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Optimum Production Plan for Cassava-Based-Crop Farmers in Nigeria: Evidence from Ebonyi State, Nigeria

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ABSTRACT

The study developed an optimal arable crop combination plans that would maximize the net returns of the cassava based smallholder farmers in Ebonyi. State, Nigeria. Multi-stage sampling procedure was used to select 80 smallholder cassava-based farmers. Well-structured questionnaire was used to obtain information from eighty (80) stratified randomly selected cassava based crop farmers in rural communities of Ebonyi State. Descriptive statistics, farm budgeting technique and linear programming model were used to analyze the data obtained. The LP result showed that 0.51ha of maize/cowpea, 0.52ha of Cassava and Maize (Ca/Ym,) 0.54ha of Cassava, Maize and Melon (Ca/Mz/Me), 0.66ha of Cassava, Maize and Yam (Ca/Mz/Ym), 0.58ha of Cassava, Maize and Groundnut (Ca/Mz/Gn) and 00.43ha of Cassava, Maize, Yam and Okro (Ca/Mz/Ym/Ok) were prescribed as solutions to maximize net returns in the optimal plan. The optimal net return was ₦351,185.92 which is 18.18% higher than the existing plan. Cassava, Maize, Yam and Pumpkin (Ca/Mz/Ym/Pu), enterprise had the highest marginal opportunity cost while Cassava and Maize (Ca/Mz) had the least. However, Capital and labour constituted the limiting resources in the optimal plan. It was concluded that the smallholder cassava-based farmers have the potential to maximize net returns as resources were not optimally allocated in the existing plan for cassava based crop activities. Farmers should therefore adopt the optimum farm plans as prescribed in the LP solution.

INTRODUCTION

Cassava is a very important crop to Nigeria, its comparative production advantage over other staples serves to encourage its cultivation even by the resource poor farmers (Olasunkanmi, Michael & Fisayo, 2012). Nigeria is the largest producers of cassava in the world; its production is currently put at about 34 million metric tons per year (FAO, 2022). Total harvested area of the crop in 2022 was 3.125million per hectares with an average yield of 10.83 tons per hectares (FAO, 2021). Nigeria cassava production is about third more than production in Brazil and almost double the respective volume of production in Indonesia and Thailand (NBS, 2021). Nonetheless, the Nigerian agriculture is still at subsistence level, with low productivity and poor return on investment as farm activities are majorly in the hand of smallholder farmers (Federal Ministry of Agriculture and Rural Development, 2019).

Smallholder farmers are key actors who play significant roles in driving many economies in the world through livelihoods creation and food crops production amongst the rural poor. Nonetheless, these farmers are resource constrained and are technically unable to determine what is optimal in farm resources allocation between competing choices for crop enterprises to undertake. The farmers' ultimate aim is to attain certain production goals by making efficient utilization of the limited available resources at their disposal and combining farm enterprises optimally as suggested by Onu, Simonyan and Igwe, (2023).

A typical farm anywhere in the world is often encountered with the challenge as to what enterprise to undertake, the level should it be taken up and the optimal combination of enterprises to adopt. According to Adewunmi *et al*. (2020) combination of farm enterprises in agricultural production economics is a needful relationship which involves allocating limited resources among two or more enterprises. However, the level to which one enterprise is combined or substituted with another enterprise partly depends on the interrelationships between such different enterprises and their corresponding values of products and costs of inputs.

Maximizing farm enterprise returns given the limited resources conditions of the farm families by prescribing an efficient enterprise system is germane to improving their growth prospects particularly in terms of increased farm income and food security. Previous studies such as those of Onu *et al*, (2023), Adewumi *et al*. (2020), Igwe *et al*. (2015), Ibrahim and Omotesho (2011) among others have used mathematical programming approaches for studies in optimum combination of farm enterprises and resource requirements in their various study areas but have failed to inquire into the possibility of maximizing farm returns in Ebonyi State, thereby leaving a gap which this study sought to fill.

This study was therefore conceived to develop an optimum production plan for the smallholder cassava based - crop farmers in Ebonyi State. It is also hoped that the outcome of the study would guide the farmers to undertake profitable and efficient farm enterprises.

METHODOLOGY

The study was conducted in Ebonyi State, Nigeria. The State which is located in Southeast Nigeria. The state lies in the humid tropical agro ecological zone of Nigeria within Longitudes 70 30ˈE and 80 30ˈE and Latitudes 50 40ˈN and 60 45ˈN (Okereke, 2012). It has a land area of 5,935 km2 (ebonyistate.gov. ng, 2023) with a projected population of 3,253,140 persons in 2025 using a growth rate of 3.5% (National Population Commission, 2023) estimates. The State shares boundaries on the North by Benue State, to the West by Enugu State, to the East by Cross River State and to the South by Imo and Abia State (ebonyistate.gov.ng, accessed 17/04/23).

The people are mostly farmers, fishermen, traders and civil servants. The local government area is blessed with abundant and fertile farmland. The major source of livelihood in this area is agriculture and the bulk of agricultural production is undertaken by smallholder farmers. Major crops grown in the area include rice, cassava, yam, maize, potatoes and vegetables among other crops.

A multi-stage sampling technique involving purposive and random sampling procedures was adopted in the selection of cassava-based food crop farmers for the study. In the first stage, Ebonyi State was purposively selected based on the preponderance of cassava production. The second stage involved a purposive selection of one (1) agricultural zone (Ebonyi South agricultural) based on the dominance of cassava production. In the third stage, two Local Government Areas (Ivo and Ohaozara). In the fourth stage, two autonomous communities were purposively selected to avoid selecting urban areas where farming is taken as secondary occupation to give a total of four autonomous communities. The fifth stage involved the random selection of two villages from each of the four autonomous communities selected to give a total of eight villages. List of cassava-based food crop farmers at the village level was obtained with the help of village heads, extension agents, and Agricultural Development Programme (ADP) offices in the LGAs and this list served as respective sampling frames for the villages. From each village, 10 cassava-based food crop farmers were randomly selected for the study. On the whole, a total of 80 cassava-based farmers were selected for the study.

Primary data were used for this study. The primary data were obtained through the use of structured questionnaire for the selected cassava-based food crops farmers. Information on resources employed – land, (hectares of crops farmed by the farmers in a production season) capital, labour (labour use in terms of number of people and hours), material inputs, cropping patterns, yield, revenue earned from sale of farm products, amount and interest on loans were also collected. In addition, depreciated value of capital implement such as cutlasses, hoes basins, wheel barrow were obtained.

Model Specification

Farm Budgeting Model

A farm budgeting model was used to estimate the costs and returns associated with the various cassava based crop enterprises undertaken by the smallholder farmers. The gross margins (GM) as well as the corresponding net farm incomes (NFI) were computed. The farm budgeting model following Onu *et al*. (2023), Adewumi *et al*. (2021) and Jirgi *et al* (2018) was used and is specified in equations (1) and (2).

$$GM = \sum_{i=1}^{n} P_{yi}Y_i - \sum_{j=1}^{m} P_{xj}X_j \quad \ldots(1)$$

$$NFI = \sum_{i=1}^{n} P_{yi}Y_i - \sum_{j=1}^{m} P_{xj}X_j - \sum_{k=1}^{o} F_k \quad \ldots(2)$$

Where;
GM = Gross Margin,
NFI = Net farm income,
Y_i = Output per unit enterprise (where i = 1, 2, 3… n products),
P_{yi} = Unit price of the product,
X_j = Quantity of the variable inputs per unit enterprise (where j =, 1, 2, 3… m variable inputs),
P_{xj} = Price per unit of variable inputs, and
F_k = Cost of fixed inputs per unit enterprise (where k =, 1, 2, 3…, o fixed inputs).

Linear programming (LP) Model

Linear programming (LP) model was used to derive optimum cassava-based enterprise combination plan for the smallholder farmers in the study area. The LP model adopted from Onu et al. (2023), Igwe *et al.* (2011); Jirgi *et al.* (2018); Adewunmi *et al*. (2021) and modified for this study is specified in equation 3. The objective function of the Linear programming model was to maximize the net return of the smallholder cassava-based food crop farmers for each enterprise undertaken. Generally, the linear programming model is given as follows:

$$\text{Maximize } Zi = \sum_{j=1}^{n} P_i X_j \ (j = 1, 2 \ldots n) \text{ --- } 3$$

Subject to:

$$\sum_{j=1}^{m} A_{ii}X_j \leq b_i t \ (i = 1,2,\ldots,m) \text{------} 4$$

and

$X_j \geq 0$ for all js

Where:

Z_i = Net Farm Income

X_j = Activity or enterprise undertaken (decision variable),

P_j = Output coefficient or net price (gross margin/unit) of each enterprise activity maximized,

A_{ij} = Input-output coefficients, that is, quantity of ith resource (land, planting material, human labour, capital, fertilizer and agrochemicals) required to produce a unit of jth cassava-based food crop activity.

β_{it} = Level of available resources for enterprises in t_{th} period,

The model for determining the optimum farm plans can also be expressed explicitly by the equation:

Maximize $Z = P_1X_1 + P_2X_2 + P_3X_3 + P_3X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + P_8X_8$ ---------------------------5

Subject to:

$A_{11}X_1 + A_{12}X_2 + A_{13}X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + A_{18}X_8 \leq L_S \ (Land)$

$A_{21}X_1 + A_{22}X_2 + A_{23}X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + A_{28}X_8 \leq H_t$ (Human l$abour$)

$A_{31}X_1 + A_{32}X_2 + A_{33}X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + A_{38}X_8 \leq C_t \ (Capital)$

$A_{41}X_1 + A_{42}X_2 + A_{43}X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + A_{48}X_8 \leq P_t$ (Planting materials)

$A_{51}X_1 + A_{52}X_2 + A_{53}X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + A_{58}X_8 \leq F_t \ (Fertilizer)$

$A_{61}X_1 + A_{62}X_2 + A_{63}X_3 + P_4X_4 + P_5X_5 + P_6X_6 + P_7X_7 + A_{68}X_8 \leq A_t \ (Agrochemical)$ and $X_1 \geq 0, _2 \geq 0, X_3 \geq 0, \ldots, X8 \geq 0$

Z - Gross Margin (₦/ha),

$X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8$ - different crop activities or enterprises undertaken (decision variables), $P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8$ - Output coefficients per hectare of the different crop activities maximized, Aij - Input- Output coefficient (quantity of i^{th} resource (land, human labour, capital, planting materials, fertilizer, and agrochemical) required to produce a unit output of j^{th} crop activity,

Ls - Level of available land in hectare for crop activities with s restriction,

H_t - Level of available human labour in man-day for crop activities in t^{th} period,

C_t - Level of available working capital in Naira for crop activities in t^{th} period,

P_t - Level of available planting materials in kilograms for crop activities in t^{th} period,

F_t - Level of available fertilizer in kilograms for crop activities in t^{th} period,

A_t - Level of available agrochemical in litres for cassava-based crop activities in t^{th} period.

RESULTS AND DISCUSSION

Costs and Return Analysis of Smallholder Cassava Based Enterprises

The result of the costs and returns analysis of each cassava based enterprise undertaken by farmers in the study area are presented in Table 1. The values estimated were on per hectare basis and the gross values of each crop output per hectare were calculated based on prevailing market prices in the study area. The variable and fixed costs of production, revenue, gross margin, net farm income, and gross ratio per unit enterprise were computed. The variable cost items included the cost expended on planting materials, labour, fertilizer, agrochemicals, marketing expenses, processing, and storage, while the fixed cost items were those of land rent, depreciation on farm tools and machinery, and interest on borrowed capital.

Table 1 Costs and returns analysis of cropping patterns of cassava-based farming farmers in Ebonyi State

S/N	Enterprises	Average value (N/hectare)						
		Total Fixed Cost	Total Variable Cost	Total Cost	Total Revenue	Gross Margin	Net-Farm Income	Gross Ratio
1	Cassava/Maize (Ca/Mz)	40,856.97	61,065.21	101,922.18	304,820.09	243,754.88	202,897.91	0.33
2	Cassava/yam (Ca/Ym)	36,061.74	61,578.68	97,640.42	398,384.18	336,805.50	300,743.76	0.25
3	Cassava/Melon (Ca/Me)	51,295.34	66,158.28	117,453.62	432,172.46	366,014.18	314,718.84	0.27
4	Cassava/Pumpkin (Ca/Pu)	44,334.11	58,323.93	102,658.04	415,691.30	357,367.37	313,033.26	0.25
5	Cassava/Groundnut (Ca/Gn)	48,861.12	56,686.32	105,547.44	346,851.44	290,165.12	241,304.00	0.30
6	Cassava/Cocoyam (Ca/Co)	39,913.50	55,206.92	95,120.42	361,136.83	305,929.91	266,016.41	0.26
7	Cassava/Okra (Ca/Ok)	45,822.13	57,353.75	103,175.88	360,029.89	302,676.14	256,854.01	0.29
8	Cassava/Maize/Melon (Ca/Mz/Me)	45,357.65	59,389.62	104,747.27	376,104.04	316,714.42	271,356.77	0.28
9	Cassava/Maize/Yam (Ca/Mz/Ym)	42,581.54	56,573.66	99,155.20	469,315.24	412,741.58	370,160.04	0.21
10	Cassava/ Maize/Cocoyam (Ca/Mz/Co)	38,280.94	53,437.95	91,718.89	358,655.63	305,217.68	266,936.74	0.26
11	Cassava/Maize/Okra (Ca/Mz/Ok)	45,385.87	56,795.62	102,181.49	363,002.99	306,207.37	260,821.50	0.28
12	Cassava/Maize/Pumpkin (Ca/Mz/Pu)	48,167.35	63,004.29	111,171.64	386,760.00	323,755.71	275,588.36	0.29
13	Cassava/Maize/Groundnut (Ca/Mz/Gn)	44,635.53	60,771.55	105,407.08	409,619.77	348,848.22	304,212.69	0.26
14	Cassava/yam/Okra/Pumpkin (Ca/Ym/Ok/Pu)	46,242.90	52,483.78	98,726.68	344,798.83	292,315.05	246,072.15	0.29
15	Cassava/Maize/Melon/Cocoyam (Ca/Mz/Me/Co)	44,135.01	60,427.23	104,562.24	400,219.85	339,792.62	295,657.61	0.26
16	Cassava/Maize/Yam/Pumpkin (Ca/Mz/Ym/Pu)	46,315.57	58,426.24	104,741.81	575,947.40	517,521.16	471,205.59	0.18
17	Cassava/Maize/Yam/okra (Ca/Mz/Ym/Ok)	44,760.03	61,980.13	106,740.16	484,174.98	422,194.85	377,434.82	0.22

Source: Field survey data, 2023

The result in Table 1 showed that the total production costs for cassava-based enterprises under study were as follow: Ca/Mz (₦101,922.18), Ca/Ym (₦97,640.42), Ca/Me(₦117,453.62), Ca/Pu (₦102,658.04), Ca/Gn (₦105,547.44), Ca/Co (₦95,120.42), Ca/Ok (₦103,175.88), Ca/Mz/Me ₦104,747.27), Ca/Mz/Ym (₦99,155.20),, Ca/Mz/Co (₦91,718.89), Ca/Mz/Ok (₦102,181.49), Ca/MzPu (₦111,171.64), Ca/Mz/Gn (₦105,407.08), Ca/Ym Ok/Pu (₦98,726.68), Ca/Mz/Me/Co (₦104,562.24), Ca/Mz/Ym/Pu (₦104,741.81) and Ca/Mz/Ym/Ok (₦106,740.16).

The estimated gross margins, net farm incomes, and gross ratios (Table 1) showed that all the crop enterprises undertaken by the cassava-based food crop farmers were profitable, given that the computed gross ratios were all less than one. Cassava/Maize/Yam/Pumpkin (Ca/Mz/Ym/Pu) enterprise is the most profitable with a net farm income of ₦471,205.59, closely followed by

Cassava/Maize/Yam/okra (Ca/Mz/Ym/Ok) enterprise with a net farm income of ₦377,434.82 and then Cassava/Maize/Yam (Ca/Mz/Ym) with a net farm income of ₦370,160.04. On the other hand, Cassava/Maize (Ca/Mz) enterprise was the least profitable enterprise with a net farm income of ₦202,897.91, closely followed by Cassava/Groundnut (Ca/Gn) enterprise with a net farm income of ₦241,304.00. The computed gross ratios showed that Cassava/Maize/Yam/Pumpkin (Ca/Mz/Ym/Pu) was the most profitable cassava-based enterprise probably because of the value attached to yam in the study area, while Cassava/Maize (Ca/Mz) was the least profitable enterprise in Ebonyi State. This is consistent with the assertions of Adewumi *et al*. (2018) in their study on optimum production pattern for cassava-based crop farmers in Irepodun and Moro LGAs of Kwara State. They reported that cassava/maize enterprise was the least profitable enterprise in Moro Local Government Area of Kwara State. The result is also analogue with the submissions of Onu et al.(2023a) who submitted that food crop combination with yam production is profitable in the Southeast, Nigeria

Cassava-Based Enterprise Combinations in Existing and Optimum Plans

The results of analysis of optimum cassava-based enterprise mix that would maximize the net returns of the farmers in the study area are presented in Table 2.

Table 2: Results of basic linear programming models of existing, and optimum cassava-based enterprise plans

S/N	Cassava-based Enterprises	Farmers existing Plan	LP Solution Optimum Plan
1	Ca/Mz	0.62(6.78)	-
2	Ca/Ym	0.53(5.8)	0.51(18.9)
3	Ca/Me	0.54(5.91)	-
4	Ca/Pu	0.63(6.89)	-
5	Ca/Gn	0.49(5.36)	-
6	Ca/Co	0.28(3.06)	-
7	Ca/Ok	0.51(5.58)	-
8	Ca/Mz/Me	0.54(5.91)	0.52(19.3)
9	Ca/Mz/Ym	0.88(9.63)	0.66(24.4)
10	Ca/Mz/Co	0.41(4.49)	-
11	Ca/Mz/Ok	0.65(7.11)	-
12	Ca/Mz/Pu	0.56(6.13)	-
13	Ca/Mz/Gn	0.74(8.1)	0.58(21.5)
14	CaYm/Ok/P	0.32(3.5)	-
15	Ca/Mz/Me/Co	0.46(5.03)	-
16	Ca/Mz/Ym/Pu	0.31(3.39)	-
17	Ca/Mz/Ym/Ok	0.67(7.33)	0.43(15.9)
	Total cropped area (ha)	9.14	2.70

Source: Field survey data, 2023

The results in Table 2 showed that the total cropped area under existing plan is 9.14 hectares whereas the total cropped area for the profit maximizing plan (optimum plan) was 2.7ha. From the table, the average cassava-based farmer should allocate his resources in such a way that the five enterprises in the optimum plan are produced according to their hectrage allocations. The recommended allocation pattern depicts the most important enterprises as Ca/Ym (0.51ha), Ca/Mz/Me (0.52ha), Ca/Mz/Ym (0.66ha), Ca/Mz/Gn (0.58ha) and Ca/Mz/Ym/Ok (0.43ha) in the optimum plan

This result is in consonance with the findings of Onu *et al.* (2023b) and Igwe *et al*. (2015) who recommended cassava/maize/melon enterprise combination for cassava based crop farmers in Abia State, Nigeria. This result also corroborates the finding of Udo *et al*., (2015b) that cassava/maize/melon and cassava/maize/pumpkin in enterprise combination is optimum for farmers in Etinan agricultural zone of Akwa-Ibom State, Nigeria. It is also interesting to note from the result that four major categories of crop (tuber, cereals legumes and vegetables) were reflected in the optimum plans prescribed in the state under study.

Marginal Opportunity Cost (MOC) or Shadow Prices Of Excluded Activities of Optimum Cassava-Based Enterprise Combinations

In LP problem, marginal opportunity costs also known as shadow prices for activities are the income penalties that would be experienced by a farmer who forcefully introduces/undertakes any such activity that has been excluded by the maximization solution. In essence, it indicates the amount by which net returns would be reduced if an excluded activity was undertaken or forced into the production plan by the smallholder farmers. The higher the value of the marginal opportunity cost of an excluded activity the lower its chances of being included in the optimum plan and vice versa. The marginal opportunity costs are presented in Table 3.

Table 3: Marginal Opportunity Cost of excluded cassava-based enterprises for farmers in Ebonyi State

S/N	Cassava-based Enterprises	LP Solution
		Optimum Plan
1	Ca/Mz	35,533.78
2	Ca/Me	63,837.49
3	Ca/Pu	52,085.40
4	Ca/Gn	121,870.71
5	Ca/Co	92,688.65
6	Ca/Ok	53,400.00
7	Ca/Mz/Co	103,463.85
8	Ca/Mz/Ok	66,198.35
9	Ca/Mz/Pu	50,846.56
10	Ca/Ym/Ok/Pu	97,647.68
11	Ca/Mz/Me/Co	167,987.28
12	Ca/Mz/Ym/Pu	193,117.05

Source: Field Survey Data, 2023

Results in Table 3 shows that the non-basic or excluded activities were twelve in the optimum plan. The results in Table 3 further showed that Ca/Mz with MOCs of ₦35,533.78 had the least MOC value in derived plan. The result also showed that Ca/Mz/Ym/Pu, had the highest MOC value of ₦193,117.05 in the plan. The income penalty or marginal opportunity cost showed by how much the return would be reduced if any of the non - basic or excluded activities which did not enter the program in Table 3 is forced into the programme. This result lends credence to previous findings (Igwe *et al*, 2013) who asserted in their study on ‘A Linear Programming Approach to food crops and livestock enterprises planning in Aba Agricultural Zone of Abia State, Nigeria’ that maize/melon/pumpkin was an excluded activity with the highest MOC value.

Net Farm Income In Existing, Optimum and Risk Efficient Cassava-Based Plans

The mean net farm income/net return obtained in Naira per hectare in the existing plan and optimum plans for cassava based food crop enterprises in the study area are presented in in Table 4.

Table 4 Gross margin in existing and optimum plans for cassava-based food crop

Farmers existing Plan (₦)	**LP Solution (Optimum Plan(₦))**
297,161.89	351,185.92
Average Increase in Net Return in the Optimum Plan (₦)	
-	54,024.03
Percentage Increment in Net Return in the Optimum Plan (%)	
-	18.18

Source: Field survey data, 2023.

The estimated net farm income in the existing farm plan was ₦297,161.89.17/ha while the net farm income in the optimum plan was ₦351, 185.92. Result in Table 4 further showed that the mean net farm income obtained in the optimum plan was higher than that obtained in their existing plan. This depicts that there is an average increase of ₦54,024.03/ha, representing 18.18% proportionate change in the optimum plan over the existing plan. This increment satisfies the increased income objective of the farmers. The implication of this increment in the optimum plan is that, an average cassava farmer in the study area has the potential to increase and maximize net returns. This result is similar to those obtained from the study carried out by Onu *et al.* (2023a) Jirgi *et al.* (2018), Adewunmi *et al*., (2018) and Udoh *et al.,* (2015b) who noted that gross margins obtained in optimized farm plans offers a higher and better value than the gross margins obtainable in the farmers’ existing farm plans.

Marginal Value Product (Mvp) of Resources Under Cassava-Based Enterprises

Any resource that is abundant, that is not used up by the programme, is not a limiting resource and therefore, has a zero shadow price as it does not constrain the attainment of a programme’s objective and vice versa (Olayemi and Onyenweaku, 1999). The status therefore of the available resources in the optimized plans that constrained the attainment of the objective programme for is presented in Table 5.

Table 5: Marginal Value Product (MVP) of Resources Under Cassava-Based Enterprises

Resources	LP Solution (Optimum Plan)		
	US	**S/S**	**SP(₦)**
A. Land	NFU	5.80	0
B. Human Labour			
1. Land preparation	FU	0	1092.16
2. Planting	FU	0	1190.28
3. Weeding	FU	0	1196.64
4. Fertilizer application	FU	0	1194.44
5. Pesticides application	FU	0	986.30
6. Harvesting	FU	0	1193.73
C. Capital			
Owned capital	FU	0	8.96
2. Borrowed capital	FU	0	11.30
D. Planting Material			
1. Cassava	NFU	690.37	0
2. Maize	NFU	450.42	0
3. Melon	NFU	400.11	0
4. Groundnut	NFU	510.10	0
5. Yam	NFU	800.47	0
6. Pumpkin	NFU	390.39	0
7. Cocoyam	NFU	340.66	0
8. Okra	NFU	286.12	0
E. Fertilizer (Kg)	NFU	9.631	0
F. Agrochemicals (L)	NFU	0.895	0

Source: Field survey data, 2023

US = Use status; S/S = Slack/Surplus resource; SP = Shadow price; FU = Fully utilized; NFU = Not fully utilized

The non-fully utilized or non-limiting resources according to the results in Table 5 include land (5.80ha), planting materials of all sorts, fertilizer and agrochemicals. This means that the optimum farm plan under this model cannot be affected if the levels of these unused resources were done away with. The resource use pattern of the optimum plan as shown in Table 5 showed that human labour and capital (owned and borrowed) were the only resources that were fully utilized in arriving at the optimal solution. This implied that the net return of the farm will increase by their corresponding shadow prices for additional unit employed. This result is analogue to those of Ibrahim *et al*. (2020) whose study on ‘optimum production plan for maize-based crop farmers in Niger State, Nigeria’ identified labour and capital as the major limiting factors. This finding is also similar to those of Onu *et al*. (2023), Onu *et al*. (2023) and Olasukonmai *et al*. (2012) who reported that human labour and capital were factors limiting the profit maximization objective of cassava based farmers in Enugu, Abia and Ogun States.

CONCLUSION AND RECOMMENDATIONS

It was concluded based on the findings of this study that resources were not allocated optimally by the smallholder cassava based crop farmers in Ebonyi State. Nonetheless, all the enterprises considered were profitable in the study area. The linear programming solution indicated that mixed crop enterprises were in a better competitive position to maximize the net returns of the farmers in the optimum plans. The farmers have the potential to maximize their net returns by adopting the optimum farm plan prescribed in the LP solution. This would help them to achieve increased farm incomes, reduced cost of production guarantee and food security. It can be concluded that appropriate combination of enterprises in crop farming not only helps to increase net farm income but also utilize all available resources efficiently.. In essence, the optimum plans should be incorporated in to extension education content of the Ebonyi State ADP.

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