Acta Sci. Pol. Agricultura 19(4) 2020, 169–180

www.agricultura.acta.utp.edu.pl pISSN 1644-0625 eISSN 2300-8504 DOI: 10.37660/aspagr.2020.19.4.1

ORIGINAL PAPER

Received: 14.05.2020
Received in revised form: 20.10.2020
Accepted: 30.10.2020

OPTIMUM ENTERPRISE COMBINATION IN A MAIZE BASED CROPPING SYSTEM IN THE SOUTHERN AGRICULTURAL ZONE OF ADAMAWA STATE, NIGERIA

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ABSTRACT

Background. Maize is a major cereal consumed by nearly all Nigerian households and accounts for about 43% of calorie intake. Rapid population growth and urbanization coupled with infrastructural developments have made agricultural resources very limited in supply and constrained maize production. This necessitates the need for an optimum enterprise combination in a maize based cropping system to guarantee the profit maximization objective of maize farming households. Hence, the study investigated optimum enterprise combinations in maize based cropping systems in the Southern Agricultural Zone of Adamawa State, Nigeria. This study would be of benefit to maize farmers that may need information on maize based enterprise combination that give optimum level of returns.
Material and methods. A multistage sampling technique was used to select 130 respondents. Data were collected during the 2018/2019 cropping season and analysed using descriptive statistics, Gross Margin (GM) analysis and the Linear Programming (LP) model.
Results. Result of the distribution of the respondents on the basis of maize based enterprises in the study area showed the largest group (40%) of the respondents practiced sole maize enterprises. The gross margin analysis revealed that seven enterprises (maize/rice, maize/groundnut, maize/sorghum, maize/soybean, maize/sugarcane, maize/yam and maize/benniseed) were sustainable as their respective total revenue was higher than their total variable cost. The linear programming model recommends that each farmer grows a mix of three crops in an area ratio of 6.15:3.35:1.50 for maize/soybean, maize/benniseed and maize/sorghum, respectively, to give a gross margin of ₦ 544,999.04 (1,192.41 €) for crops grown on an area of 11 ha.
Conclusion. The study recommended crop mixtures based on their hectarage allocation as prescribed in the optimum farm plans would have generated income as follows: maize/soybean (₦ 367,449.89 (804.15 €)), maize/benniseed (₦ 104,034.25 (227.85 €)) and maize/sorghum (₦ 73,514.89 (160.85 €)). The recommended crop mixtures would have increased the farmers' gross margin by 17%.

Key words: limited farm resource, optimization, profit maximization

INTRODUCTION

Maize (*Zea mays* L.), also refers to as corn in some parts of the world, is a crop grown wildly in a range of agro-ecological environments. Kudi *et al.* (2011) opined that maize is one of the most important cereal crops in Sub-Saharan Africa as it accounts for about 43 percent of calorie intake in this region and it is one

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of the major cereals consumed by nearly all Nigerian households in either a fresh or processed form (Timon *et al.,* 2020). Nigeria produces 43% of the total maize grown in West African countries (Usman, 2016).

According to Owoeye (2017), 80% of maize in Nigeria is consumed by humans and animals while the residual 20% is utilized in a variety of industrial processes for the production of starch, ethanol and alkaline.

The northern part of Nigeria, as reported by Ibrahim (2007), is suitable for the production of cereals such as sorghum, maize, and millet, whereas, the southern part has the potential to produce tubers such as cassava, yam, cocoyam, and other crops like plantain as well as maize.

A maize based cropping system or a maize based enterprise is the cultivation of a maize crop in combination with one or more crops in the same field and at the same time. Farmers who practice a maize based cropping system are always pre-occupied with decisions on how to optimise the combinations used in a maize based enterprise, given scarce resources, so as to achieve the objective of profit maximization. Unfortunately, these decisions are made based on a trial and error method, which often results in uncertain outcomes (Igwe *et al.*, 2013). According to Kelani *et al.* (2020), farmers practice what has been handed down from generation to generation and there are no conscious efforts towards knowing which enterprise combination would maximize their goal.

It is against this backdrop that the study sought to determine the optimum enterprise combination in maize-based cropping systems in the Southern Agricultural Zone of Adamawa State, Nigeria through using linear programming. The study specifically sought to describe the socio-economic characteristics of respondents, identify the maize based enterprises in the study area, and estimate the profitability of those maize based enterprises.

MATERIAL AND METHODS

Study Area

The study was conducted in Adamawa South Agricultural Zone of Adamawa State, Nigeria. The State is located between latitude 7.0° N and 11.0° N, and longitude 11.0° E, and 14.0° E (Adebayo, 1999). The rainy season commences in April and lasts to the first ten days in October, while the highest rainfall is mostly being recorded in August and September (Njodi *et al.*, 2019). The southern agricultural zone has 9 Local Government Areas (LGA), namely: Toungo, Ganye, Jada, Mayo-belwa, Demsa, Numan, Lamurde, Guyuk and Shelleng. This zone is well noted for its agricultural potential, which has earned her the name, the food basket of Adamawa State (Maurice, 2012). The area has rich agricultural land suitable for growing maize, cowpea, groundnut, soy bean, banbara nuts, sugarcane, and cashew among other crops (Philip *et al.*, 2019). Domestic animals such as cattle, goat, and sheep are also being reared to supplement farmers income.

Sampling procedure and sample size

A multi-stage sampling technique was used. The first stage involved a purposive selection of 2 Local Government Areas (Ganye and Jada) out of the 9 Local Government Areas (LGA) in the agricultural zone. Their selection was based on their maize production level (Maurice *et al.*, 2015). The second stage involved a random selection of 8 districts from the 2 selected LGAs. The final stage involved simple random sampling technique using balloting to select 130 respondents from a sample frame of 1,336 registered maize farmers drawn from 16 farming communities (Table 1). Primary data for the study were collected with the aid of a well administered questionnaire.

Method of data analysis

Descriptive statistics were used in describing the socio-economic characteristics of the respondents. Gross Margin analysis was used to determine the profitability level of the maize based enterprises. The GM model used was as follows:

$$GM = TR - TVC$$

where:

GM = Gross Margin (₦·ha^{-1}),
TR = Total Revenue (₦·ha^{-1}),
TVC = Total Variable Cost (₦·ha^{-1}).

Table 1. Sampling frame of the respondents

LGA	District	Farming Communities	Sample Frame	Random Selection
Ganye	Bakari-Gusso	Bakari-Gusso	90	9
Ganye	Jaggu	Garga	40	4
		Jaggu	100	10
Ganye	Timdore	Wadore	50	5
		Timdore	100	10
Ganye	Sugu	Yelwa	140	14
		Sugu	120	12
Jada	Danaba	Gamu	110	11
		Nawai	90	9
Jada	Mbulo	Nadeu	62	6
		Gansanii	73	7
Jada	Kojoli	Boro	85	8
		Sandasini	68	7
Jada	Mapeo	Dabora	39	4
		Babidi	84	8
		Sitim	85	8
Total			1,336	130

Source: Adamawa State Agricultural Development Programme (2018).

Linear Programming (LP) was used as a mathematical procedure for determining the best plan among alternatives, where there is resource limitation. Zalkuwi *et al.* (2014) stated that the LP model is a solution that fulfils both of the constraints of the problem, the set objectives to be met and the non-negativity constraint. The theoretical framework that guides the study is based on optimization and theory of production. Cobb and Douglas (1928) defined theory of production as the economic process of producing output from the input, whereas optimization implies efficiency. The basic assumption of the theory about the objective function is for the maize farmer to get the best plan from among alternatives when there is resource limitation.

The linear programming model used for the optimum farm plans can be expressed by the equation as follows:

Maximization $P = \sum sjXj[\,j = 1,2,3..n]$

Subject to:

$\sum(ajXj[\,j = 1,2,3..n])$……………………….……$\leq a_j$ (Land restriction)

$\sum(bjXj[\,j = 1,2,3..n])$………………………..$\leq b_j$ (Seed restriction)

$\sum(cjXj[\,j = 1,2,3..n])$……………………….$\leq c_j$ (Agrochemical restriction)

$\sum(djXj[\,j = 1,2,3..n])$……………………….$\leq d_j$ (Fertilizer restriction)

$\sum(ejXj[\,j = 1,2,3..n])$……………………….$\leq e_j$ (Labour restriction)

X_j [j=1,2,3..n] ≥ 0 (Non-negativity constraint) where:

P = Gross Margin (Objective Function),
X_j = Area under j^{th} crop production activity,
S_j = Gross Margin per unit of the j^{th} crop activity,
a_j = Land coefficient for j^{th} crop,
b_j = Seed requirement for j^{th} crop activity,
c_j = Agrochemical requirement for j^{th} crop activity,
d_j = Fertilizer requirement for j^{th} crop activity,
e_j = Labour requirement for j^{th} crop activity,
a_j = Available land in hectare,
b_j = Quantity of seeds available in kg,
c_j = Quantity of agrochemical available in liters,
d_j = Quantity of fertilizer in kg,
e_j = Human labour available in man-hour,
n = Number of crop production activities.

The parameters were estimated using the Tora Optimization System (TOS), version 2.00.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Table 2 shows that the majority (76.2%) of the maize farmers were males while their female counterpart constituted 23.8%. The result in Table 2 further shows that the mean age of the respondents was 39 years. This implies that the farmers were within the age bracket that can provide the physical strength required for manual farming activities. The majority (87.69%) of the respondents had various forms of formal education ranging from primary (46.9%), secondary (27.7%), and tertiary education (13.1%), whereas 12.3% of the respondents had no form of formal education. This level of education suggests that the majority of those involved in the maize based cropping systems in the study area are educated and have the capacity to accept new agricultural innovations and technologies that can increase their farm gross margin. The mean household size for the study was 10 people, which is in line with the findings of Augustine *et al.* (2018), whose study reported an average family size in northern Nigeria of 9 people per household.

Table 2 also shows that the maize based cropping system in the study area was carried out as small-scale enterprises, as evidenced by a mean farm size of 1.8 hectares. This means that food crop production in the study area is undertaken mainly on a small-scale basis.

Table 2. Socio-economic characteristics of respondents

Variable	Frequency	Percentage	Mean	Minimum	Maximum
Gender					
Male	99	76.2			
Female	31	23.8			
Total	130	100.0			
Age (years)					
20–30	28	21.5	39	20	65
31–40	48	36.9			
41–50	30	23.1			
51–60	16	12.3			
61 and Above	8	6.2			
Total	130	100.0			

Table 2 continued

Education					
Informal	16	12.3			
Primary	61	46.9			
Secondary	36	27.7			
Tertiary	17	13.1			
Total	130	100.0			
Household Size					
1–5	45	34.6	10	1	21
6–10	41	31.5			
11–15	15	11.5			
16–20	21	16.2			
21 and Above	8	6.2			
Total	130	100.0			
Farmland Size (hectare)					
≤ 2.0	54	41.5	1.8	0.5	2.7
2.1–3.0	40	30.8			
3.1–4.0	31	23.8			
4.1 and Above	5	3.8			
Total	130	100.0			

Source: Field Survey, 2018.

Distribution of respondents on the basis of maize based enterprise

The results in Table 3 shows that the majority (60%) of the respondents were involved in only one of the forms of maize based enterprise. While those solely on maize cultivation constituted 40%. Table 3 also shows that sole maize cropping predominates any other form of maize based cropping system in the study area. The dominance (40%) of sole maize enterprises over any other form of maize enterprises may be attributed to the small-scale nature of the maize farmers. This finding gives credence to the findings of Babatunde *et al.* (2008), who found in their study that the majority of maize farmers in Kwara State were involved in sole maize cultivation.

Table 3. Distribution of respondents

Enterprise	No of Respondents	%
Sole maize	52	40.0
Maize/cowpea	22	16.9
Maize/yam	8	6.2
Maize/groundnut	19	14.6
Maize/beniseed	2	1.5
Maize/millet	6	4.6
Maize/rice	6	4.6
Maize/sugarcane	3	2.3
Maize/soybean	6	4.6
Maize/sorghum	3	2.3
Maize/bambaranut	3	2.3
Total	130	100.0

Source: Field Survey, 2018.

Profitability of maize based enterprises per hectare in the Adamawa South Agricultural zone

Gross margin analysis in Table 4 reveals that seven enterprises (maize/rice, maize/groundnut, maize/sorghum, maize/soybean, maize/sugarcane, maize/yam and maize/benniseed) were profitable. Their respective total revenue was more than the total variable cost. This will serve as an incentive for the sustainability of these cropping enterprises in the study area.

Table 4 also shows that Labour cost was the dominant cost of production the area. This agrees with the findings of Osivweneta *et al.* (2011), who reported in their study that the cost of labour had the highest average percentage (59%) among the other farm resources used. Agriculture practices like land clearing, ploughing, sowing, weed control treatments, fertilizer application, pesticides application and harvesting, which are often done manually, require much labour; hence, the preponderance of labour cost in the total cost of production in the study area.

Table 4. Profitability analysis per hectare of enterprise

Enterprise	Item	Quantity Used	Price/unit ₦	Cost ₦	Total Cost %
Maize/Rice	Seed	43.78	56.32	2,466.57	7.0
	Agrochemical	20.21	267.18	5,400.00	15.4
	Fertilizer	72.10	102.18	7,368.42	21.0
	Labour	18.71	1,058.54	19,810.53	56.5
	TVC			35,040.27	
	TR			74,813.16	
	GM (TR-TVC)			39,772.89	
Maize/Cowpea	Seed	34.12	70.42	2,402.67	5.4
	Agrochemical	14.73	317.54	4,678.40	10.5
	Fertilizer	70.66	105.66	7,466.67	16.8
	Labour	27.00	1,123.00	29,970.00	67.3
	TVC			44,517.74	
	TR			78,240.00	
	GM (TR-TVC)			33,722.26	
Maize/Groundnut	Seed	65.31	42.83	2,797.51	6.2
	Agrochemical	19.20	280.64	5,388.33	11.9
	Fertilizer	68.58	102.20	7,009.17	15.5
	Labour	29.83	1,007.00	30,040.00	66.4
	TVC			45,237.01	
	TR			93,247.73	
	GM (TR-TVC)			48,010.72	

Table 4 continued

Maize/Sorghum	Seed	45.00	98.27	4,422.22	9.4
	Agrochemical	16.56	202.25	3,348.33	7.1
	Fertilizer	136.11	104.08	14,166.67	30.2
	Labour	20.14	1,237.51	24,927.78	53.2
	TVC			46,865.00	
	TR			95,805.56	
	GM (TR-TVC)			48,940.56	
Maize/Soy Bean	Seed	49.28	56.53	2,785.55	10.6
	Agrochemical	21.89	295.25	6,462.78	24.6
	Fertilizer	51.94	120.59	6,263.89	23.8
	Labour	13.81	782.23	10,802.59	41.1
	TVC			26,314.81	
	TR			86,075.56	
	GM (TR-TVC)			59,760.75	
Maize/Sugarcane	Seed	49.00	122.04	5,980.00	13.4
	Agrochemical	23.70	222.15	5,265.00	11.8
	Fertilizer	68.00	100.15	6,810.00	15.2
	Labour	34.45	772.95	26,625.00	59.6
	TVC			44,680.00	
	TR			95,635.00	
	GM (TR-TVC)			50,955.00	
Maize/Yam	Seed	44.23	68.16	3,014.53	7.2
	Agrochemical	17.55	344.62	6,047.17	14.5
	Fertilizer	68.87	101.10	6,962.26	16.6
	Labour	18.32	1,408.74	25,811.32	61.7
	TVC			41,835.28	
	TR			94,791.51	
	GM (TR-TVC)			52,956.23	
Maize/Benniseed	Seed	35.00	50.00	1,750.00	6.9
	Agrochemical	14.63	196.15	2,868.75	11.4
	Fertilizer	35.63	100.00	3,562.50	14.1
	Labour	12.30	1,385.44	17,043.75	67.6
	TVC			25,225.00	

Table 4 continued

	TR			56,287.50	
	GM (TR-TVC)			31,062.50	
Maize/Bambaranut	Seed	36.64	62.32	2,283.18	5.8
	Agrochemical	17.64	259.79	4,581.82	11.6
	Fertilizer	54.55	106.67	5,818.18	14.7
	Labour	19.57	1,369.11	26,790.91	67.9
	TVC			39,474.09	
	TR			68,000.00	
	GM (TR-TVC)			28,525.91	
Maize/Millet	Seed	39.38	64.33	2,532.81	6.3
	Agrochemical	14.06	335.56	4,718.75	11.8
	Fertilizer	64.06	99.51	6,375.00	15.9
	Labour	24.20	1,092.82	26,446.88	66.0
	TVC			40,073.44	
	TR			68,203.13	
	GM (TR-TVC)			28,129.69	
Sole Maize	Seed	41.26	70.52	2,909.66	6.2
	Agrochemical	16.75	335.33	5,615.86	11.9
	Fertilizer	70.46	103.49	7,291.95	15.4
	Labour	26.46	1,187.06	31,408.21	66.5
	TVC			47,225.68	
	TR			84,769.34	
	GM (TR-TVC)			37,543.66	

Source: Computed from field Survey data 2018.

Where TVC is the Total Variable Cost, TR is the Total Revenue and GM is the Gross Margin.

Optimum farm plan in the maize based enterprise

The optimum farm plan in the unplanned (existing) and planned farm plans are presented in Table 5. The result presents an optimum farm plan of ₦ 367,449.89 (804.15 €) for maize/soybean, ₦ 104,034.25 (227.85 €) for maize/ benniseed and an optimum farm plan of ₦ 73,514.89 (160.85 €) for maize/sorghum, all of which are maize based intercrop systems. This finding infers that maize based enterprises were more lucrative than sole maize cropping in the study area, Adamawa South Agricultural Zone. This finding supports Oviasogie (2005) findings, who found that mixed cropping gives a higher gross margin than sole cropping.

Table 5. Optimum maize-based enterprises

Enterprise	Value ha	Unplanned (Existing) Activity Level ₦	Planned farm plan ₦
Maize/Rice	0.00	39,722.89	**
Maize/Cowpea	0.00	33,784.26	**
Maize/Groundnut	0.00	41,010.72	**
Maize/Sorghum	1.50	48,940.56	73,514.89
Maize/Soybean	6.15	59,760.75	367,449.89
Maize/Sugarcane	0.00	50,955.00	**
Maize/Yam	0.00	52,956.23	**
Maize/Benniseed	3.35	31,062.50	104,034.25
Maize/Bambara nut	0.00	28,525.91	**
Maize/Millet	0.00	28,129.69	**
Sole Maize	0.00	37,543.66	**
Gross Margin		452,392.17	544,999.04

Source: Analyzed from field Survey data 2018.
** Excluded Activity

The optimization results, which show the reduced cost (shadow price) of the excluded activities, resource use level in the optimum farm plan, difference in the existing and optimum plans in the study area are presented in Table 5a, 5b, and 5c.

Reduced cost (shadow price) of the maize based cropping system

The reduced cost indicates the amount by which farm gross margin would reduce if any of the excluded activities are forced into the LP. In a maximization case of linear programming, shadow prices (reduced cost) are profit penalties; they indicate the amount by which the gross margin would be reduced if any of the excluded activities costs were forced into the programme. The result in Table 5a showed eight activities that were excluded with maize/millet having the highest reduced cost (₦ 19,655.18) and maize/sugarcane with the least (₦ 1,225.15). This means that maize/millet with the highest reduced cost has the least chance of entering the planned (optimum) solution.

Table 5a. Reduced cost of maize based enterprise combination

S/N	Excluded Activities	Reduced Cost ₦
1	Maize/Rice	14,161.92
2	Maize/Cowpea	15,217.17
3	Maize/Groundnut	12,300.24
4	Maize/Sugarcane	1,225.15
5	Maize/Yam	4,872.07
6	Maize/Bambara nut	17,543.08
7	Maize/millet	19,655.18
8	Sole maize	17,737.40

Source: Analyzed from field Survey data 2018.

Resource use level in the planned (optimum) farm plan

The factors limiting the achievement of the profit maximization objective in the study area as obtained from the LP output is presented in Table 5b. The study revealed that land, agrochemical and fertilizer resources were fully utilized by the programme. This suggests that land, agrochemical and fertilizer were the limiting resources in the maize based cropping systems, as they constrained the attainment of the profit maximization objective of the maize based enterprises in the study area. The result in Table 5b further indicates the amount by which the gross margin would increase if these inputs were increased by one unit. The gross margin would increase by ₦ 6,227.00 for one additional hectare of land, ₦ 6.95 for one additional litter of agrochemical and ₦ 1.37 for one additional kilogram of fertilizer. The finding gives credence to the findings of Giroh *et al.* (2018), who reported that gross margin would increase by ₦ 1.74 for one additional kilogram of fertilizer.

Table 5b. Resources allocation and use pattern

Resource Constraint	User Status	Slack (surplus)	Dual price, ₦
Land (ha)	Fully utilized	0.00	6,227.00
Seed (kg)	Not fully utilized	3,713.42	0.00
Agrochemical	Fully utilized	0.00	6.95
Fertilizer (kg)	Fully utilized	0.00	1.37
Labour(man-hour)	Not fully utilized	96,442.06	0.00

Source: Analyzed from field Survey data 2018.

Gross margin (₦/ha) in existing and optimum farm plans

The result in Table 5c revealed the gross margin in Naira (₦) per hectare in the unplanned plan was ₦ 452,392.17 (991.16 €) while in the planned plan it was ₦ 544,999.03 (1,192.41 €). This means that there is a 17% increase in the planned farm plan as compared to the unplanned farm plan. The implication of this increase is that an average farmer in Adamawa South Agricultural Zone has the potential to increase their gross margin. This finding agrees with the findings of Ibrahim *et al.*, (2019), who reported a positive return (76%) earned over the existing farm plan in their study on an optimum production plan for maize-based crop farmers in Niger State, Nigeria.

Table 5c. Gross margin (₦·ha^{-1}) in existing and optimum farm plans

Gross Margin for Unplanned Plan ₦	Gross Margin for Planned Plan ₦	Increase/Decrease over Unplanned plan ₦	Increase/Decrease Percentage %
452,392.17	544,999.03	92,606.86	17

Source: Data Analysis, 2018.

CONCLUSIONS

The study has provided additional empirical evidence that determination of an optimum (planned) farm plan via traditional farm organization will not only ensure an increase in farm profitability, but it will also enhance the efficiency of resource usage as well as guarantee the sustainability of maize based enterprises in the Adamawa South Agricultural Zone. In addition, the optimum farm plan will not undermine the profit maximization objective of the maize based farming household in the study area, rather it will enhance the gross margin. Based on this finding, farmers should produce crop mixtures, maize/soybean (6.15 ha), maize/benniseed (3.35 ha) and maize/sorghum (1.50 ha) based on their hectarage allocation as prescribed in the optimum farm plan.

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OPTYMALNE POŁĄCZENIE PRZEDSIĘBIORSTW W OPARCIU O SYSTEM UPRAWY KUKURYDZY W POŁUDNIOWEJ, ROLNEJ STREFIE STANU ADAMAWA, NIGERIA

Streszczenie

Kukurydza jest głównym zbożem spożywanym przez prawie wszystkie nigeryjskie gospodarstwa domowe i jest źródłem około 43% kalorii. Szybki wzrost liczby ludności i urbanizacja w połączeniu z rozwojem infrastruktury sprawiły, że zasoby rolne pod względem podaży i produkcji kukurydzy są bardzo ograniczone. Istnieje zatem potrzeba optymalnego połączenia przedsiębiorstw w systemie upraw opartym na kukurydzy, aby zagwarantować cel maksymalizacji zysków gospodarstw domowych. Dlatego w ramach prezentowanych badań określono optymalne kombinacje przedsiębiorstw w systemach upraw opartych na kukurydzy w południowej, rolniczej strefie stanu Adamawa w Nigerii. Do badań wybrano 130 respondentów spośród 1336 zarejestrowanych plantatorów kukurydzy pochodzących z 16 społeczności rolniczych. Zastosowano metodę wielostopniowego doboru próby. Dane zebrano w sezonie zbiorów 2018/2019 i przeanalizowano za pomocą statystyk opisowych, analizy marży brutto i modelu programowania liniowego. Wynik rozmieszczenia respondentów ze względu na przedsiębiorstwa na badanym obszarze wykazał, że największa grupa badanych przedsiębiorstw (40%) opierała produkcję tylko na kukurydzy. Siedem grup przedsiębiorstw (kukurydza/ryż, kukurydza/orzeszki ziemne, kukurydza/sorgo, kukurydza/soja, kukurydza/trzcina cukrowa, kukurydza/ignam i kukurydza/sezam) było zrównoważonych, ponieważ ich całkowity dochód był wyższy niż ich całkowite koszty zmienne. Model programowania liniowego rekomenduje, aby każdy rolnik uprawiał trzy mieszanki upraw w stosunku powierzchniowym 6,15:3,35:1,50 odpowiednio dla kukurydzy/soi, kukurydzy/sezamu i kukurydzy/sorga, co daje marżę brutto 544 999,04 ₦ (1,192.41 €) dla upraw uprawianych na obszarze 11 ha. W badaniach wykazano, że mieszanki upraw, zgodnie z zaleceniami optymalnych planów gospodarstw, przyniosłyby następujące dochody: kukurydza/soja (367 449,89 ₦ (804.15 €)), kukurydza/nasiona sezamu (104 034,25 ₦ (227.85 €)) i kukurydza/sorgo (73 514,89 ₦ (160.85 €)). Zalecane mieszanki upraw mogą zwiększyć marżę brutto rolników o 17%.

Słowa kluczowe: maksymalizacja zysku, ograniczone zasoby gospodarstwa, optymalizacja