Scientific Paper

Agroproductive evaluation of two clones of *Manihot esculenta* Crantz in Matanzas province

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Abstract

Objective: To evaluate the agroproductive characteristics of two varieties of *Manihot esculenta* Crantz for their inclusion as animal feedstuff in Matanzas province, Cuba.

Materials and Methods: A study was conducted in areas of the Pastures and Forages Research Station Indio Hatuey. Two *M. esculenta* varieties (INIVIT Y-93-4 and Señorita) were evaluated. A randomized block design was used with three replicas. The height, number of total roots, commercial and non-commercial and number of absorbent hairs per plant, were measured. The comparison was made through sample inference for two independent samples, from a Student's t-test, with significance level of $p < 0,05$. In addition, correlations and regressions were made to know the interrelation between the variable height and the planting days.

Results: No significant differences were found for the variable height between the two varieties (154,4 and 141,8 cm for Señorita and INIVIT Y-93-4, respectively). However, statistical differences were noted in root length and weight ($p < 0,001$). The variety INIVIT Y-93-4 showed the highest root number and weight. Meanwhile, no differences were found in root diameter (0,38 and 0,39 mm for Señorita and INIVIT Y-93-4, respectively). Both varieties had yields over 15 t ha^{-1}, the variety Señorita standing out with 23 t ha^{-1}.

Conclusions: The two varieties were developed and produced under the edaphoclimatic and management conditions conceived for this study. Nevertheless, the variety Señorita showed better performance than INIVIT Y-93-4 in most of the morphoagronomic variables.

Keywords: animal feeding, height, *Manihot esculenta*, yield

Introduction

Tropical systems for ruminants utilize pastures and forages as feed source. However, their nutritional quality varies depending on the climate conditions, situation that generates dry matter deficit during the dry season, which affects the intake and productive performance of the animals.

Due to its high yield in the tropic (16 000 kg/ha), *Manihot esculenta* Crantz is a viable alternative in animal feeding (Hermida, 2015). It is considered an energy source with high content of vitamins, minerals and fiber (Herrera *et al*., 2019).

This is a tropical plant efficient in the transformation of solar energy. It is cultivated in Latin America, Africa and Asia and is among the ten main crops in the world, with approximately 277 million tons annually produced (FAOSTAT, 2016). In the America region, if compared with other roots and tubers, *M. esculent*a shows the highest growth rate of annual consumption (1,9 %) and, in terms of forage production, it contributes 0,95 % (Santos *et al*., 2019).

At present, *M. esculenta* is used for feeding cattle (Arce, 2015), poultry (Connolly-Juárez, 2017; Herrera *et al*., 2019) and pigs (Lezcano-Perdigón *et al*., 2014), with encouraging results in the productive performance of the animals.

According to Milian *et al*. (2000), the collection of *M. esculenta* is preserved in Cuba, at the Research Institute on Tropical Food Crops of Villa Clara. It constitutes the third germplasm bank of America, with 440 accessions. Most of them are autochthonous, with high phenotypic variability. From them, 60,6 % has tasty roots; 90,8 % has low fiber content and 60,9 % has soft to moderately hard pulp.

The introduction of new clones and technologies has allowed the extension of more soil- and input-demanding production forms, in order to increase the production of *M. esculenta* for human and animal consumption. Although this crop has diversity of clones, very often their productive potentialities are unknown. From these conditions,

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the objective of this study was to evaluate the agro-productive characteristics of two *M. esculenta* varieties in Matanzas province for their inclusion as feedstuff.

Materials and Methods

Location. The study was conducted in areas of the Pastures and Forages Research Station Indio Hatuey. This facility is located between 22° 48' 7" North latitude and 81° 2' West longitude, at 19,01 masl., in the Perico municipality, Matanzas province, Cuba.

Climate and soil. The rainfall and temperature data were taken from the Meteorological Station located in areas of the institution (table 1). The recorded values are within the normal ranges of these variables for the months in which the research was conducted. The study was carried out on a ferralitic red soil (Hernández-Jiménez *et al*., 2015).

Treatments and experimental design. Two *M. esculenta* varieties were evaluated: INIVIT Y-93-4 and Señorita, from the Research Institute of Tropical Food Crops (INIVIT, for its initials in Spanish) of Santo Domingo, Villa Clara province. For setting up the experiment a randomized block design was used, with three replicas.

Both varieties were planted in January, 2018. The duration depended on the variety: for Señorita it was 12 months because it has long cycle; while for INIVIT Y-93-4 it was 8 months (short cycle).

Experimental procedure. Planting was manual. Stakes that were 15 cm long and had approximately five buds were placed horizontally at the center of the row. Seven 10-m long rows were used, with a 0,90 x 1,00 m planting frame. The size of each experimental plot was 70 m^2. Neither irrigation nor fertilization was used.

Morphoagronomic and yield measurements. One month after the stakes were planted, plant height was measured from the stem basis to the bud. The measurement was done in centimeters, with the aid of a metric tape. It was carried out every month, on seven plants per replica, randomly selected and identified with a previously numbered zinc tag.

The determination of the number of total roots per plant, number of commercial roots per plant, number of non-commercial roots and absorbent hairs per plant, was carried out by counting the total number of roots. Afterwards, the commercial roots were separated from the non-commercial ones. Those that were more than 20 cm long and weighed more than 220 g were considered commercial. The length of the tuberous root was measured with a graduated ruler in all the evaluated plants in each replica, and it was averaged later.

The diameter of the tuberous roots was measured seven times per replica in the central part of the root, and for this a caliper was used.

At the harvest moment, the average weight of the commercial root was measured, for which 15 commercial roots (five per replica) were randomly selected and individually weighed. In addition, the agricultural yield was determined, which was calculated

Table 1. Climate conditions during the experimental stage.

Month/year	Temperature, ºC	Rainfall, mm
January, 2018	20,5	19,3
February	22,8	11,8
March	21,5	3,0
April	24,4	123,8
May	24,8	668,1
June	26,5	183,2
July	27,1	141,4
August	26,4	262,6
September	26,3	134,4
October	25,4	97,1
November	23,9	5,9
December	22,4	38,0
January, 2019	20,0	59,8

Source: Indio Hatuey Meteorological Station (2019) from the yield of two 6-m^2 areas in each replica and it was estimated for one hectare. In the case of the variety Señorita, the harvest was carried out in January, 2019, and for INIVIT-Y-93-4, in September, 2018.

Statistical analysis. The data were processed through the statistical package SPSS®, version 22.0 for Windows. The comparison was done through sample inference for two independent samples, from a Student's t-test, with significance level of $p < 0,05$. The correlation and regression analysis was used to know the interrelation between the variable height and planting days. As rule of selection of the best fit equation, it was taken into consideration, among the criteria indicated by Guerra *et al*. (2003), that the real and adjusted determination coefficient (R^2) was higher than 0,70. In addition, the significance level was considered.

Results and Discussion

Table 2 shows the average height during the experimental period. No significant differences were found between the two varieties. This could have been due to the fact that the two varieties were managed under similar management conditions (climate, soil, plantation characteristics, absence of irrigation and fertilization), and both showed favorable growth for the prevailing conditions in the study. These values are lower than those reported by Pérez (2015), who evaluated the agroproductive performance of five clones of *M. esculenta* (Señorita, CEMSA 74-6329, INIVIT Y-93-4, CCS El Vaquerito and Señora) in the Villa Clara province, which reached a height of up to245,7 cm. However, the results of this study are over the ones referred by Rodríguez-Cuevas *et al*. (2017), who studied varieties that did not exceed 100,0 cm.

The height was similar to the one found by João *et al*. (2016), when analyzing the varieties Venezuelan and M-Tai, which varied between 134 and 187 cm, by being treated with arbuscular mycorrhizae. When *M. esculenta* has a height over 1,50 m, the harvest of the branches becomes easier if it is aimed at forage production, besides forming a crop with more uniform crown, which facilitates the work (Brito *et al.,* 2013).

Figures 1 and 2 show the existing correlation between height and days in the variety Señorita and INIVIT Y-93-4, respectively. In both varieties, the height showed an increasing height as the days after planting passed, physiological process that should occur when the prevailing conditions favor crop growth. Plant height is a fundamental morphological descriptor, related to the expression of the genotypic trait (Fukuda and Guevara, 1998; Beovides-García *et al*., 2014). Thus, this is an indicator of the genetic expression and of the fact that the prevailing conditions were favorable in this study, because there were no physiological affectations that

Table 2. Average height of the plants.

Indicator	Treatments	Mean	SE ±	P - value
Height	Señorita	154,4	4,052	0,52
	INIVIT Y-93-4	141,8	5,061	

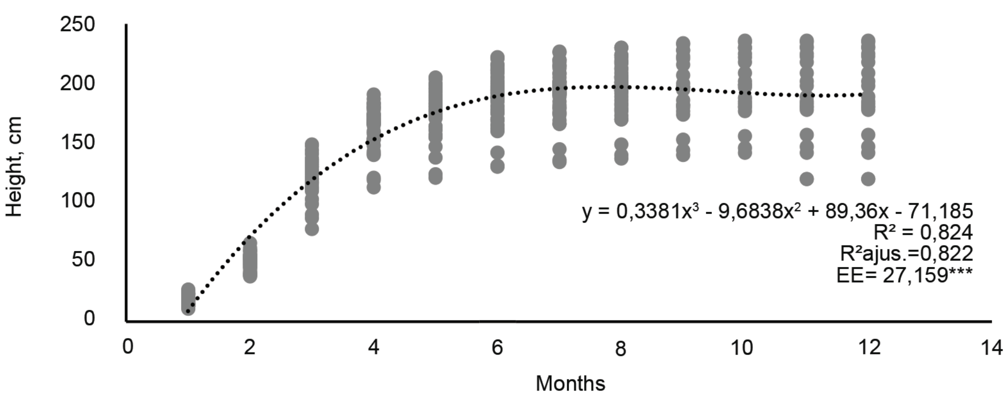

Figure 1. Adjustment curve of height (cm) with regards to time (days) for each block under study in the variety Señorita.
p < 0,001

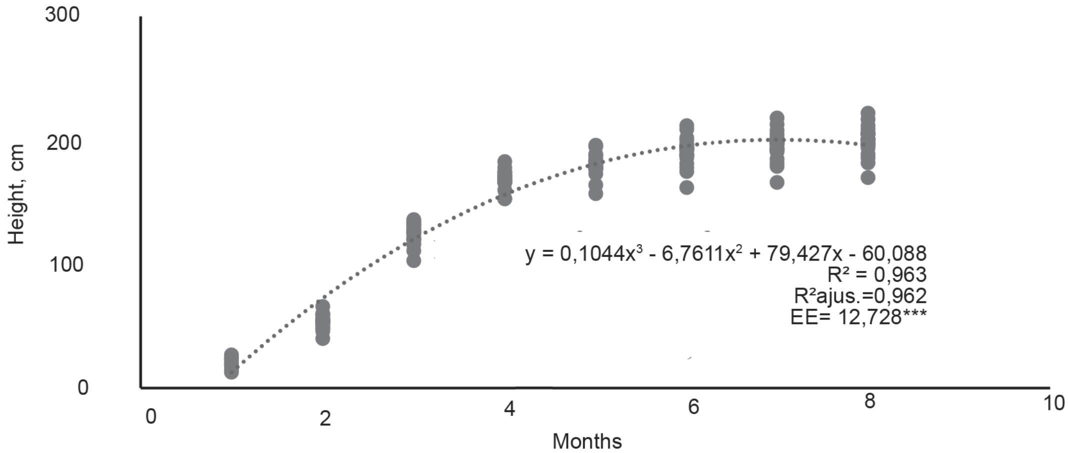

Figure 2. Adjustment curve of the height (cm) with regards to time (days) for each block under study in the variety INIVIT Y-93-4
$p < 0,001$

could affect plant growth. This coincides with the report by Santos *et al*. (2019) in a study about the physiology of this crop.

In the variety Señorita, the model that explained with higher goodness of fit this relation was the third-order polynomic equation with coefficient $R^2 = 0,824$*** and adjusted $R^2 = 0,822$***.

In the variety INIVIT Y-93-4, the model that explained with higher goodness of fit this relation was the third-order polynomic equation, with determination coefficient higher than 0,90 ($R^2 = 0,963$*** and adjusted $R^2 = 0,962$***).

Table 3 shows the morphological indicators of the roots per variety. Significant statistical differences were found in root length and weight ($p < 0,001$). The variety INIVIT Y-93-4 showed higher root length and weight. Nevertheless, no significant differences were found in the root diameter, whose values were 4,38 and 4,39 for Señorita and INIVIT Y-93-4, respectively.

When determining the weight of commercial roots per plant, the highest values were reached in the clone INIVIT-Y-93-4, which was statistically higher than Señorita. The values are within the range referred by León *et al.* (2013), who characterized 101 clones of cassava from the morphological and agronomic point of view in the experimental field of the Central University of Venezuela. These authors referred that the roots showed weights that varied between 0,3 and 4,66 kg/plant.

These variations in the morphological characteristics of the root (length, diameter and weight) of *M. esculenta* depend on the expression of the genotypes, as response to the environmental conditions that can influence the performance of the variables stem and root diameter and length, branch and stem number and height (Gabriel *et al*., 2014). However, in this study such performance is not ascribed to the climate conditions, because both varieties were subject to a similar management regime, as described above. Thus, the variations in both varieties can be due, mainly, to the genotypic expression that each one of them can express.

Table 4 shows the quantity of total, commercial roots and absorbent hairs per variety. The variety Señorita statistically differed in the variables number of total roots, number of commercial roots ($p < 0,001$) and absorbent hairs ($p < 0,05$).

Table 3. Morphological indicators of the roots.

Indicator	Varieties	Mean	SE ±	P - value
Root length, cm	Señorita	24,9	0,4723	0,000
	INIVIT Y-93-4	27,8	0,5035	
Root diameter, cm	Señorita	4,39	0,0572	0,889
	INIVIT Y-93-4	4,38	0,0505	
Root weight, kg	Señorita	0,33	0,0114	0,000
	INIVIT Y-93-4	0,39	0,0121	

Table 4. Quantity of total and commercial roots, and absorbent hairs per variety.

Indicators	Varieties	Mean	SE ±	P - value
Total roots	Señorita	16,2	0,953	0,00
	INIVIT Y-93-4	9,8	0,559	
Commercial roots	Señorita	11,1	0,611	0,00
	INIVIT Y-93-4	6,9	0,516	
Non-commercial roots and absorbent hairs	Señorita	19,1	2,325	0,042
	INIVIT Y-93-4	13,9	0,843	

Shindoi *et al*. (2018) evaluated the performance of ten cultivars of *M. esculenta*, collected by farmers from Argentina, and found 10-15 total roots and 9-11 commercial roots. These values are similar to those obtained in this study, except in the commercial roots of INIVIT Y-93-4, which showed lower results.

León-Pacheco *et al*. (2019) in two producing zones of Venezuela carried out the evaluation of 16 genotypes, selecting variables of vegetative type. These authors reported, in the Aragua and Cojedes states, values of 10,35 and 7,41 and 2,75 and 4,23 for the number of total and commercial roots, respectively, which are lower than those obtained in this experiment. However, total root weight showed higher values (2,0-2,6 kg) than the ones recorded in this study (0,3 kg).

This performance can be ascribed to the characteristics of the evaluated clones, and coincides with the statement by Coqueiro (2013), who indicated that the performance of the agronomic variables depends on the genotype-environment response. It could be stated then that the conditions under which this study was conducted could have favored the production and development expression in Señorita. This cultivar has had excellent acceptance, not only due to its production potential, but for its stability and adaptability. This difference in the above-mentioned variables was also shown in the yield (fig. 3).

Figure 3 shows the agricultural yield of both varieties. The variety Señorita reached higher value (23 t/ha), and was over the national mean reported for this crop (19 t/ha), according to reports by Beovides *et al*. (2013). INIVIT Y-93-4 showed a similar yield to the national mean.

Beovides *et al*. (2014) when making a morphological and agronomic characterization of 50 Cuban *M. esculenta* cultivars, from the Cuban collection of germplasm preserved by the Research Institute of Tropical Food Crops (INIVIT), and where the two varieties of this study were included, proved that the yields can exceed 39 t/ha. The above-cited authors stated that the varieties CPA Victoria de Girón, Crema-1 and Señora were the ones with the best performance, with 39,4; 34,0 and 31,7 t/ha, respectively. Yet, FAO (2018) refers that there is great potential, with new clones, for production increases to occur under optimum conditions, and that cassava yields can reach 80 t ha^{-1}, compared with the current world average of only 11,3 t/ha.

The performance of the two varieties could have been influenced by rainfall, which was 1 748,4 mm throughout the experimental cycle. According to Pastrana *et al*. (2015), to obtain the best yields and development of this crop, the water availability should be, approximately, 1 247 mm during the crop cycle. This performance could have been also related to the edaphic conditions and the variety.

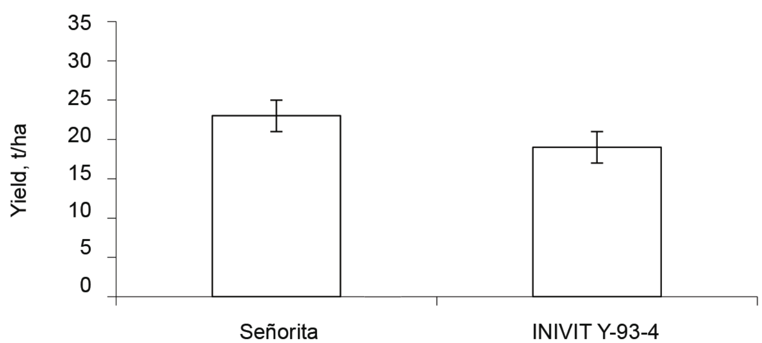

Figure 3. Agricultural yield of the varieties.

The studied clones, for their agronomic performance, can be used as food and feed. Nevertheless, regarding animal feeding, it is important to state that it is costly to obtain conventional feedstuff (concentrate feed), and *M. esculenta* can be part of alternative feeding, mainly in the feed scarcity season. For its preservation, it can be conserved as silage (Miranda-Yuquilema *et al*., 2018), using the roots and foliage. It can also be combined with other raw materials that help obtain a feedstuff with better nutritional quality for the animals.

The *M. esculenta* root is a source of energy and, particularly, of starch. It is rich in carbohydrates, has high content of amilopectins and shows between 3,0 and 5,0 % of total sugars. Its lipid content is very reduced, just like the content of crude fiber and other components of the diet fiber (Valdivié-Navarro *et al.,* 2011; Aranda-Baños, 2019).

In Cuba, the utilization of *M. esculenta* can substitute imported cereals for the elaboration of balanced feedstuffs aimed at animal feeding, with contribution of carbohydrates in the ration. For such reason, it constitutes an option for small and medium farmers.

Conclusions

The two clones were developed and produced under the edaphoclimatic and management conditions conceived in the study. The variety Señorita showed better performance than INIVIT Y-93-4 in most of the morphoagronomic variables. To conduct ensilability trials of the roots, forages and/or mixed for their possible use as feed, is recommended.

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Authors’ contribution

- Fernando Ruz-Suarez. Executed the experiments with the corresponding measurements and searched for bibliographic information.
- Tania Sánchez-Santana. Generated the idea of the research, searched for bibliographic information and reviewed the manuscript.
- Yuseika Olivera-Castro. Generated the idea of the research, searched for bibliographic information and reviewed the manuscript.
- Maritza Rizo-Alvarez. Contributed to the execution of the experiments with the corresponding measurements and searched for bibliographic information.
- Dariel Morales-Querol. Contributed to the execution of the experiments with the corresponding measurements and searched for bibliographic information.

Conflicts of interests

The authors declare that there is no conflict of interests among them.

Bibliographic references

Aranda-Baños, F. M. *Alternativas nutricionales en cerdos, en etapa de crecimiento, para disminuir los costos de producción*. Componente práctico del examen de grado de carácter complexivo, presentado al H. Consejo Directivo de la Facultad, como requisito previo para obtener el título de Ingeniero Agropecuario. Babahoyo, Ecuador: Facultad de Ciencias Agropecuarias, Universidad Técnica de Babahoyo, 2019.

Arce, J.; Rojas, A. & Poore, M. Efecto de la adición de pollinaza sobre las características nutricionales y fermentativas del ensilado de subproductos agroindustriales de yuca (*Manihot esculenta*). *Agron. Costarricense*. 39 (1):131-140. https://www.scielo.sa.cr/pdf/ac/v39n1/a10v39n1.pdf, 2015

Beovides-García, Y.; Milián-Jiménez, Marilys D.; Coto-Arbelo, O.; Rayas-Cabrera, Aymé; Basail-Pérez, Milagros; Santos-Pino, Arletys *et al.* Caracterización morfológica y agronómica de cultivares cubanos de yuca (*Manihot esculenta* Crantz). *Cultivos Tropicales*. 35 (2):43-50. https://www.redalyc.org/articulo.oa?id=193230070006, 2014.

Beovides-García, Y.; Milián-Jiménez, Marilys D.; Rodríguez-Pérez, D.; Gálvez, L.; Fernández, K.; Rodríguez, M. I.; Molina, A. *et al.* Cultivares cubanos de yuca (*Manihot esculenta* Crantz) con rendimiento y potencial genético para la agroindustria. *Centro Agrícola*. 40 (3):71-78. http://cagricola.uclv.edu.cu/descargas/pdf/V40-Numero_3/cag123131934.pdf, 2013.

Brito, Carmem L. L.; Viana, A. E. S.; Barbosa, Greice M.; Lopes, S. C.; Santos, V. da S. & Silva, Virgiane A. Caracterização de clones de mandioca (*Manihot esculenta* Crantz) por meio de descritores morfológicos em Cândido Sales-Bahia. *Anais do XV Congresso Brasileiro de Mandioca*. Salvador, Brasil: Sociedade Brasileira de Mandioca. https://ainfo.cnptia.embrapa.br/digital/bitstream/item/95814/1/CARACTERIZACAO-DE-CLONES-152-pratica-21468-VANDERLEI.pdf, 2013.

Connolly-Juárez, D. S. *Inclusión de harina de follaje y raíz de yuca (*Manihot esculenta *crantz), en la alimentación de pollos de engorde y su efecto en el comportamiento productivo*. Tesis para optar por el requisito parcial para optar al título profesional de Ingeniero Zootecnista. Managua: Facultad de Ciencia Animal, Universidad Nacional Agraria, 2017.

Coqueiro, G. R. *Avaliação de variedades de mandioca no nordeste do Estado do Pará*. Tese apresentada para obtenção do título de Doutor em Agronomia (Agricultura). Botucatu, Brasil: Faculdade de Ciências Agronômicas, Universidade de Estadual Paulista Júlio de Mesquita Filho, 2013.

FAO. Estadísticas mundiales de yuca. Roma: FAO https://blogagricultura.com/estadisticas-yuca-produccion/, 2018.

FAOSTAT. *Manihot esculenta* Roma: FAO. http://faostat.external.fao.org/, 2016.

Fukuda, Wania M. G. & Guevara, Claudia L. *Descritores morfológicos e agronômicos para a caracterização de mandioca (*Manihot esculenta *Crantz)*. Cruz das Almas, Brasil: EMBRAPA-CNPMF, 1998.

Gabriel, Luana F.; Streck, N. A.; Uhlmann, Lilian O.; Silva, M. R. da & Silva, Stefanía D. da. Mudança climática e seus efeitos na cultura da mandioca. *Rev. bras. eng. agríc*. 18 (1):90-98, 2014. DOI: https://doi.org/10.1590/S1415-43662014000100012.

Guerra, Caridad W.; Cabrera, A. & Fernández, Lucía. Criterios para la selección de modelos estadísticos en la investigación científica. *Rev. cubana Cienc. agríc*. 37 (1):3-10. https://www.redalyc.org/pdf/1930/193018072001.pdf, 2003.

Hermida, H. Inclusión de harina de raíz de yuca en la dieta de pollos camperos K-53. *Pastos y Forrajes*. 38 (2):207-212. http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S0864-03942015000200009&lng=es&nrm=iso, 2015.

Hernández-Jiménez, A.; Pérez-Jiménez, J. M.; Bosch-Infante, D. & Castro-Speck, N. *Clasificación de los suelos de Cuba 2015*. Mayabeque, Cuba: Instituto Nacional de Ciencias Agrícolas, Instituto de Suelos, Ediciones INCA, 2015.

Herrera, Magdalena; Solís, T.; Godoy, V. & Benitez, Mileisys. Meal of cassava (*Manihot esculenta* Crantz) leaves in diets for naked neck broilers (Gen Nana). *Cuban J. Agric. Sci*. 53 (1):59-64. scielo.sld.cu/pdf/cjas/v53n1/2079-3480-cjas-53-01-59.pdf, 2019.

João, J. P.; Espinosa-Cuellar, A.; Ruiz-Martínez, L.; Simó-González, J. & Rivera-Espinosa, R. Efectividad de cepas de HMA en el cultivo de la yuca (*Manihot esculenta* Crantz) en dos tipos de suelos. *Cultivos Tropicales*. 37 (1):48-56. http://scielo.sld.cu/pdf/ctr/v37n1/ctr07116.pdf, 2016.

León, R.; Polanco, Delia; Zárraga, P.; Zambrano, Marisela; Ramos, E.; Perdomo, Dinaba *et al.* Caracterización morfológica y agronómica de un banco de germoplasma de yuca (*Manihot esculenta* Crantz). *Rev. Fac. Agron., UCV.* 39 (2):93-104. http://saber.ucv.ve/ojs/index.php/rev_agro/article/view/7197, 2013.

León-Pacheco, R. I.; Fuenmayor-Campos, Francia C.; Rodríguez-Izquierdo, A. J.; Montilla, J.; Pinto, O.; Flores, Yadira *et al.* Selección de clones promisorios de yuca provenientes del programa de mejoramiento genético del INIA-CENIAP, Venezuela. *Bioagro*. 31 (2):143-150. https://revistas.uclave.org/index.php/bioagro/article/view/2642, 2019.

Lezcano-Perdigón, P.; Berto, D. A.; Bicudo, S. J.; Curcelli, Felipe; Gonzáles-Figueiredo, Priscila & Valdivié-Navarro, M. I. Yuca ensilada como fuente de energía para cerdos en crecimiento. *AIA*. 18 (3):41-47. https://www.researchgate.net/publication/342697169_Yuca_ensilada_como_fuente_de_energia_para_cerdos_en_crecimiento, 2014.

Milian, M. D.; Sánchez, I.; Rodríguez, S.; Ramírez, T.; Cabrera, M.; Medero, V. *et al.* Caracterización, evaluación y conservación de la colección cubana de germoplasma de yuca *(Manihot esculenta* Crantz). *Proceeding IV International Scientific Meeting Cassava biotechnology Network*. Brasilia. p. 626, 2000.

Miranda-Yuquilema, J. E.; Marín-Cárdenas, A.; González-Pérez, Mabel & Valla-Cepeda, Angélica P. Efecto de un biopreparado sobre las características fisicoquímicas y microbiológicas del ensilaje de yuca con caupí. *The Biologist*. 16 (2):251-260, 2018. DOI: http://dx.doi.org/10.24039/rtb2018162246.

Pastrana, F. E.; Alviz, H. & Salcedo, J. Respuesta de dos cultivares de yuca a la aplicación de riego en condiciones hídricas diferentes. *Acta Agronómica*. 64:48-53, 2015. DOI: https://doi.org/10.15446/acag.v64n1.43935.

Pérez, H. *Evaluación agroproductiva de cinco clones de yuca (*Manihot esculenta Crantz.*) en la CCS "El Vaquerito"*. Tesis para aspirar al título de Ingeniero Agrónomo. Santa Clara, Cuba: Facultad de Ciencias Agropecuarias, Universidad Central "Marta Abreu" de Las Villas, 2015.

Rodríguez-Cuevas, M.; Sumano-López, D.; López-López, R.; Dios-López, M. O. & García Sánchez, A. *Características vegetativas de cultivares de yuca (*Manihot esculenta *Crantz) del banco de germoplasma del campo experimental Huimanguillo, Tabasco*. México, 2017.

Santos, J. A.; Narváez, L.; Salcedo, Saula; Acevedo, Alba N.; Mercado, L. C. & Salcedo, J. G. Fisiología del cultivo de yuca en el bosque seco tropical de Sucre, Colombia. *Temas Agrarios*. 24 (1):17-26, 2019. DOI: https://doi.org/10.21897/rta.v24i1.1774.

Shindoi, M. M.; Avico, Eda L. & Sarco, Pamela C. Comportamiento agronómico de diez cultivares de mandioca (*Manihot esculenta* Crantz) en Colonia Benítez, Chaco. *Agrotecnia*. 27:9-13, 2018. DOI: http://dx.doi.org/10.30972/agr.0272039.

Valdivié-Navarro, M.; Curcelli, F.; Bicudo, S. J.; Bernal, H. & Rodriguez, B. A raiz de mandioca. En: M. I. Valdivié-Navarro y S. J. Bicudo, eds. *Alimentação de animais monogastricos*. Campus de Botucatu, Brasil: FEPAF-UNESP. p. 13-32, 2011.