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Optimal Farm Plan For Maize And Legumes Intercropping Systems In Federal Capital Territory, Nigeria

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ABSTRACT

The study evaluated the Optimal Farm Plan for Maize and Legumes Intercropping Systems in the Federal Capital Territory, Nigeria. Primary data were used for this study. A multistage sampling technique was used to select a sample size of three hundred and twenty-two (322) maize-legume farmers in the study area. Data were analyzed using Descriptive Statistics, Farm Budgetary Technique, and Linear Programming. From the results most of the farmers are male with an average age of 49 years. The mean household size was 7 people. The average farmer has 27 years of experience in maize-legume farming. The benefit-cost ratio was calculated to be 1.56, 2.42, and 1.69 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively. The gross margin ratio was 0.62, 0.76, 0.66 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively. The return on investment was 0.56, 1.42, and 0.69 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively showing that the enterprises were profitable. From the linear programming results, only maize-groundnut enterprise was optimized. This implies that the other enterprise combinations were excluded from the optimal plan and if included will lead to a reduction in the value of the objective function. Based on the findings it was recommended that labour-saving processing techniques like the simple shelling equipment for groundnuts should be adopted to reduce be labour costs, extension officers should be employed to advocate for better land, seed, and labour utilization since it had a greater divergence from optimum values, and farmers should adopt the optimum farm plans prescribed, that is, produce the crop mixtures maize/groundnut that fit into the plan based on their resource allocation.

Keywords: Farm, Maize, Legumes, Farm plan, Intercropping

INTRODUCTION

1.1. Background to the Study

Intercropping is defined as the simultaneous cultivation of two or more crop species in the same field for either the entire growing period or a part thereof (Vandermeer, 1989). This practice can achieve higher yields on a given piece of land by making more efficient use of the available resources, while also contributing to soil fertility and soil conservation (Lithourgidis *et al.,* 2011; Yu *et al*., 2016). Although it is an ancient and traditional cropping system, intercropping is still applied worldwide (Lithourgidis *et al*., 2011). Maize-legume intercropping is currently receiving global attention because of its great importance in world agriculture. Intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms (Sullivan, 2003). It is a system of cultivating cereal as the primary food crop but on a legume base. Usually, cereals such as maize (*Zea mays*), millet (*Pennisetum glaucum*), and sorghum

(*Sorghum bicolor*) are often intercropped with leguminous crops like beans (Phaseolus vulgaris), cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogea*), pigeon pea (*Cajanus cajan*), and soybean (*Glycine max*).

In the past three decades, maize has spread rapidly into the moist savannas of West Africa, replacing traditional cereal crops such as sorghum and millet, particularly in areas with good access to fertilizer inputs and markets (Manyong *et al*., 2002). Due to the availability of short-season early maturing varieties, cultivation has also gradually spread to the Guinea savanna where the growing period is 90 – 100 days (Badu-Apraku *et al*., 2011). On the other hand, soybean cultivation is increasing in the savannas of Nigeria because of its importance as a major food and cash crop and its wide use in the food and feed industry (Sanginga *et al*., 2002).

Cropping systems in the Nigerian savannas are intensifying because of high population pressure. Increasing crop yield is essential and this will lead to pressure on natural resources and threaten the sustainability of farming systems (Amjadian *et al*., 2013). Where farmers practice intercropping, they mostly intercrop cereals (maize, millet, and sorghum) with soybean, cowpeas, or groundnut. In general, intercropping has been reported to be more productive than monocropping (Ghosh *et al*., 2006). This may be through efficient use of light energy and other growth resources. Also, optimization of land resource use could be achieved when crops are grown under intercropping and plant population density increased. Intercropping offers potential advantages for resource utilization, decreased inputs, and increased sustainability in crop production (Egbe *et al*., 2010). Because of the increasing population farmers are forced to plan their crop enterprises to fit into the limited land they have every year (Ayanwale *et al*., 2013). Cereals like maize, sorghum, and pearl millet can be used for intercropping with legumes (Singh *et al*., 2008) due to their dissimilar growing patterns, morphology, phenology, and nutrient requirement. Legumes, with their adaptability to different cropping patterns and ability to fix atmospheric Nitrogen offer minimum competition for Nitrogen nutrition and greater opportunities to sustain productivity (Sanginga *et al*., 2002).

Despite the advantages of cereal-legume intercropping, the prevailing production practice for maize–legume intercropping in Nigeria is traditional. In most cases, maize is grown along with some legumes at an arbitrary spacing that results in low yields (Futuless, 2010). Combinations of certain crops result in increased competition among the component crops and this causes low yields, which may make some crop species unsuitable for intercropping. Increased competition may be for water, nutrients, light, or any combination of the three, ultimately leading to changes in crop productivity levels (Carruthers *et al.,* 2000). Layek *et al.* (2014) reported that several indices such as land equivalent ratio (LER), crop equivalent yield, relative crowding coefficient, competition ratio, aggressivity, actual yield loss, intercropping advantage, and monetary advantage index (MAI) have been suggested to describe the competition and economic advantage of intercropping compared to monocropping. Higher land equivalent ratio (LER >1), indicating an advantage in intercropping, has been reported with maize–soybean intercropping in comparison to monocropping (Matusso *et al*., 2013).

Optimization implies looking for the decision which gives the best possible value of some measures of performance from amongst the set of possible decisions. An optimal cropping pattern with maximum profit is important for agricultural planning. Several optimization techniques such as Linear Programming (LP), Dynamic Programming (DP), and Genetic Algorithm (GA) have been applied in agriculture. However, the Linear Programming (LP) model as an analytical tool for studying the economic aspects of farm management is more popular because of the proportionate characteristics of the allocation problems (Wankhade and Lunge, 2012; Sofi *et al*., 2015). Its technique has been used to study the problems of resource allocation among farmers and in the present stage of development focuses on deriving optimum production plans for farmers. Singh (2009) stated that information on the optimal allocation of resources as to what crop activities to undertake, how much land to allocate among competing for crop activities, and what method and combinations of inputs to use on each crop activity so that net farm incomes are maximized is crucial to the farmer. Identifying the best farm plan is a difficult task for smallholder crop farmers who are characterized by low literacy and resource levels. These farmers often make farm planning decisions by trial-and-error method which often results in uncertain outcomes. Linear

programming (LP), as applied to farm planning represents a systematic method of determining mathematically the optimum plan for the choice and combination of farm enterprises, to maximize income or minimize costs within the limits of available farm resources (Yang, 1995). On a technical stand, Nigerian farmers are predominantly small-scale farmers who operate with crude implements, cultivate small pieces of land and have a poor resource base. They are faced with the problem of optimal utilization of their meager resources to raise their incomes and consequently their living standards (Singh, 2009).

METHODS AND MATERIALS

2.1 The Study Area

The research study was conducted in Federal Capital Territory (FCT), Nigeria. Federal Capital Territory (FCT) is located between Latitudes 8°25′and 9°25′ North of the equator and Longitudes 6°45′ and 7° 45′ East of Greenwich Meridian. The territory covers an area of 8,000 Square Kilometers and occupies about 0.87% of Nigeria and situated wholly within the region generally referred to as the "Middle Belt" (Balogun, 2001). Federal Capital Territory (FCT) is bordered on all sides by four states namely Niger, Nasarawa, Kogi, and Kaduna. The FCT had a population of 776, 298 people in 2006 (NPC, 2006). Currently, the population is about 3,095,000 people in 2019 which is about a 6.03% increase from 2018 (Macrotrend, 2020). Federal Capital Territory (FCT) experiences two weather conditions in the year. These are the rainy season which begins around March and runs through October, the dry season (usually characterized by bright sunshine) which begins from October and ends in April. Within these periods, there is a brief period of harmattan occasioned by the North East trade wind, with a resultant dusty haze and intense coldness and dryness. The average annual rainfall is about 1,256 mm per annum. The temperature in the FCT ranges between 30°C – 37°C yearly with an average temperature of 27.3°C. The major occupation of people in the rural areas of FCT is farming. However, others are engaged in other non-farming employment at the Local Government Area councils. Crops grown in Federal Capital Territory are maize, millet, sorghum, rice, cowpea, groundnut, soybean, eggplant among others.

2.2 Method of Data Collection

Primary data were used for this study. Trained enumerators from Agricultural Development Program (ADP) were contracted for primary data collection using well-structured questionnaires.

2.3 Sampling Techniques and Sample Size

Multi-stage sampling method was used to select the target respondents (maize-legumes farmers). In the first stage, three area councils were randomly selected using the ballot-box raffle draw method, they are Abaji, Gwagwalada, and Kwali. In the second stage, twelve (12) wards were randomly selected using the ballot-box raffle draw method, four (4) wards per area council, they are Adgaba, Ebaji, Bandagi, Yangoji, Tunga Maji, Dobi, Ibua, Kilankwa I & II, Pai, and Wako. In the third stage, twenty-four (24) villages were randomly selected using the ballot-box raffle draw method. From equation (3.1), a proportionate random sampling method (a proportionate of 30% of farmers) was used to select a sample size of three hundred and twenty-two (322) maize-legume (groundnut, soybean, and cowpea) farmers from the sample frame. Using Cochran (1977), the sample size was determined using the formula:

$$n_0 = \frac{Z^2PQ}{e^2} = 322 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

n_0 = Sample Size (Units),

Z^2= Abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level, e.g., 95%), (=1.96)

P = Estimated Proportion of an Attribute that is Present in the Population (=30%),

Q = 1-P = 70%, and

e^2= Desired Level of Precision = 5%.

2.4 Method of Data Analysis

The following analytical tools were used to achieve the stated objectives in this study:

2.4.1 Descriptive Statistics

This was used to examine the socio-economic characteristics of farmers in the study area. Descriptive statistics following Igwe & Onyenweaku (2013) was used for the analysis. Descriptive statistics involve the use of mean, frequency, graph, pie chart, and percentages to describe the gender, marital status, household size, age, level of education among others of the maize-legume farmers in the study area.

2.4.2 Farm Budgetary Technique

Costs and return analysis in maize-legume production as stated in specific objectives one (i) was calculated using farm budgeting techniques following Alabi *et al*. (2013). The net farm income for the enterprise combinations (Maize-Soybean, Maize-Groundnut, and Maize-Cowpea enterprises) was calculated as follows:

$$GM_{ij} = \mathrm{TR} - \mathrm{TVC} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

$$NFI_{ij} = \mathrm{GM} - \mathrm{TFC} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

$$\mathrm{TR} = \mathrm{P} \times \mathrm{Q} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

Where;

GM_{ij} = Gross Margin (N),

TVC = Total Variable Cost (N),

NFI_{ij} = Net Farm Income (N),

TR = Gross Revenue (N),

TFC = Total Fixed Costs (N),

P = Price of Output (N/Kg), and

Q = Output Produced (Kg).

2.4.3 Depreciation of Assets

Depreciation is on fixed assets like hoes, sprayers, and classes. It forms the fixed cost component. The straight-line method of evaluating depreciation was used to obtain fixed costs for the durable farm tool. The straight-line depreciation method is specified as:

$$D = \frac{P - S}{N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

Where:

D = Depreciation on Production Asset (Naira),

P = Original Cost of Production Asset (Naira),

S = Salvage Value of Asset (Naira), and

N = Number of Years of Life of the Asset.

2.4.5 Yield/Seed Equivalent Ratio

Maize seed and yield equivalent were calculated following Uddin, Rahman, Bagum, Uddin, and Rahaman (2003). This was done to ensure that the enterprises' yield and seed inputs were computed in the appropriate value. The formula for equivalent ratio calculation is given below:

$$EM_{S\&Y_{ij}} = \frac{Q_{S\&Y_{ij}} \times P_{S\&Y_{ij}}}{R_{ij}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.6)$$

$EM_{s\&y}$= Maize Equivalent (Kg),

$Q_{s\&y}$= Quantity of Seed/Yield for Groundnut, Cowpea, and Soybean,

$P_{S\&Y_{ij}}$= Price of Seed/Yield for Groundnut, Cowpea, and Soybean, and

R_{ij}= Price of Maize Seed/Yield.

This was estimated for the variables before the Linear programming models.

3.5.9 Linear Programming

Linear programming was used to determine the optimum farm plans for maximum resource allocation for maize-legume farmers as stated in specific objective five (v). The model used for determining the

optimum farm plans can be expressed following Alabi *et al* (2012), Jalal *et al* (2016), and Ibrahim *et al* (2019) by the equation: The general form of the objective function is stated thus:

$$\text{Maximize } Z \approx \sum_{j=1}^{n} C_i X_i \quad \text{,where j} = 1 \text{ to n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

Subject to the following constraints:

$\sum_{j=1}^{m} A_{ij} A_j \leq b_i$ Land Constraint

Labour Constraints: The labour constraints were added to make the model parsimonious given that the variables were additive. However, labour comprises of activities such as

$\sum_{j=1}^{m} B_{ij} A_j \leq b_i$ Land Preparation Constraints,

$\sum_{j=1}^{m} C_{ij} A_j \leq b_i$ Planting Constraints,

$\sum_{j=1}^{m} D_{ij} A_j \leq b_i$ First Weeding Constraints,

$\sum_{j=1}^{m} E_{ij} A_j \leq b_i$ Second Weeding Constraints,

$\sum_{j=1}^{m} F_{ij} A_j \leq b_i$ Fertilizer Application Constraints,

$\sum_{j=1}^{m} G_{ij} A_j \leq b_i$ Insecticide Application Constraints, and

$\sum_{j=1}^{m} H_{ij} A_j \leq b_i$ Harvesting Constraints.

Capital Constraints:

$\sum_{j=1}^{m} j_{ij} A_j \leq b_i$ Seed Constraints,

$\sum_{j=1}^{m} K_{ij} A_j \leq b_i$ Fertilizer Constraints,

$\sum_{j=1}^{m} L_{ij} A_j \leq b_i$ Agrochemicals Constraints,

$\sum_{j=1}^{m} M_{ij} A_j \leq b_i$ Transportation Constraints, and

$A_j \geq 0$ = Non-Negativity Condition.

Where,

Z = Objective Function [Net Farm Income (₦/ha)],

X_j = Quantities of Activities where there are N Activities to be Considered,

C_j = Unit Cost of Input in N/Kg/Litre for Both Maize, Soybean, Groundnut, and Cowpea Enterprises,

$A_{jj}, b_{ij}, \ldots, O_{ij}$ = Resource Requirements Per Unit of Activity i.e How Much of a Resource is Required for Each Activity Unit,

m = Number of Resources,

n = Number of Activities, and

b_i= Available Productivity Resources in Limited Supply (Constraints).

RESULTS AND DISCUSSION

3.1 Socioeconomics Characteristics of Maize-Legume Farmers in the Study Area

The socio-economic characteristics of maize-legume farmers are presented in Table 1.

The results show that about 51.87% of the sampled respondents were between the ages of 21 and 50 years, while 48.14% were between 51 and 70 years of age. The mean age of all respondents was 49 years. This shows that maize-legume production in the study area was undertaken by active, energetic, and young farmers. This agrees with the findings of Igwe *et al*. (2013) and Ibrahim *et al* (2019) who posited in their studies that farmers were relatively young and in their active age.

About 81.92% of the sampled farmers had less than 10 members as household size. Averagely, sampled farmers had 7 people per household. This finding agrees with the findings of Nasiru *et al*. (2012) and Ibrahim *et al* (2019) who reported that 51.7% of the sampled farmers had household sizes of 10 to 19 members, while 15% had household sizes above 20 members.

Furthermore, a greater proportion of the respondents (73.91%) had farming experience less than 30 years. The average farming experience was 27 years. This result agrees with that of Mafimisebi *et al.* (2013) who reported in his findings that 9.2% of respondents had less than 5 years of farming experience. Also, 88.20% of the sampled farmers were married, while 8.07% were single.

The results further show that 28.26% of the respondents had farm sizes ranging between 0.1-0.9 hectares, while 51.55% of the respondents had farm sizes ranging between 1.0- 1.9 hectares. The mean farm size in the area was found to be 1.98 hectares. This implies that the majority of the maize-legume crop farmers in the study area were small-scale farm holders. This agrees with the finding of Fasasi (2007) and Ibrahim *et al* (2019) who reported that the highest percentage of food produced in Nigeria comes from small-scale farmers. Table 4.1 further revealed that 58.69% of the respondents earned between ₦400,001 – ₦800, 000 as annual farm income, while the average annual farm income of the farmers was estimated to be ₦343, 143.82. This suggests an average monthly income of ₦28,595.31. This depicts that most maize-legume farmers were low-income earners.

Table 1: Socio-Economic Profiles or Characteristics of the Maize-Legume Farmers in the Study Area

Variables	Frequency	Percentage	Mean
Age (Years)			49
21 – 30	28	8.70	
31 – 40	64	19.88	
41 – 50	75	23.29	
51 – 70	155	48.14	
Household Size (Units)			**7**
1 – 5	80	24.84	
6 – 10	216	67.08	
11 – 20	24	7.45	
20 – 30	2	0.62	
Farm Experience (Years)			**26.80**
1 – 10	19	5.90	
11 – 20	92	28.57	
21 – 30	127	39.44	
31 – 40	68	21.12	
41 – 50	16	4.97	
Farm Size (Ha)			**1.98**
0 – 1.0	91	28.26	
1.1 – 1.9	166	51.55	
2.0 – 5.0	58	18.01	
5.1 – 10	7	2.17	
Annual Income			**343,143.82**
1 – 400,000	85	26.39	
400, 001 – 800, 000	189	58.69	
800, 001 – 1, 000, 000	48	14.90	
Total	322	100	

Source: Field Survey (2021)

3.2 Enterprise Combinations

From the results, 44% of the farmers were involved in maize-groundnut production. About 29% were involved in maize-soybean production, while 27% were involved in maize-cowpea production. The results suggest that maize-groundnut was the preferred enterprise combination in the study area.

3.3 Gross Margin Analysis of Maize- Legumes Production in the Study Area

Table 2 shows the result of the costs and returns of maize-legumes production in the study area. From the results, total labour cost accounted for 35.64% of the total cost of the production of maize and soybeans, while rent on land accounted for 35.86% of the total cost of production of maize and soybeans. This

implies that a greater percentage of the costs of were cost renting land and hiring of labour. This shows that the cost of acquiring land for agricultural purposes is high in the study area. Also, the result implies that the cost of hired labour is on the high side in the study area. Meanwhile, inputs like seeds, fertilizer, and agrochemicals were available to the farmers at less expensive prices compared to the other two enterprises, hence the least percentage (22.77%) of the total variable cost was spent on them.

The result in Table 4.2 further shows that an average farmer in the study area incurred a total variable cost (TVC) of ₦58,363.05, and had a gross margin of ₦93,610.26. The gross margin ratio was 61.59%. This means that there is a return of 61kobo for every one naira invested in maize-soybeans production, this implies that the production of maize and soybeans is a profitable enterprise in the study area. This is in line with the results of Sadiq *et al.* (2013). The result of the costs and returns of maize-groundnut production in the study area also in Table 4.2 shows that rent on land made up 37.52% of the total cost of the production of maize and groundnut, 29.90% of the total cost was spent on acquiring labour, while 26.31% of the total cost was spent on production inputs. This implies that the cost of acquiring land for agricultural purposes is high in the study area. Also, the result implies that the cost of hired labour in the study area is on the high side. Inputs like seeds, fertilizer, and agrochemicals were available to the farmers at less expensive prices compared to the cost of acquiring labour or hiring land under the same enterprise.

Also, an average farmer in the study area incurred a total variable cost (TVC) of ₦54,996.92 and had a gross margin of ₦170,765.34. The gross margin ratio was 75.63%. This means that there is a return of 75kobo for every one naira invested in maize-groundnut production, this implies that the production of maize and groundnut is a profitable enterprise in the study area. This result agrees with the findings of Adesoji *et al.* (2016). The result of the costs and returns of maize-groundout-soybean production shows that rent on land made up 40.85% of the total cost of the production of maize-cowpea, while 26.89% and 26.73% of the total cost was spent on labour and inputs respectively.

An average farmer incurred a total variable cost (TVC) of ₦48,682.14, and a gross margin of ₦96,198.81 in the production of maize-cowpea. The gross margin ratio suggests that the production of maize-cowpea is a profitable enterprise in the study area. This finding aligns with the results of Buah *et al.* (2009). The total revenue for maize-soybean, maize-groundnut, and maize-cowpea enterprise was estimated to be ₦151,973.31, ₦225,762.25, and ₦144,880.95 respectively. The benefit-cost ratio was calculated to be 1.56, 2.42, and 1.69 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively. The return on investment was 0.56, 1.42, and 0.69 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively. This implies that maize-soybean, maize-groundnut, and maize-cowpea production in the study area are profitable enterprises. The findings are in line with the results of Mercy (2017) and Ibrahim (2019).

Table 2: Gross Margin (Per Hectare) Analysis of Maize-Legumes Intercropping System

Items	MS (₦)	% of Total Cost	MG (₦)	% of Total Cost	MC (₦)	% of Total Cost
Input Costs						
Maize Seed Cost	4,085.18		3,827.95		4,841.00	
Soybean Seed Cost	2,840.72					
Groundnut Seed Cost			3,097.46			
Cowpea Seed Cost					3,659.52	
Fertilizer (KG)	12,238.06		13,131.00		11,667.43	
Agrochemical (Litre)	3,056.22		4,492.20		2,730.69	
Total Input Costs	**22,220.18**	**22.77**	**24,548.60**	**26.31**	**22,898.65**	**26.73**
Labour Cost						
Land Preparation (Mandays)	7,078.36		6,255.90		5,412.70	
Planting (Mandays)	2,009.54		1,588.97		1,310.48	
Fertilizer Application (Mandays)	2,282.79		2,352.09		2,126.98	
Manure (Mandays)	704.15					
Agrochemical Application (Mandays)	2,742.76		1,890.38		1,692.06	
Weeding (Mandays)	8,415.67		6,686.03		5,492.06	
Harvesting (Mandays)	5,410.56		3,409.07		2,840.21	
Threshing (Mandays)	4,340.72		3,115.06		2,562.96	
Storage	1,800.00		2,600.00		1,600.00	
Total Labour Cost	34,784.55	35.64	27,897.50	29.90	23,037.46	26.89
Transportation Cost	1,358.32		2,550.82		2,746.03	
Fixed Cost						
Rent on Land	35,000.00	35.86	35,000.00	37.52	35,000.00	40.85
Depreciation						
Sprayer	2,145.75		1,891.20		993.65	
Hoe	1,500.86		798.40		529.31	
Cutlass	576.57		587.06		456.58	
Total Depreciation	**4,223.18**		**3,276.66**		**1,979.55**	
Total Fixed Cost (A)	**39,223.18**		**38,276.66**		**36,979.55**	
Total Variable Cost (B)	**58,363.05**		**54,996.92**		**48,682.14**	
Total Cost (A+B)	**97,586.23**		**93,273.57**		**85,661.69**	
Revenue						
Maize Sold (₦)	101,235.09		154,519.06		88,386.24	
Maize Consumed (₦)	19,080.07		20,744.10		18,730.16	
Soybean Sold (₦)	25,908.57					
Soybean Consumed (₦)	5,749.57					
Groundnut Sold (₦)			33,666.06			
Groundnut Consumed (₦)			16,833.03			
Cowpea Sold (₦)					29,100.53	
Cowpea Consumed (₦)					8,664.02	
Cowpea Sold (₦)						
Total Revenue (₦) (C)	**151,973.31**		**225,762.25**		**144,880.95**	
Gross Margin (D = C – B)	**93,610.26**		**170,765.34**		**96,198.81**	
NFI (F = D – A)	**54,387.08**		**132,488.68**		**59,219.27**	
B/C	**1.56**		**2.42**		**1.69**	
ROI	**0.56**		**1.42**		**0.69**	
GMR	**0.62**		**0.75**		**0.66**	

MG = Maize-Groundnut Enterprise
MS = Maize-Soybean Enterprise
MC = Maize-Cowpea Enterprise

Source: Field Survey (2021)

4.8 Optimal Farm Plan for Maize-Legumes Producing Farmers in the Study Area

4.8.1 Existing Net Farm Income and Optimum Net Farm Income

Table 3 presents the result for different cropping patterns, their existing values, and optimum values. The result shows that maize-groundnut with an optimal net farm income of ₦67,595,181.78 is the most viable

combination. Hence if all the resources available were combined in an optimal proportion a net farm income of ₦67,595,181.78 may be realized from the land area of 510.19 hectares compared to the 640 hectares available to maize-legume farmers. According to the result, the other combinations are not as viable as the maize-groundnut combination. This means that maize-groundnut is a good competitive position to yield more than other crop combinations. This finding supports Oviasogie (2005) who reported that mix cropping enterprise was more productive than sole cropping and gave higher returns. In a maximization LP problem, reduce cost is expected to be negative and it refers to the income penalties indicating the amount by which farm income would be reduces if any of the excluded activities are forced into the program. The result showed that two (2) activities were excluded from the program which maize-soybean enterprise and maize-cowpea enterprise. Maize-soybean enterprise had the highest reduced cost of ₦35,750.19 and maize-cowpea enterprise had a reduced cost of ₦21,317.11. This implies that if these activities are forced into the program or undertaken, the value of the objective function will be reduced by the values of their respective reduced cost, that is, ₦35,750.19 and ₦21,317.11 respectively as they have the highest propensity to depress profit as prescribed by the program.

Table 3: Gross Margin of Current Plan and Optimal Plan

Crop Combination	Current Value	Optimal Value	Reduced Cost
Maize-Soybean	54, 387.08	-	-35,750.19
Maize-Groundnut	132,488.68	67,595,181.78	-
Maize-Cowpea	59,219.27	-	-21,317.11

Source: Field Survey (2021)

Table 4 shows the production resources, their statuses, slack or surplus, and their shadow prices. The result shows that farm size, seed, labour, fertilizer, and transportation are not binding, and any increase in the variables will not have led to a positive increase in production. The result showed that agrochemical has a shadow price of ₦38,340.99. This implies that an increase in agrochemicals leads to an increase in maize-groundnut output. The zero shadow prices of the other resources suggest that they are not binding resources and do not constraint the production process, therefore, increasing any of the resources will not lead to maximization of output because they were actually in excess.

Table 4: Shadow Price of Excluded Activities in Gross Margin Maximizing Objective of Maize-Legume Crop Farmers in the Study Area

Resource	Status	Slack	Shadow Price
Farm Size (Ha)	Not binding	130.40	0
Seed (Kg)	Not binding	5,743.76	0
Labour (Mandays)	Not binding	1,392.73	0
Fertilizer (Kg)	Not binding	7,975.79	0
Agro Chemical (Litre)	Binding	0	38,340.99
Transportation (Naira)	Not binding	159,533.77	0

Source: Field Survey (2021)

4.8.2 Existing Resource Use and Optimum Resource Use

Table 5 presents the constraints, their final values, allowable increase, and decrease. From the result, the optimal plan that would ensure maximization of gross margin given the resource constraints would be to cultivate 510.2 hectares of farmland as against the 640.6 hectares available to the farmers. In the case of any changes, whether increase or decrease, this condition will still hold, as long as the allowable increase or decrease limits are not exceeded. Also, the optimal amount of seed would be 16,388Kg (32.120Kg/Hectare), given the constraints faced during the production and provided that the allowable increase and decrease limits are not exceeded by any change. The amount of labour that will lead to maximizing output will be 6,369 mandays (13 man-days/hectare). For this condition to remain, any

change that must occur, must not exceed the stated allowable increase or decrease limits. The quantity of fertilizer to apply for maximum productivity will be 41,834Kg (81.99kg/Hectare). It must however be noted that just as in the case of the other variables, the allowable increase and decrease limits must not be exceeded by any change, for this condition to hold. The value of agrochemicals for optimum productivity is 1763 litres. The allowable increase limit arising from any change 216, while the allowable decrease is 1763litres (3.55Litre/Hectare). Also, from the result, the value for transportation for maximization of output is ₦1,301,416(₦ 2,550.84/Hectare).

Table 5: Existing Resource Use and Optimum Resource Use

Resources	Optimum Value	Existing Plan	Allowable Increase	Allowable Decrease
Farm Size (Hectares)	510.20	640.60	Unlimited	130.40
Seed (Maize Equivalents in Kg)	16,388.77	22,132.53	Unlimited	5,743.76
Labour (Man days)	6,369.21	7,761.93	Unlimited	1,392.73
Fertilizer (Kg)	41,834.21	49,810	Unlimited	7,975.78
Agrochemical (Litre)	1,763	1,763	216.12	1,763
Transportation (Naira)	1,301,416.23	1,460,950	Unlimited	159,533.77

Source: Field Survey (2021)

4.0 CONCLUSION

From the study, it can be concluded that maize-soybean, maize-groundnut, maize-cowpea are profitable enterprises in the study area. The benefit-cost ratios was calculated to be 1.56, 2.42, and 1.69 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively. The gross margin ratio was 0.62, 0.76, 0.66 for maize-soybean, maize-groundnut, and maize-cowpea enterprise respectively. The return on investments was 0.56, 1.42, and 0.69 for maize-soybean, maize-groundnut, and maize-cowpea enterprises respectively.

Only fertilizer in maize-soybean enterprises was optimally utilized.

5.0 RECOMMENDATIONS

The gross margins were greatly influenced by high labour costs during the production, therefore there is a need to reduce labour requirements for instance through labor-saving mechanical technologies to offset rising labour costs, adoption of labor-saving processing techniques like the simple shelling equipment for groundnuts. In addition, increased mechanization for ploughing and weeding and also less labor-demanding legume varieties should be developed.

Since the resource use efficiency shows a great divergence (351%) from optimal levels of use of land, for maize-soybean farmers, seed (85%) for maize-groundnut farmers, and labour (218%) for maize-cowpea farmers than any other input. It is therefore recommended that extension officers focus more effort in this critical area to help farmers optimally utilize available resources.

Based on these findings, farmers should adopt the optimum farm plans prescribed, that is, produce the crop mixtures maize/groundnut that fit into the plan based on their resource allocation. This would help them to achieve the increased yield, increased farm income, and optimal utilization of production resources. Effective farm advisory services on efficient allocation of farm resources and appropriate cropping patterns should be incorporated into programs to promote increased agricultural productivity among farmers.

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