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Agronomic, economic and energy performance of cassava genotypes in the southwestern Amazon region

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***Abstract*— Cassava is an important crop in many parts of the world. It is a staple food for millions of people, and it is also used in a variety of other applications. Cassava is a rich source of carbohydrates and can be used to produce fuel-grade ethanol. The purpose of this study was to evaluate the agronomic, economic, and energy performance of several cassava genotypes in the southwest region of the Brazilian Amazon. Root productivity, flour yield, dry mass, starch content, number of roots per plant, number of rotten roots per plant, plant and first branch height, gross and net costs and income, and the crop's energy balance were evaluated. The genotypes affected all evaluated characteristics. The BRS Kiriris genotype excelled in terms of flour yields, root productivity, and absence of rot disease. The highest net revenues were observed for the most productive genotypes. The research disclosed an average energy demand of 9.78 GJ ha^{-1}. BRS Kiriris (252,7 GJ ha^{-1}) produced the most favorable energy balance, with an energy efficiency of 26.9. The greatest demand for direct energy costs for root production was for nitrogen fertilization (37,9%), followed by the use of herbicides (27,9%), which have a high energy charge associated with their manufacture. Cassava is a valuable source of biofuel feed in the Brazilian Amazon's southwest region. The selection of the appropriate cassava genotype is crucial for achieving adequate levels of activity sustainability.*

I. INTRODUCTION

Cassava is a good source of carbohydrates, and it is able to grow in a wide range of edaphic conditions, particularly in dystrophic and alic soils (Costa et al., 2021). This makes it an important crop for farmers in many developing countries, where it can help to improve food security and reduce poverty (Oku et al., 2021).

Additionally, the cassava plant distinguishes out for its many current and potential uses, yielding goods not only from the roots but also from the shoots; it is mostly used for animal and human food (Passos et al., 2018; Abrell et al., 2022). The leaves of the plant are also a good source of proteins and vitamins A and C, which are important for maintaining good health (Latif and Muller, 2015). In fact, cassava is a staple food for millions of people, and it is an important part of the diet for about 600 million people around the world (FAO, 2022).

Cassava is the most important crop in Rondônia, both economically and socially (IBGE, 2022). The state's economy relies heavily on agriculture, which has a strong family structure. In turn, the economic structure of the state of Rondônia is based mainly on family farming. The state is the largest agrarian settlement project in Brazil and has the largest number of family farmers in the North region, with more than 91,400 farms establishments (IBGE, 2017). The family sector accounts for no less than 74% of the gross value of agricultural production in the state, and employs 271,000 people, the equivalent of 84% of the workforce working in the field and produces more than 90% of the state's agricultural production (IBGE, 2017).

It has also been demonstrated that cassava can be used as an alternative to produce ethanol from its roots after they have been cut and crushed, water is added, and the starch hydrolysis process begins to convert it into glucose, which is then converted by yeast into ethanol (Fukuda; Iglesias 2002; Adelekan, 2010; Ado et al. 2009; Oparaku, 2010). The species has great potential as a raw material for energy production, particularly in remote Amazonian locations (Martins et al., 2019; Fathima et al., 2022). Also explore the possibilities of growing marginal land and utilizing lower agricultural inputs than corn and sugarcane crops (Nakamya, 2022, Kirsner et al., 2022).

The objective of this work was to evaluate different cassava genotypes in terms of agronomic, industrial, economic and energy performance for regions with eutrophic soils in the southwest Amazon region, in Brazil.

II. MATERIAL AND METHODS

The experiment was carried out in Ouro Preto do Oeste, Rondônia, in the experimental field of Embrapa (Brazilian Agricultural Research Corporation), located at 10°44'04"S and 62°15'19"W., average altitude of 250 m. The typical climate of this region, according to Köppen, is type Aw, defined as humid tropical with a rainy season (October to May) in summer and dry in winter. Has accumulated water deficiency (175 mm) from June to September and accumulated water surplus (781 mm) from November to April. The range of the average annual temperature ranges from 30,3ºC a 21,2ºC, being the highest in the months of July and August and annual average of 24,6ºC. The annual precipitation is 1.939 mm, with average relative humidity of the air around 81.3 (EMBRAPA, 2009).

The soil in the experimental area is classified as a eutrophic oxisol (SANTOS et al., 1999), with the chemical attributes of the 0-20 cm layer presented in Table 1.

Table 1. Results of soil chemical analysis (0-20 cm deep) in experimental area[1].

pH	K	Ca	Mg	Al+H	Al	OM	P	BS
Water	mmolc/dm3					g kg^{-1}	mg dm^{-3}	%
6.1	2.9	22.9	13.7	29.7	0.0	13.9	26.0	57.0

[1] P (Mehlich 1), K (Mehlich 1), Ca2+ (KCl - 1 mol L^{-1}), Mg2+ (KCl^{-1} mol L^{-1}), Al3+ (KCl^{-1} mol L^{-1}), H +Al (H por SMP), OM Organic matter (Na_2 Cr_2 O_7) and pH in water and BS, base saturation. Analyzes carried out at the Soil Laboratory of Embrapa.

The experimental design was in randomized blocks, with four replicates. The treatments comprised fourteen cassava genotypes from the cassava breeding program at Embrapa, namely 960707, CNPMF 043, CNPMF 1721, CNPMF 09, 91-21-05, ACRE-1, 1668, Caipó, BRS Dourada, BRS Gema de Ouro, Pirarucu, EAB 451, Xingu and BRS Kiriris. The Pirarucu genotype is the most used variety in the region for flour production.

The standard method of soil preparation consisted of two harrowing. After soil preparation, mechanized planting furrows separated by 0.50 meters were opened. At planting, 40 kg ha^{-1} of N - urea, 60 kg ha^{-1} of P_2O_5 - simple superphosphate, applied in the planting furrow, and 100 kg ha^{-1} of K_2O - KCl were used as fertilizer (half of which was applied at planting and the other half 100 days after planting). Planting occurs at the beginning of the rainy season, with harvesting and evaluations occurring in 12 months later. The plots consisted of four 10-meter-long rows, with only the two rows in the plot's center being evaluated.

The following response variables were measured: root yield, expressed in kilograms per hectare (t ha^{-1}), average percentage of starch in the roots using the hydrostatic balance method according to Grossman & Freitas (1950), by 9 kg samples use (PRAUDE et al., 2005), dry matter (using the formula MS = 15.75 + 0.0564 x R; where R= mass of 9 kg of roots immersed in water), flour yield, number of marketable roots per plant, number of rotten roots per plant, plant height (m), height of the first branch of the main stem (cm), shoot mass (t ha^{-1}) and the harvest index (CI) which comprises the ratio between the mass of tuberous roots and the total mass of the plant, according to the formula: IC = 100[mass of roots/(mass of roots + mass of shoot)].

In order to examine the economic viability of genotype use, economic and financial balances of the treatments were conducted. According to Conab (2022), an inventory was conducted to determine the production costs of the examined varieties. Consequently, the net revenues and cost-benefit ratio for each treatment were computed based on the observed differences in productivity (Gomes et al., 2013).

In regard to environmental sustainability, the direct and indirect energy balances of the evaluated systems were performed. Throughout this process, the energy inputs were quantified by multiplying the physical product by the relevant conversion indices, estimated in Giga Joules (GJ) (Campos; Campos, 2004; Furlaneto et al., 2014). Thus, the energy balancing aims to establish the energy flows by determining the overall demand and efficiency, as indicated by the net gain and the output-to-input ratio (Pimentel et al., 2002).

To account for the energy available and used by such process, transformations are performed on production matrices. As available energy or energy revenue (GJ ha^{-1}), considering the conversion to energy of root yield, weighting the starch content in the roots, and the quantity of remaining biomass in the field. As consumed energy (GJ ha^{-1}), the sum of the energy indices corresponding to correctives, fertilizers, pesticides, and other inputs utilized in the production system, as well as the energy consumed by operations (planting, fertilization, harvesting, etc.), were estimated (Gomes et al., 2013).

The industrial process of converting starch into alcohol, along with the preparation of the raw material, extraction of ethanol from starch and other plant parts, and distribution, was not considered for this study. Consequently, only the agricultural aspect of the production of roots in the field was accounted for, restricting the scope of the research.

The allocation of the impact characterized by energy consumption will be conducted directly and exclusively on the commercial product tuberous roots, taking into account the generation of aboveground biomass, a component of the agricultural system's integrated nutrient cycling, and not for energy production (not exported). The qualification of the required energy followed the logic of two types: direct, when agricultural inputs were used directly in the production system (cassava cutting, limestone, fertilizers, organic residues, and pesticides), and indirect, when goods and services such as fuel, machine depreciation, and labor were considered.

Diesel oil consumption was evaluated according to Romanelli and Milan's (2012) formula:

$DC = Fc * Pt * Ot$

Where:

DC: represents fuel (diesel) consumption in liters ha^{-1};

Fc: is the consumption factor (0.163 liters kW^{-1} h^{-1});

Pt: represents the rated power of the tractor in kilowatts;

Ot: represents the time required for the operation performed on one hectare (hour ha^{-1}).

For all machinery and implements, the idea of incorporated depreciation was applied (Romanelli & Milan, 2010), wherein, based on the usable life of the implement and tractor, it was calculated what proportion of these was allocated to do each operation on each cropped hectare. The usable life of tractors as determined by CONAB in 2015 was utilized.

Incorporated depreciation = IDr

$IDr = (MEE * MM)/(ML * OC)$ (MJ ha^{-1});

MEE=Machinery embodied energy (MJ kg^{-1});

MM=Machinery mass (kg);

ML=Machinery lifetime (hours);

OC=Operating capacity (ha h^{-1}).

For each evaluated genotype, the energy input and output flow were evaluated, taking into account the energy demand or energy input (EE) and the energy produced or energy output produced (SE). Based on these evaluations, the energy balance was computed by subtracting the energy generated (SE) from the energy required for production, or energy cost (EE). In addition, the ratio of the energy produced by the demanded (RES; input/output ratio) and the energy footprint of the included production (PEP= MJ ton) were computed.

In the context of cassava, it was estimated that starch produced by the tuberous roots might was hydrolyzed to yield ethanol for energy production (Quintero et al., 2015). Based on the research by Veiga et al. (2105), the increased calorific value of cassava cuttings was estimated to be 18,95 MJ kg^{-1}, with an average relative humidity of 50%. (2015). According to EPE (2016), diesel had an embodied energy of 35.55 MJ $liter^{-1}$, while NPK fertilizer had 74 MJ kg^{-1} for N, 12.60 for P_2O_5, and 6.80 for K_2O according to Pelizzi (1992).

According to Fluck & Baird (1982) and Pimentel (1980), herbicides have an energy burden of 454,20 MJ kg^{-1}, while insecticides have an energy load of 184,70 MJ kg-

^{1}. Labor, considering the energy embodied in an hour's work at 2.20 MJ hour^{-1} according to Pimentel (1980) and machinery and implements in general at 68.90 MJ kg^{-1} according to Fluck & Baird (1982). This experiment utilized a New Holland TL85E cab tractor with 83 horsepower (61 kilowatts). The internal transport of raw materials and roots for processing was performed using a Volkswagen 8150 light-medium truck with 107 kW of power, a total gross weight of 8 tons, and a load capacity of 5 tons.

The data of the agronomic results obtained were submitted to the analysis of variance, and the means of the treatments, when significant, compared by the Scott-Knott test, at 5% probability.

III. RESULTS AND DISCUSSION

There was an effect of the genotypes on the evaluated agronomic attributes, demonstrating the genetic heterogeneity among the materials for the evaluated parameters (Table 2).

Table 2. Summary of analysis of variance for root yield (t ha^{-1}) (RY), starch content (SC) (%), dry matter content (DMc) (%), flour yield (FY) (%), plant height (PH) (m), first branch height (FBH) (cm), number of roots per plant (NRP) number of rotten roots per plant (NRRP) for the genotype assay experiment of cassava, evaluated in Ouro Preto do Oeste, RO.

Variation Source	GL	Mean square							
		RY	SC	DMc	FY	PH	FBH	NRP	NRRP
Genotypes	13	338.28**	17.28**	17.28**	30.8*	0.41*	1274.8*	2.7*	0.03*
Block	3	206.18	15.72	15.72	27.98	0.26	1736.4	2.66	0.1
Error	39	77.99	2.94	2.94	5.23	0.36	913.2	1.16	0.02
CV (%)		29.89	6.03	5.18	8.89	15.86	33.22	22.27	18.76
Average		29.55	28.45	33.1	25.73	3.82	90.98	4.85	0.15

*Significant, at 5% probability, by the F test (p≤0.05). **Significant, at 1% probability, by the F test (p≤0.01).

Root yields increased by 192%, ranging from 16.01 t ha^{-1} for genotype 1721 to 46.87 t ha^{-1} for the Kiriris cultivar (Table 3). All genotypes, except four genotypes (1721, ACRE, CPM09 and CNPMF043) showed yields higher than the state average of 22.4 and all tested treatments present superior yields than the national 15,0 t ha^{-1} (IBGE, 2022). The EAB451, Pirarucu, Caipó, 91-21-05, Xingu, Dourada, Gema and Kiriris genotypes stood out with the highest root yields, with Kiriris standing out with 46.87 t ha^{-1} (Table 3).

Table 3. Averages of root yield (ton ha^{-1}) (RY), plant height (m) (PH) and height of the first branch (cm)(FBH) number of roots per plant (NRP), number of rotten roots per plant (NRRP), flour yield (FY) (%), dry matter content (DMc) (%) and starch content in the roots (SC) (%) of different cassava genotypes evaluated in Ouro Preto do Oeste, RO

Genotypes	**RY**		**PH**		**FBH**		**NRP**		**NRRP**		**FY**		**DMc**		**SC**	
	t ha^{-1}		**m**		**cm**		**(roots by plants)**				**(%)**					
1721	16.0	a	3.7	a	73.5	a	3.6	a	0.28	a	29.3	c	35.7	c	31.1	c
ACRE	17.6	a	3.7	a	63.8	a	5.0	b	0.23	a	28.2	c	35.0	c	30.3	c
CPM09	20.2	a	3.6	a	102.5	a	4.1	a	0.33	a	19.5	a	28.5	a	23.8	a
CNPMF043	21.1	a	4.0	a	76.5	a	5.7	b	0.16	a	22.0	a	30.3	a	25.6	a
96-07-07	22.5	a	3.9	a	67.8	a	5.4	b	0.07	a	24.5	b	32.2	b	27.5	b
1668	27.3	a	4.0	a	102.0	a	5.1	b	0.04	a	24.3	b	32.0	b	27.3	b
EAB451	29.8	b	4.0	a	94.0	a	4.2	a	0.25	a	26.7	c	33.8	c	29.2	c
PIRARUCU	30.7	b	4.2	a	122.0	a	5.1	b	0.13	a	26.8	c	33.9	c	29.2	c
CAIPÓ	34.1	b	2.8	a	81.3	a	5.6	b	0.19	a	27.2	c	34.2	c	29.5	c
91-21-05	34.5	b	3.9	a	103.0	a	5.7	b	0.14	a	24.1	b	31.9	b	27.2	b

XINGU	35.2	b	3.9	a	109.5	a	4.6	a	0.11	a	26.2	c	33.5	c	28.8	c
DOURADA	37.0	b	3.9	a	74.0	a	5.1	b	0.06	a	26.5	c	33.7	c	29.0	c
GEMA	40.8	b	3.9	a	104.0	a	3.4	a	0.09	a	25.2	b	32.7	b	28.0	b
KIRIRIS	46.9	b	4.0	a	100.0	a	5.5	b	0.00	a	29.9	c	36.2	c	31.6	c
Average	29.5		3.8		91.0		4.9		0.15		25.7		33.1		28.5	

The averages followed by the same letter, in the columns, do not differ from each other, according to the Scott Knott test (5%).

The productivity value observed in the Kiriris cultivar was higher than that found by Oliveira et. al., 2020, who obtained up to 28.5 t ha^{-1} in São Domingos, Sergipe and by Gonçalves et al. (2021) in Cruz das Almas (41.7 t ha^{-1}). In the other hand, the observed yield in this study is similar to found by Passos et al., 2014 in the same conditions (46.53 t ha^{-1}). The Kiriris cultivar, in addition to high productive potential, dual aptitude (table or flour industry), from the BAG of Embrapa Mandioca e Fruticultura, presents tolerance to root rot and low levels of hydrocyanic acid (FARIAS NETO et al., 2013).

Plant heights ranged from 2.82 m (CAIPÓ) to 4.15 m (PIRARUCU), with an average of 3.82 m among the evaluated clones. For the average height of the first branch, the lowest value observed in ACRE (63.75 cm) and the highest height for PIRARUCU (122.00 cm). On average, the clones had a height of 90.98 cm. The height of the first branch is an important measure of the architecture of the cassava plant, aimed at defining implantation strategies in different production systems (intercropping, for example), phytotechnical crop management and harvesting.

The Kiriris clone was the only genotype that did not show rotten roots. These genotypes may be resistant to root rot, that is, be a material with resistance to pathogens. Root rot is one of the limiting factors for cassava production in regions of high rainfall (Abrell et al., 2022), especially for the Várzea and Terra Firme ecosystems in the Amazon. It is estimated that, in the Amazon region, losses reach more than 80% in the floodplain, and can reach up to 50% in terra firme. Losses and total losses have been observed, mainly in plantations carried out in areas with dense or compacted soils and subject to flooding (MATTOS & CARDOSO, 2003). A low-cost alternative, despite the use of genetic resistance (Hohenfeld et al., 2022) is the use of adequate planting period, drainage, ridges, and in these areas, planting can always be carried out in times of lower rainfall and river floods.

The highest flour yields were observed for genotypes 1721, Acre, EAB451, Pirarucu, Caipó, Xingu, Dourada and BRS Kiriris with the highest value (29.92%). The dry mass of roots presents a high correlation with the starch content, with the magnitude of r = 0.98, directly influencing the amount of flour produced (FUKUDA AND BORGES, 1991), (Table 3). The dry matter content is usually the character that determines the greater or lesser value of the industries to the producers at the time of commercialization and is directly related to the industrial yield of the various products derived from cassava (Latif and Muller, 2015). In this way, it is desirable that the cultivars responsible for the highest root productivity are also those that present the highest dry matter contents in the roots, maximizing the yield of the final product per unit of cultivated area (VIDIGAL FILHO et al., 2000).

Regarding the starch content, the ideal is that the material has at least 30% starch (CONCEIÇÃO, 1987). The highest values of starch content were identified in the BRS Kiriris, accession 1721 and Acre genotypes. This result is a representation of the adequate starch content of these genotypes, in addition to the good productivity achieved by the materials.

The Pirarucu variety had a starch content of 29.24% of the genotypes. However, the highest values of starch content were identified in the BRS Kiriris and accession 1721 genotypes. These presented approximate increments of 30.6 and 32.7%, respectively, in the starch content in relation to the control genotype (Pirarucu). This result is a representation of the adequate starch content of these genotypes, in addition to the good productivity achieved by the materials. The Kiriris cultivar had 31.59% of starch content, higher than the content found by SOUZA (2011), of 28.2%. The starch content is the most important parameter when selecting cassava genotypes for industry, since it determines the potentiality of the final product of the genotypes and, as a result, the crop's profit (Passos et al., 2018; Ceballos et al., 2004).

The use of different genotypes provided differences in economic indicators (table 4).

Table 4. Economic analysis of different cassava genotypes evaluated in Ouro Preto do Oeste, RO.

Genotypes	Gross income	Production cost	Net Revenue	break-even point
	(R$ ha^{-1})	(R$ ha^{-1})	(R$ ha^{-1})	(Mg ha^{-1})
1721	3371,39	2857,48	513,91	13,57
ACRE	3702,00	2889,40	812,59	13,72
CPM09	4247,40	2942,07	1305,33	13,97
CNPMF043	4441,13	2960,77	1480,36	14,06
96-07-07	4742,26	2989,85	1752,41	14,20
1668	5757,26	3087,86	2669,40	14,66
EAB451	6277,39	3138,08	3139,31	14,90
PIRARUCU	6471,12	3156,79	3314,34	14,99
CAIPÓ	7182,88	3225,51	3957,37	15,32
91-21-05	7265,01	3233,44	4031,57	15,35
XINGU	7401,89	3246,66	4155,23	15,42
DOURADA	7787,25	3283,87	4503,38	15,59
GEMA	8581,14	3360,53	5220,61	15,96
KIRIRIS	9869,88	3484,97	6384,92	16,55
AVERAGE	6221,29	3132,66	3088,62	14,88

Price per ton in November 2014 = R$ 210,58 (1 dollar PTAX=R$ 3.75)

The higher productivity 46.87 t ha^{-1} (BRS Kiriris) promoted higher production cost 3484.97 R$ ha^{-1}. The lowest production cost per ton was 2857.48 R$/ha (accession 1721), with productivity of 16.01 t ha^{-1}. This treatment obtained a break-even point of 16.55 Mg ha^{-1}, showing little significant difference with the other genotypes.

The cassava crop is among the annual crops, as one of the most efficient in the use of energy used in its production compared to the production of energy products. On average, the energy demand for the production of a crop with a productivity of 30 tons of roots was 9.78 GJ ha^{-1} (Table 5). This value is close to that found by other authors (Chamsing, et al., 2006; Bamgboye & Kosemani, 2015; Veiga et al., 2015).

Table 5: Energy balance of cassava genotypes cultivated in Ouro Preto do Oeste.

Genotypes	**Energy demand**	**Energy recipe**	**Energetic balance**	**Embodied energy**	**Efficiency Energetic**
		GJ ha^{-1}		**GJ tonne^{-1}**	
1721	8,33	89,66	79,88	0,61	9,2
ACRE	8,45	98,45	88,67	0,56	10,1
CPM09	8,49	112,95	103,18	0,48	11,6
CNPMF043	8,71	118,10	108,33	0,46	12,1
96-07-07	8,98	126,11	116,34	0,43	12,9
1668	9,33	153,10	143,33	0,36	15,7
EAB451	9,21	166,94	157,16	0,33	17,1
PIRARUCU	9,11	172,09	162,31	0,32	17,6
CAIPÓ	8,71	191,02	181,24	0,29	19,5

91-21-05	9,78	193,20	183,42	0,28	19,8
XINGU	9,44	196,84	187,06	0,28	20,1
DOURADA	9,63	207,09	197,31	0,26	21,2
GEMA	9,91	228,20	218,42	0,24	23,3
KIRIRIS	10,20	262,47	252,70	0,21	26,9
AVERAGE	9,78	165,44	155,67	0,33	16,9

In fact, Veiga et al. (2015) evaluating the energy footprint of several agricultural crops in Brazil point to cassava as the most efficient crop, second only to oil palm in energy efficiency (ratio between energy produced and demanded for the production of the energy crop). These authors presented an energy demand for cassava production of 11.03GJ ha^{-1}. The cassava crop, despite being considered highly rustic, is responsive to the use of inputs, mainly soil amendments and fertilization. The conduction planting of a cassava crop in eutrophic soils such as those used in this study can generate a lower demand for fertilizers and soil acidity correctives and generate a more favorable energy balance than when the crops are conducted in conditions of naturally dystrophic soils and alics, which are predominant in Brazil.

The highest average energy demand for root production came from direct expenses with the crop, and among these, the highest demand was the nitrogen fertilization of the cassava crop (represented 37.9% of the total energy demand), followed by the use of of herbicides to control invasive plants and weeds Figure 3.

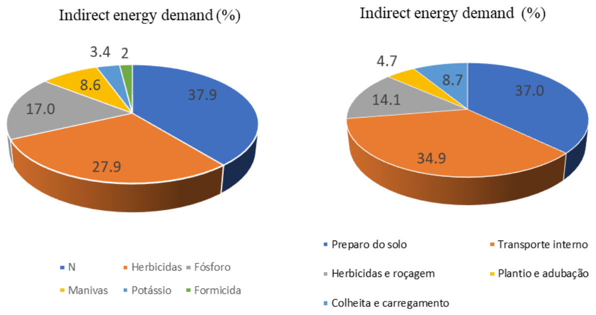

Fig.3: Direct and indirect energy demand (%) for the production of cassava roots in the southwest region of the Amazon.

In turn, when analyzing the indirect energy demand in percentage terms, there is a greater demand for soil preparation and internal transport of inputs and post-harvest roots.

Energy efficiency (energy production/energy demanded for production) was always positive, demonstrating the crop's potential for energy generation, whether for food or for the production of biofuels. Efficiency ranged from 9.2 to 26.9, with an average between genotypes of 16.9, higher than that found by other authors, including Veiga et al. (2015). This variation is expected not only because of the difference in the productive expression of roots by different genotypes, but also because of the genotypic variation commonly present in cassava in terms of starch content in the roots (Table 3) and alcohol concentration (Madukosiri, 2013). This author identified the superiority of three varieties of cassava in terms of potential for alcohol production in Nigeria.

Also in Nigeria, cost inventories and evaluation of the energy balance of several cassava-producing farms were carried out, obtaining an average of 8.57 MJ ha^{-1} of energy demand for the production of roots, and an average productivity of 9.9 tons of roots (Bamgboye & Kosemani, 2015), demonstrating that, given the production system used and regional conditions, the demand was very close to that obtained in this study (9.8 GJ ha^{-1}), despite the average of our work having was approximately three times higher than that obtained by the authors, which demonstrates the greater energy efficiency in cassava production under the conditions of the Brazilian region.

Average root yields in Nigeria (10 to 15 Mg ha^{-1}), the world's largest cassava producer, are close to national and Rondônia. This highlights not only the importance of choosing cultivars, it is essential not only for increasing crop productivity, the profitability of agricultural activity and energy yield, giving the producer more sustainability in the broadest sense of his property and the possibility of sustainable regional development.

IV. CONCLUSION

Caipó, Xingu, Dourada and BRS Kiriris stood out for their higher starch content in the roots, associated with higher flour yields and root productivity levels achieved.

The BRS Kiriris clone was the only genotype that did not show rotten roots, genotypes like this one can show resistance to root rot, being able to be resistant to pathogens.

All cassava genotypes present a favorable energy balance, however, the use of highly productive genotypes in tuberous roots promotes a better energy balance.

The use of superior genotypes provides increments in the productivity of roots and co-products for regions with eutrophic soils in the southwest region of the Amazon.

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