. Specifically, labour, farm size, seed and fertilizer appeared important productive inputs for all the six crops. However, the use of capital only appeared important input for groundnut while agrochemicals explained increased output in the cases of cowpea and rice certified seeds. But as expected, the labour, farm size, the seed planted and the quantity of fertilizer applied all positively and significantly affected the quantity of harvested certified seeds.

The production elasticities with respect to labour are positive as expected and statistically significant for all the six crops at different critical probability levels. The magnitudes of the coefficients of labour in the six models indicate that certified seed production is highly inelastic to changes in the amount of labour

used. Thus, a unit increase in man days would induce less than proportionate increase in the output of certified seeds, and vice versa. The result explains the labour intensive nature of crop cultivation that characterized low input agriculture of sub Saharan region.

The estimated coefficients for farm size are positive for the six models, which conform to *a priori* expectation, and significant at different alpha levels. Therefore, land is confirmed to be a positive driver for increase certified seed production. This suggests that land is a significant factor associated with changes in seed outputs. Thus output of certified seeds could still be increased if farm size is increased.

The coefficients of the variable associated with planting seeds

Table 2. Farm gross margin and net farm profit in 2005 and 2006.

| Crop | Gross farm income (GFI/Ha) | | Total variable cost (TVC/Ha) | | Total fixed cost (TFC/Ha) | | Gross farm margin (GFI-TVC/Ha) | | Net farm margin (GM-TFC/Ha) | | O/I index | | P**value | |
|-----------|----------------------------|--------|------------------------------|--------|---------------------------|-------|--------------------------------|-------|-----------------------------|-------|-----------|------|----------|------|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| Maize | 134000 | 194665 | 87606 | 128407 | 9081 | 10186 | 46394 | 66259 | 36413 | 56073 | 1.37 | 1.40 | 0.40 | 0.37 |
| Cowpea | 65379 | 38037 | 38479 | 14559 | 7348 | 6072 | 26899 | 23479 | 19552 | 17407 | 1.45 | 1.84 | 0.84 | 0.43 |
| Soybean | 44319 | 89145 | 21634 | 53850 | 9696 | 9173 | 22685 | 35294 | 12989 | 26121 | 1.42 | 1.41 | 0.41 | 0.42 |
| Rice | 89583 | 58835 | 47954 | 31215 | 8631 | 8396 | 41630 | 27620 | 32998 | 19224 | 1.58 | 1.49 | 0.49 | 0.58 |
| Groundnut | 30028 | 57048 | 16615 | 32206 | 7135 | 8968 | 13413 | 24842 | 6279 | 15875 | 1.26 | 1.38 | 0.39 | 0.27 |
| Sorghum | 18447 | 70229 | 5718 | 24308 | 3362 | 9246 | 12729 | 45921 | 9367 | 36675 | 2.03 | 2.09 | 1.09 | 1.03 |
| Overall | 63625 | 69817 | 36334 | 47424 | 7692 | 8673 | 27291 | 22393 | 19599 | 13720 | 1.46 | 1.24 | 0.24 | 0.46 |

Table 3. MLE estimates and inefficiency estimates result.

| Variables | Seed types | | | |
|-----------------------------|-----------------------|------------------------|------------------------|-----------------------|
| | Maize | Cowpea | Soybean | Rice |
| Production Function | | | | |
| Constant | 2.6032 (1.9483)** | 1.3924 (1.6943)* | 2.5823 (3.1724)*** | 4.8001 (2.9978)*** |
| Labour | 0.4823 (2.2848)*** | 0.2692 (3.1081)*** | 0.1469 (2.8126)*** | 0.1212 (1.6912)* |
| Capital | 0.1884 (1.4742) | 0.2109 (1.3294) | -0.0524 (-1.0538) | 0.3143 (1.6123) |
| Farm size | 0.4782 (3.7025)*** | 0.6462 (2.9383)*** | 0.3351 (2.5161)** | 0.1430 (2.7301)*** |
| Seed | 0.3961 (1.6988)* | 0.4420 (3.7606)*** | 0.1217 (1.8930)** | 0.1472 (4.7008)*** |
| Fertilizer | 0.2538 (2.6129)** | 0.1285 (1.9691)** | 0.1329 (2.9843)*** | 0.4075 (3.708)*** |
| Agro-chemical | 0.1815 (0.3213) | 0.0923 (1.7031)* | 0.2109 (1.5734) | 0.2439 (2.2129)** |
| Diagnosis Statistics | | | | |
| Sigma | 0.5105*** | 0.4735*** | 0.4181*** | 0.4210*** |
| Square | 0.6402*** | 0.6345*** | 0.6824*** | 0.5921*** |
| Ln(likelihood) | 21.0482 | 27.1002 | 24.2061 | 19.2093 |
| Inefficiency Model | | | | |
| Constant | 1.2611 (1.9547)** | 0.2135 (0.9561) | 1.0242 (1.8643)** | 1.9001 (2.0621)** |
| Gender | 0.0823 (0.9721) | 0.2411 (1.9113)* | 0.1796 (0.8114) | 0.0923 (1.1293) |
| Age | 0.7241 (1.0280) | 0.1153 (1.6321) | 0.4831 (1.401) | 0.1843 (1.6901)* |
| Education | -0.2481 (-1.1193) | -0.2731 (-0.7431) | 0.0476 (1.1258) | 0.0927 (1.7004)* |
| Farm size | 0.3177 (1.5768) | 0.4838 (2.6481)** | 0.1921 (1.7611)** | 0.2431 (1.5643) |
| Duration | -0.4821 (-1.6767)* | -0.6322 (-1.9731)** | -0.0784 (-2.1253)** | 0.1764 (0.9431) |
| Region | 0.7013 (1.1299) | 0.0193 (3.4441)*** | -0.1754 (-1.7684)** | 0.0844 (0.9654) |
| Groundnut | | | 2.9784 (1.8610)* | 0.4781*** |
| Soybean | | | 0.2348 (1.2891) | 0.5148*** |
| Rice | | | 0.0684 (0.9664) | 28.1142 |
| Sorghum | | | -0.3148 (-1.0194) | |
| Overall | | | 0.3246 (1.6948)* | |
| | | | -0.1452 (-1.9721)** | |
| | | | 0.1148 (0.486) | |
| | | | 0.1148 (-0.3794) | |

***, Significant at the 0.01 level; **, at the 0.05 level; *, at the 0.10 level. Source: Summarized from computer output.

are positive as expected and statistically significant at different probability levels for the six crops. Therefore, under proper agronomic practices, certified seed production responds less proportionately to increase planting seeds.

The production elasticities with respect to fertilizer are positive as expected and statistically significant. The magnitudes of the coefficients of fertilizer for the six models are less than unity, which indicate that the outputs of the various certified seeds are inelastic to changes in the level of fertilizer used. The significance of the fertilizer variable is derived from the fact that fertilizer is a major land-augmenting input in the sense that it improves the productivity of existing land by increasing crop yields per ha²⁰.

Inefficiency model: The estimated coefficients of the inefficiency functions for the six crops explain determinants and sources of technical inefficiency levels among the individual producers. As shown in Table 3, coefficients of age and education were not statistically significant inefficiency determinants in all the six crops except for rice model, and thus did not affect the technical efficiency (TE) of resource use among maize, cowpea, soybean, groundnut and sorghum farmers in the PROSAB scheme. On the other hand, the coefficients of gender were positive and significant, meaning that gender of the head of the household has significant effects on technical efficiency of cowpea, and sorghum seed production. Farm size coefficients are positive and significant for all the crops except maize and rice. This result supports the inverse relationship hypothesis between farm size and productivity. Thus, farmers maintaining small size farms appear to be more efficient in input use. Duration coefficients are negative and statistically significant in the case of maize, cowpea, soybean and groundnut, but positive and significant in the case of sorghum. Since the dependent variable of the inefficiency function represents the mode of inefficiency function, a positive sign of an estimated significant coefficient implies that the associated variable has a negative effect on efficiency and a negative sign indicates that the reverse is true. It, therefore, follows that the early maturing varieties increase farm efficiency. Thus, farmers' output would be closer to the production frontier as the maturity duration decreases in the case of maize, cowpea, soybean and groundnut certified seed production. This may be explained by the fact that the study area is often characterized by drought which constitutes one of the major causes of yield loss in the savannas². Thus, maize, cowpea,

soybean and groundnut seed that mature early tend to thrive better. As a result, technical efficiency of maize, cowpea, soybean and groundnut seed producers increases when they plant early maturity seed varieties. This can be explained by the fact that early maturity seed varieties have adequate rainfall that allows the seeds to fully mature. This observation agrees with Kamara *et al.*²¹ where they found that the grain yield of late maturity maize varieties in savannas of northeast Nigeria were, on average, are as productive as early maturity maize varieties..

Seed farm specific resource use efficiency indices in Borno State under the PROSAB scheme:

The distribution of resource use efficiency indices for the six crops as presented in Table 4 exhibits rather a cluster efficiency index across seed farms in PROSAB scheme with minimal disparities. Across the six crops, about 80% of the farms had an efficiency value around the efficiency values of 0.21 and 0.70 and the mean efficiency values for the six crops are between 0.55 and 0.58, leaving inefficiency gaps of between 0.45 and 0.42. Specifically, the result indicates that for average maize seed farmer to attain the technical efficiency level of their most efficient partner, they would realize about 40.2% [i.e. 1-(0.58/0.97)] cost savings in maize certified seed production. On the other hand, the least technical efficient maize certified seed farmers in the scheme area had about 98.9% [i.e. 1-(0.01/0.97)] cost savings. In the case of sorghum, the most efficient farmer realized about 39.3% [i.e. 1-0.57/0.94] cost savings in sorghum certified seed production, while the least technical efficient sorghum certified seed farmers in the scheme had about 97.8% [i.e. 1-(0.02/0.94)] cost savings.

Only about 19% of the farms had efficiency value between 0.71 and 1.00, with none of the farms having efficiency index that correspond to the frontier value as revealed by the maximum values for each seed type. However, the observed distribution predicts that a good proportion of certified seeds were not produced by the PROSAB farmers because of an inefficient use of the identified farm resources. Specifically, scare inputs may be allocated to various uses on the basis of their marginal shadow values thereby preventing the farmers from reaching the efficiency frontier. This is so, because very few farms were closer to the unity value of efficiency, thus indicating that the farmers under the PROSAB scheme were faced with multifarious constraints. The analysis revealed that some of these problems include variation in gender-

Table 4. Distribution of efficiency indices among PROSAB seed producers by seed types in Borno State, Nigeria.

| Efficiency class | Maize | Cowpea | Soybean | Rice | Groundnut | Sorghum |
|------------------|-------|--------|---------|------|-----------|---------|
| 0.01-0.10 | 3 | 2 | 3 | 2 | 1 | 1 |
| 0.11-0.20 | 7 | 6 | 4 | 1 | 3 | 2 |
| 0.21-0.30 | 13 | 8 | 4 | 2 | 3 | 2 |
| 0.31-0.40 | 20 | 11 | 9 | 2 | 4 | 3 |
| 0.41-0.50 | 25 | 15 | 13 | 8 | 9 | 10 |
| 0.51-0.60 | 33 | 20 | 18 | 11 | 17 | 15 |
| 0.61-0.70 | 10 | 9 | 8 | 4 | 3 | 2 |
| 0.71-0.80 | 6 | 5 | 6 | 3 | 2 | 2 |
| 0.81-0.90 | 4 | 4 | 5 | 2 | 1 | 1 |
| 0.91-1.00 | 2 | 1 | 2 | 2 | 1 | 1 |
| Observations | 123 | 81 | 72 | 37 | 44 | 39 |
| Mean value | 0.58 | 0.56 | 0.55 | 0.59 | 0.58 | 0.57 |
| Min. value | 0.01 | 0.03 | 0.01 | 0.02 | 0.03 | 0.02 |
| Max. value | 0.97 | 0.96 | 0.96 | 0.91 | 0.92 | 0.94 |

participation and the long gestation period of crops seed planted. Empirical results from literature have also identified poor management and inadequate farm inputs, including credit facilities as constraints facing small-scale farmers in Nigeria which prevent them from attaining maximum technical efficiency in resources use²⁰. In subsistence farming, as in the case of PROSAB seeds farmers, farm resources are mostly allocated to multiple uses in the basis of their marginal shadow values, thereby preventing the farmers from reaching the production efficiency frontier⁹.

Conclusions

The study revealed that adult males were predominant in the scheme. The literacy rate among participating farmers was high, about 79% of the total respondents. Labour availability was not a problem, as most farmers had a large household which constituted a major source of labour. About 84% of participants were full-time small-scale arable crop farmers. Labour, farm size, seed and fertilizer were identified as the major productive inputs for increased certified seed production. A mean technical efficiency value of between 55% and 58% for farmers, under this PROSAB scheme in Borno State was discovered. This implies that seed farms output has not reached that production frontier. Hence, certified seed production can still be increased by about 45% and 42% using the available technology.

The study revealed that quality seed is crucial for agricultural development, especially in a food insecure region of sub-Saharan Africa. Therefore, it is imperative to develop an effective seed production and delivery system that would ensure a constant supply of quality seeds to farmers, as this would help to remove some of the constraints to higher technical efficiency and increase productivity in the sub region. PROSAB seeds production (a community-based scheme) was initiated to produce quality seeds to increase farm productivity, reduce inefficiency in resource use, as well as to promote farmers well being.

The study recommends that seeds producers, especially female producers, should have access to labour-saving technologies such as herbicides and threshers, to increase technical efficiency in seeds crop production. Secondly, given the significance of seeds that have a shorter duration to maturity, quick maturing varieties of seeds should be promoted among farmers in the study area.

Acknowledgements

The authors thank the Canadian International Development Agency (CIDA) for financing this study and the extension staff of the Borno State Agricultural Development Programme (BOSADP) for collecting the data the seed producers.

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