PRODUCTION FUNCTION ANALYSIS AND PROFITABILITY OF SORGHUM-GROUNDNUT INTERCROPPING IN DOMA LOCAL GOVERNMENT AREA OF NASARAWA STATE, NIGERIA

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ABSTRACT
The continuous cultivation of particular piece of land by farmers with little or no measures to improve the soil condition has seriously affected the productivity of the farmers in the study area. The study was on production function analysis and profitability of sorghum-Groundnut intercropping system in Doma Local Government Area of Nasarawa State, Nigeria. A multi stage sampling procedure was adopted in the research; Primary data were collected with the use of structured questionnaire administered on 80 respondents on their socio-economic characteristic, inputs and output, cost included and the revenue realized. Simple descriptive statistics, Gross margin and regression analysis were the analytical tools used in analyzing the data. Labour made the highest proportion of the total variable cost while Agro-chemical has the lowest proportion. The gross margin and return per naira invested were found to be N198,949.92 and N3.72. Thus these positive values show that sorghum-groundnut intercrop was profitable. The result showed that the regression model form had the best fit to data, with 0.652.meaning that 65% of the variation in sorghum-groundnut outputs was accounted by the variables included in the model. The finding also shows that F-test value of 40.075 is significant at 1% indicating goodness of fit. Labour had positive regression coefficient indicating direct relationship with the output. Pest and disease, High cost of inputs and storage problem were identified as major constraints to sorghum-groundnut intercropping in the study area. Therefore, it is recommended that capacity building on improve intercropped technologies be promoted as soil management and risk minimization.

KEY WORDS
Production function, analysis profitability, sorghum, groundnut, intercropping.

Agricultural development is the foundation for economic development, and agricultural sector is the prime area of consideration for economic progress. A review of the past performance of agriculture since 1970 in Nigeria clearly shows that it contributes more than 30% of the annual Gross Domestic Product (GDP), employs about 68% of the labour force accounts for over 70% of the non-oil exports, and provides over 80% of the food needs of the country (Adegboye, 2014).

In Nigeria, Agricultural contribution to the GDP and exports has been low since the 1980s and food imports continued to rise in value. 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, 2010; Akosile, 2013; Nyako, 2016). Nigeria has witnessed a considerable decline in food production and a widening gap in the supply and demand brought about by population growth of about 3.5% per annum relative to food production growth of about 15% per annum (Gulai, 2010; Ya’aishen Modu et al., 2010).

By 2016, the agricultural growth rate was 2.9%, yet this growth rate is still lower than expected. Although, opinions differ on the magnitude of Nigeria’s food problem, 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, 2014). This brought about a distortion of the labour market and distribution effects on the production of food and cash crops in the country. Agriculture in Nigeria is dominated by small-scale farmers who produce about 80% of the total food requirement (Fayinka, 2014). These farmers are characterized by strong dependence on agricultural labour market, little or no forms of savings or storage facilities and cultural practices adopted are highly labour intensive (Festus, 2015; Fakayode, et al., 2018).

Sorghum (*Sorghum bicolor L moench*) is one of the most important staple crops in Nigeria, and is the most important cereal food in the Northern states that covers the Guinea savannah ecological zone (FAO, 2015). Sorghum production surpasses all other crops (FMEST, 2014). In terms of food contribution, sorghum is the major cereal consumed by the majority of the population (NAERLS, 2017).

Sorghum has a unique property that makes it well suited for food uses. Some sorghum varieties are rich in antioxidants and all sorghum varieties are gluten free, an alternative for wheat allergy sufferers (Annon, 2010). Sorghum is one of the most drought tolerant cereal crops that can cultivated together with leguminous crops such as groundnut and cowpea. It offers farmers the ability to reduce costs on irrigation and other on-farm expenses. Sorghum requires an average temperature of at least 25°C to produce maximum yield. In general, is a very competitive crop and does well in competing with weeds in narrow rows (FAOSTAT, 2010).

Sorghum is a very high nitrogen feeding crop especially when combined with legumes. Its growth habit is similar to that of maize. It has a waxy coating on its leaves and stems which helps to keep water in the plant even in intense heat (Annon, 2010). The leaves and grain of sorghum are used for livestock feeds and stalks for thatching houses and making fences. Sorghum is a very valuable industrial crop for brewing alcoholic and non-alcoholic drinks as well as in the baking and confectionary industry. In Nigeria, according to NRC (2016), sorghum has greater untapped potential than any other crop. It even postulated that if the twentieth century was the century of rice, wheat and maize, then the twenty first century could become the century of sorghum.

Groundnut (*Arachis hypogaea L.*) belongs to the genius Arachis in family leguminosea (Fabaceaea) which has replaced the traditional bambara groundnut (*Vigna Subterranean*) in many areas of the country (Ashley, 2013; Dauna, 2013). It’s a leguminous crop that can be intercropped with cereals such as maize and sorghum. Groundnut seeds contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrates (20%). Groundnut is grown in nearly 100 countries with China, India, Nigeria, U.S.A, Indonesia and Sudan as major producers. Developing countries accounted for 96 percent of the global groundnut area and 92 percent of the global production. Asia accounts for 58 percent of the global groundnut area and 67 percent of the global ground production with annual growth rate of 1.28 percent for area, 2.00 percent for production and 0.71 percent for productivity.

Groundnut is the 13th most important food crop of the world. It is the world’s 4th most important source of edible oil and 3rd most important source of vegetable protein (Taru, et al., 2010). It is one of the most popular commercial crops in Nigeria which accounted for 70 percent of the total Nigeria export earning between 1956 and 1967 but declined between 1967 and mid 1980s due to combine effect of drought and disease (Misari et al., 2010). According to Taru, et al. (2010), major groundnut zones in Nigeria are the Sudan and northern Guinea Savanna where the soil and agro climatogical conditions are favorable. It requires 500 to 1600 mm of rainfall, which may last for 70 to 200 days of rainy season in the Sudan savanna.

Intercropping legumes and non-legumes is an agricultural practice of cultivating two or more crops in the same piece of land at the same time which is commonly practiced in many parts of the world in order to increase the productivity per unit area of the land (Dauna, 2013). Onuk et al. (1019) reported that due to the rapid rate of population growth in Nigeria, it is logical to emphasize that the rate of growth in output of food crops may not be sufficient to meet the demand for food by the increasing population. Therefore, this calls for food crops production
mixture strategies. Intercropping is a common crop production system which has been posited to allow more efficiency in resource utilization. Is generally believe that the growing of crops in mixture is a logical practice that has evolved over generations and which presents a kind of balance between technical (biological and physical) and human (economic and social) factors. The crops are not necessarily sown at the same time and their harvest time may be quite different, but they are simultaneously grown for significant growing periods. Moreover, intercropping allows efficient use of both space and time to optimize beneficial effects (Dauna, 2013). According to Cambel (2016) intercropping promotes diversification and allows greater flexibility in adjusting to short- and long-term changes in the production and marketing situations, and also intercropping provides better weed control and reduces pest and disease incidence. Furthermore intercropping is a popular cropping system among small scale farmers in the tropics (Ashley, 2013). As reported by Onuk et al. (2017), that intercropping offers the farmers the opportunity to engage natives' principle of diversity of their farms. Furthermore, the mentioned that the economic viability of the production mixtures is considered as vital incentive for making the practice popular among farmers, particularly small-holder farmers. Cereal/legume intercropping increased dry-matter production and grain yield more than their monocultures. The Nitrogen (N) transfer from legume to cereal increased the cropping system’s yield and efficiency of N uses. The taller cereal reduces biological N fixation and yield of the associated legume (Dauna, 2013). According to Sangakkara (2015), the competitive relationships between the non-legume and the legume affected the growth and yield of the leguminous crops in close proximity.

Sorghum and groundnut are important crops to the livelihood of millions of relative poor people in Nigeria (Singh et al., 2017). The economic importance and uses of these crops have led to the expansion of their production in many parts of Nigeria (Gibbon and Pain, 2015). However despite the alleged superiority of mixed cropping to sole cropping and despite effort by extension workers throughout the northern states of Nigeria, to impress farmers with this superiority, there has been no apparent shift from sole cropping to mixed cropping (Abalu, 2017).

Also, Sorghum and groundnut are some of the major food crops in Nasarawa state and is being produced in Doma Local Government Area mainly by small-scale farmers whose production systems are generally characterized by the use of traditional method, poor use of available resources, inadequate, familiarity improved techniques and low yield among others. Added to these there is no adequate information on the economics of mixed sorghum production. However mixed (with groundnut) sorghum production remains a valuable source of livelihood of the people in the area. It is therefore in view of the importance sorghum and groundnut holds for the small scale farmers and the Nigerian economy that there is a clear need for the conduct of studies on the economics of sorghum under groundnut cropping system.

The production and socio-economic characteristics of the farmers, inconsistent government policies, the poor infrastructural base, all interact and affect the agricultural sector, resulting in low production, high price of food items, inflation, under-development and poverty. If Nigeria is ready to go back to agriculture, the problem of poverty, hunger and malnutrition could be alleviated. Adequate production of most Nigeria staple crops such as sorghum which is consumed in many parts of the country, will contribute positively to the agricultural sector.

The general objective of farmers is sustainable production at reasonable levels and at minimal risk, to satisfy subsistence and commercial needs (Beets, 2010). According to Akinwunmi (2011), sorghum has greater untapped potentials than any other crop. The crop is also drought-tolerant with a high potential yield, which plays an important role in tropical Africa and elsewhere, especially as a source of food and fodder (Brink and Belay, 2016). In view of this, this study seeks to provide information on production on the profitability of sorghum-groundnut intercropping system so as to estimate the profitability of sorghum production in the cropping system.
Furthermore, farmers need to have a proper understanding of mixed sorghum-groundnut intercropping system and to ascertain their profit margin because farmers with limited resources have limited capacity to tolerate failure in production (Alabi, 2012).

Objectives of the study:
- Determine the input-output relationship in sorghum-groundnut intercropping system in the study area;
- Estimate the cost and returns of sorghum-groundnut intercropping system;
- Examine the constraints of sorghum-groundnut intercropping system in the study area.

MATERIALS AND METHODS OF RESEARCH

The study was conducted in Doma Local Government Area (LGA) of Nasarawa State. It is one of the thirteen (13) LGAs of the State and located in the Southern Zone of the Nasarawa Agricultural Development Programme (NADP). The LGA has ten districts namely; Galadima, Agbashi, Madochi, Doka, Madaki, Rukubi, Sabongari, Akpanada, Alagye, and Sarkin Dawaki (NADP, 2019). It lies between latitude 7° and 9° 33’ N and longitude 7° and 10° 32’ E. The area has distinct wet (March to October) and dry (November to February) seasons. The average rainfall of the study area is approximately 107.6 mm and has high temperature throughout the year with an annual mean ranging between 22.7°C and 36.8°C. The soil texture is sandy loam which supports the production of varieties of crops such as cassava, yam, beniseed, melon, rice, millet, maize, groundnuts, and sorghum among others. The LGA covers a land area of 2,714 km² and has estimated population of 184,009 inhabitants (NPC, 2006). Main tribes that live in the area are; Alago, Agatu, Migili, Eggon, Bassa, Tiv, Hausa/Fulani, and Mada. The LGA shares border with Lafia, Keana, Keffi and Kokona to the East, East-South, South-West and West respectively. The major occupation of the inhabitants is farming.

A multi-stage sampling technique was adopted to select the respondents for this study. The first stage was the purposive selection of four districts (Doka, Madaki, Rukubi, and Sabongari) out of the ten districts in the LGA. This is due to the high agricultural production in these areas. The second stage involved the random selection of four (4) villages from each of the selected districts, while the final stage involved the random selection of five (5) sorghum-groundnut intercropping farmers from each of the selected villages, making a total of 80 respondents that were used for the study.

Primary data were collected through the use of structured interview schedule to elicit relevant information from the respondents. Ordinary Least Square regression was used to achieve objective I (determination of the relationship between input-output in sorghum and groundnut intercropping). Gross Margin Analysis was used to achieve objective II, while Descriptive Statistics was used to achieve objective III.

The regression equation is expressed explicitly below:

\[ Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + u \]

Where:
- \( Y \) = Output from sorghum - groundnut intercropping system (kg);
- \( a \) = constant term;
- \( b_1 \) – \( b_4 \) = Regression coefficient;
- \( x_1 \) = fertilizer (kg);
- \( x_2 \) = agrochemical (litre);
- \( x_3 \) = labour cost (₦);
- \( x_4 \) = quantity of seed (kg);
- \( u \) = Error term.
Gross margin analysis by definition is the difference between the gross farm income and total variable cost. Normally, gross margin analysis is used to test the effects of changes that do not alter the fixed cost of production, especially the cost of land and other durable factors. It is used to determine the potential profitability and effect on farmer’s farm income. It has the advantage of being simple as well as useful in the analysis of the profitability of small farms that have small and negligible fixed costs.

The gross margin analysis was estimated from costs and returns in sorghum-groundnut intercropping system. This tool was used to achieve objective (II).

Gross margin model is expressed as follows:

\[ GM = TR - TVC \]

Where: \( GM \) = Gross margin (₦/ha); \( TR \) = Total revenue or total value of output from the sorghum enterprise (₦/ha). It is the product of average output per hectare multiplied by the market price; \( TVC \) = Total variable cost or the costs that are specific in producing (sorghum-groundnut) output (₦/ha).

\( TVC \) varies according to output and are incurred on variable inputs. This includes cost of inputs like seeds, fertilizer, and harvesting, processing, labour cost (hired/family).

RESULTS AND DISCUSSION

Influence of input on the output of sorghum-groundnut intercropping. Several models were employed and used for the analysis of the data and the best was selected as the lead model for reporting. The model selected for this study was the double log regression model which best fits the data. The result presented in table 1 show that labour and seed had a positive regression coefficient indicating direct relationship with output. The result revealed that the computed \( R^2 \) is 0.652 this implies that 65% of the variation in the dependent variable was explained by the independent variables included in the model. The result also revealed that the regression coefficient of labour was 0.061 and significant at 1% risk level. This implied that, if labour is increased by 1% the value of the output of sorghum-groundnut intercropping will increase by approximately 0.061%. The results further indicated that seeds have a positive coefficient while fertilizer and agrochemicals have negative coefficients and were not significant at all levels. This indicated that any increase in each of these variables will lead to decrease in revenue arising from the enterprise.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Std. Error</th>
<th>t-statistic</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour ( X_1 )</td>
<td>0.061079</td>
<td>0.016480</td>
<td>3.754240</td>
<td>0.0000</td>
</tr>
<tr>
<td>Seed ( X_2 )</td>
<td>0.196241 ( \text{NS} )</td>
<td>0.122354</td>
<td>1.610734</td>
<td>0.1092</td>
</tr>
<tr>
<td>Fertilizer ( X_3 )</td>
<td>-0.132981 ( \text{NS} )</td>
<td>0.207682</td>
<td>-0.640268</td>
<td>0.5230</td>
</tr>
<tr>
<td>Agrochemical ( X_4 )</td>
<td>-0.585652 ( \text{NS} )</td>
<td>0.241341</td>
<td>-2.426842</td>
<td>0.1061</td>
</tr>
<tr>
<td>( R^2 = 0.652 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted ( R^2 ) = 0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data analysis, 2019 ** Significant at 1% \( \text{NS} \) = Not Significant.

Cost and Returns of sorghum-groundnut intercropping in the study area. Table 2 presented the cost and return analysis of sorghum-groundnut intercropping. The entries revealed that labour contributed most to the total cost of production with 57.50%, while, planting materials (seeds), fertilizer, and agro-chemicals accounted for 24.2%, 16.5% and 1.8% of the total cost of production respectively. This implies that sorghum-groundnut intercropping is labour intensive.
The gross margin (GM = TR - TCV) was computed to be ₦198,949.92 per hectare. The return per capital (naira) invested was ₦3.72, this implies that for every one naira invested there was a profit of ₦3.72 naira. These positive values indicated that sorghum-groundnut intercropping in study area is a profitable enterprise that could be promoted not only as an enterprise, but as poverty reduction measure and sustainable and cheaper soil management practice.

Table 2 – Enterprise budget per hectare for Sorghum-Groundnut intercropping

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue/ha:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>161,150.96</td>
<td>47</td>
</tr>
<tr>
<td>Groundnut</td>
<td>171,137.20</td>
<td>53</td>
</tr>
<tr>
<td>Total Revenue (TR)</td>
<td>332,288.17</td>
<td>100</td>
</tr>
<tr>
<td>Variable Cost/ha:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Labour</td>
<td>52,083.02</td>
<td>57.5</td>
</tr>
<tr>
<td>Planting Material (Seed):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sorghum</td>
<td>16,161.40</td>
<td>10.9</td>
</tr>
<tr>
<td>• Groundnut</td>
<td>22,811.53</td>
<td>13.3</td>
</tr>
<tr>
<td>Fertilizer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Organic Manure</td>
<td>15,612.10</td>
<td>9.3</td>
</tr>
<tr>
<td>• SSP</td>
<td>14,859.53</td>
<td>7.2</td>
</tr>
<tr>
<td>Agro Chemicals</td>
<td>11,810.85</td>
<td>1.8</td>
</tr>
<tr>
<td>Total Variable Cost (TVC)</td>
<td>133,338.25</td>
<td>100</td>
</tr>
<tr>
<td>Gross Margin (TR-TV C)</td>
<td>198,949.92</td>
<td></td>
</tr>
<tr>
<td>Return per capital (naira) invested</td>
<td>(TR/TVC)</td>
<td>3.72</td>
</tr>
</tbody>
</table>


Entries in table 3 showed the constraints faced by sorghum-groundnut farmers based on their responses. The constraints listed in the questionnaire include; pests and diseases, high cost of inputs, storage problem, transportation, poor marketing outlet, inadequate capital, inadequate extension contact and government policy.

Table 3 – Constraints faced by sorghum-groundnut famers in the study area

<table>
<thead>
<tr>
<th>Constraints</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pest and Disease</td>
<td>29</td>
<td>36.2</td>
</tr>
<tr>
<td>High Cost of Inputs</td>
<td>19</td>
<td>23.8</td>
</tr>
<tr>
<td>Storage Problem</td>
<td>14</td>
<td>7.5</td>
</tr>
<tr>
<td>Inadequate Capital</td>
<td>9</td>
<td>11.2</td>
</tr>
<tr>
<td>Inadequate Extension Contact</td>
<td>9</td>
<td>11.2</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Suggestion for Improvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of Resistant Varieties</td>
<td>30</td>
<td>37.0</td>
</tr>
<tr>
<td>Provision of Capital</td>
<td>25</td>
<td>30.9</td>
</tr>
<tr>
<td>Availability of Extension Contact</td>
<td>16</td>
<td>19.8</td>
</tr>
<tr>
<td>Availability of Good Storage Facility</td>
<td>9</td>
<td>12.3</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>


The analyzed results as captured in table 3 revealed that, 36.2% of the respondents identified pests and diseases as a major constraint, (28.8%) indicated high cost of inputs as their constraints, while 17.5% reported storage problem as their constraints and 11.2% of the respondents stated that inadequate capital and extension contact as their constraints. Despite these challenges, the farmers still reported high level of return per naira invested in sorghum-groundnut intercropping enterprise.
Similarly, the results of the study also revealed that majority (37.0%) of the respondents suggested provision of resistant variety, 30.9% suggested provision of capital and access to loan as a measure to tackle the constraint of inadequate capital. Also, 19.8% suggested availability of extension agents for extension services, while 12.3% suggested availability of good storage facilities as a measure to reduce constraint of storage facilities.

CONCLUSION

The study revealed that despite the challenges faced by the farmers, sorghum-groundnut intercropping enterprise is a paying business that needs to be promoted for obvious reasons namely; business, sustainable soil management measures and as a poverty alleviating drive. It is recommended that; that there should be aggressive enlightenment on the importance of crop combination as a palliative to cheaper soil management measures. More change agent needs to be employed, trained and deployed to places of need. There should be more deliberate efforts at getting relevant stakeholders (NARIs, agro-dealers, donors, among others) coming together to develop and promote the availability of improved seed and resistant varieties of sorghum and groundnut for food and multiplication.

REFERENCES