Description of cultivar

Doña Aurelia: new cultivar of pine nuts for the tropics of Mexico

José Luis Solís Bonilla[1]
Biaani Beeu Martínez Valencia[1§]
Héctor Rómulo Rico Ponce[2]
Jorge Alberto Basulto Granier[3]
Carlos Hugo Avendaño Arrazate[1]
Alfredo Zamarripa Colmenero[4]

[1]Experimental Field Rosario Izapa-INIFAP. Tapachula-Cacahoatan road km 18, Tuxtla Chico, Chiapas. CP. 30870. Tel. 55 38718700, ext. 86418. (solis.joseluis@inifap.gob.mx). [2]Experimental Field Apatzingan Valley-INIFAP. Apatzingán-Uruapan road km 17. Antúnez, Uruapan, Michoacán. CP. 60781. Tel. 55 38718700, ext. 84602. (rico.hectorromulo@inifap.gob.mx). [3]Experimental Field Mocochá-INIFAP. Mérida-Motul Highway km 25, Mérida, Yucatán. CP. 97454. Tel. 55 38718700, ext. 88224. (basulto.jorge@inifap.gob.mx). [4]Ministry of Agriculture and Rural Development (SADER). Free Municipality 377, Santa Cruz Atoyac, Mexico City. CP. 03310.

[§]Corresponding author: martinez.biaani@inifap.gob.mx.

Abstract

For more than eight years, INIFAP has carried out research work focused on inputs for the production of biofuels, including the mexican pine nut (*Jatropha curcas* L.). Throughout this time, genetic tests were established in four tropical environments in Mexico based on selected genotypes according to their agronomic and industrial attributes. The main selection criteria addressed were: grain yield, oil content, growth habit (bearing and branching pattern) and the presence of female flowers. The best genotypes of the trials were two varieties with the presence of 100% female flowers and a variety with a predominance of male flowers, but also with the presence of female and hermaphrodite flowers. One of these varieties with 100% female flowers was registered under the name 'Doña Aurelia' with a breeder's title number 1541. This variety has proven to be stable in terms of morphological and production characteristics over the years of evaluation and study. This variety can produce an average yield in humid tropics of 0.49 t ha^{-1} in the first year of the crop, with a potential yield at the first year of 0.98 t ha^{-1}, under dry tropic conditions. It reaches yields of 3 tons of dry grain per hectare at the fourth year of production. The average oil content in the seeds of the variety is 53.4%. The physicochemical characteristics of the oil are: 98.57 $gI_2/100$ iodine index, 00.921 g cm^{-3} density, 34.894 $mm^2 s^{-1}$ viscosity and 2.974 mg KOH g^{-1} acid number and with a fatty acid composition of 35.36% fatty acids saturated and 64.64% unsaturated fatty acids, according to the American standard ASTM 'Doña Aurelia' is considered of good quality as raw material for the production of biodiesel.

Keywords: genetic improvement, Mexican pine nut, new cultivar.

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During the last decade, the effects of climate change have intensified. In various parts of the world, dependence on fossil fuels begins to be reduced with the impulse to the use of renewable energies, such as biodiesel, which has encouraged technological innovation, both in the field of energy and in the sustainable use of natural resources (Huang *et al*., 2012; Zamarripa and Solis, 2013a, 2013b; WorldAtlas, 2018; Gielen, *et al*., 2019; Laviola *et al*., 2019).

In this regard, Mexico has demonstrated a great commitment to the international environment and sustainable development agenda and participates in more than 90 agreements and protocols in force, including the Kyoto protocol and the Paris agreement, being a leader in issues such as climate change and biodiversity (INECC, 2016). However, the country's economic growth remains closely linked to greenhouse gas emissions and the loss of forests and jungles. This implies important challenges to promote economic growth and development, but at the same time ensure that natural resources continue to provide the environmental services on which the welfare of the population depends.

In addition to the above, the *Jatropha curcas* L. species has been considered one of the viable alternatives for the production of biodiesel in Mexico (Zamarripa and Solis, 2013a; Sujatha *et al*., 2019). However, the lack of improved varieties with high yield of grain and oil, being one of the main limitations of this crop. Given this problem, INIFAP through the National Bioenergy Research Program has worked on the search, development and selection of varieties of *Jatropha curcas* with high grain yield, oil content and good oil quality, as well as climate adaptation dry and wet

The investigations carried out in the South of Mexico allowed the obtaining of the clone variety 'Doña Aurelia' of high productive capacity for use in system interspersed with the female clonal cultivar 'Gran Victoria' and the pollinator cultivar 'Don Rafael' also generated in INIFAP and that will later be described in future issues of this magazine. In this way, the yield of grain and oil can be increased up to 1 200% in the first year, compared to the average of plantations without the use of improved varieties (Solis *et al*., 2016). The improvement method used to obtain this variety was clonal selection, with an evaluation and selection period of more than eight years (Zamarripa and Pecina, 2012; Solis *et al*., 2019). This method has been used successfully in many species such as coffee, cocoa, sugar cane, cassava (Montagnon, 2000; Resende and Barbosa, 2005; Cueto *et al*., 2007).

The genetic improvement and varietal selection began with the morphological, agronomic, biochemical and genetic characterization of more than 1 600 plants *J. curcas* established in the National Germplasm Collection of nine states of southern Mexico (Zamarripa *et al*., 2012). Phenotypic studies and selection of outstanding individuals by some particular character, were carried out during the years 2008 to 2010. Based on agronomic and industrial characteristics, promising genotypes were selected and variety trials were established in four environments in Mexico, to assess agronomic behavior. The main selection criteria used were grain yield, oil content, growth habit (bearing, branching pattern) and high presence of female flowers. These genetic materials were assessed for an evaluation and selection period of more than eight years.

Doña Aurelia, is an early variety of medium vigor, has an abundant branch, open cup and drip area of 4 m^2, an average of 61 branches per plant. Doña Aurelia produces semi-compact clusters with medium-sized elliptical fruits (Figure 1). One of the important characteristics of this variety is the inflorescences, with fully pistillated flowers that remain for most of the year (Zamarripa *et al*., 2017). It has an average yield of 211 clusters, with 909 female flowers.

Figure 1. Characteristics of the plant of the clonal cultivar 'Doña Aurelia': branching from the base, canopy cover and plant height.

Being plants with 100% female flowers, it is considered a highly productive material (Figure 2). The use of the clonal cultivar 'Doña Aurelia' in a system interspersed with the clonal cultivars 'Don Rafael' and 'Gran Victoria'; from the fourth year of age it is feasible to obtain grain yields greater than 1.5 t per hectare. The seed is medium in size, with an average weight of 0.83 g. This cultivar has proven to be stable in terms of its characteristics over years of study and to produce an average yield in good environments of 0.49 t ha^{-1} in the first year of production.

Figure 2. Cultivate clonal 'Doña Aurelia': a) plant architecture; b) and c) ripe and green fruits; and d) 100% female flowers.

Reaching three tons of dry grain per hectare in the fourth year of production. The average oil content in the seeds of the cultivar is 53.4%. The sowing of 36.5% of the total area corresponds to the 'Doña Aurelia' clonal cultivation interspersed with the 'Gran Victoria' clonal cultivation in 36.5% and with 27% of the 'Don Rafael' pollinator cultivar allows an increase of 20 to 240 kg ha^{-1} the grain yield obtained by the producer's materials in the first year, with greater increases in successive years and yields exceeding the fourth year of production.

The clonal cultivar 'Doña Aurelia' can be sown, in areas of the tropics identified as environments with high and medium productive potential, with an height of 0 to 900 meters above sea level, temperature between 18 °C and 28 °C and rainfall between 900 and 1 500 mm per year, from the states of Chiapas, Tamaulipas, Michoacán, Yucatan, Veracruz, Oaxaca and Guerrero.

Table 1 provides information on the physicochemical composition in seeds and oil of the cultivar 'Doña Aurelia'. As for the composition of fatty acids, this cultivar has a larger portion of polyunsaturated fatty acids (39.75%) than saturated (35.36%). The smallest portion of fatty acids is monounsaturated (24.89%). The main fatty acids in the seed oil of this cultivar are oleic acid with a content of 30% and linoleic acid with a content of 32% (Zamarripa *et al*., 2017; Solis *et al*., 2019).

Table 1. Seed characteristics and physicochemical composition of the cultivar oil 'Doña Aurelia'.

Characteristic	Values
Seed weight (g)	0.83 ±0.012
Almond Weight (g)	0.512 ±0.005
Shell weight (g)	0.302 ±0.056
Seed moisture (%)	3.84 ±0.987
Oil content (%)	53.44 ±0.318
Oleic acid (%)	30 ±0.654
Linoleic acid (%)	32 ±0.543
Iodine Index ($gI_2/100$)	98.57 ±1.067
Density 15 °C ($g\ cm^{-3}$)	0.921 ±0.001
Viscosity 40 °C ($mm^2\ s^{-1}$)	34.894 ±0.115
Acidity Index (mg KOH g^{-1})	2.794 ±0.459
Saponification index (mg KOH)	91.55 ±0.433
Oil yield ($L\ ha^{-1}$) at the fourth year	1 571 ±2.623

Solis *et al.* (2016).

Table 2 shows the physicochemical characteristics of biodiesel from the *J. curcas* oil of the clone cultivar 'Doña Aurelia', obtained by a heterogeneous transesterification using potassium hydroxide with methanol. The biodiesel obtained from the oil of the clonal cultivar 'Doña Aurelia' is within the ranges of the American standard ASTM and European EN-14214.

Table 2. Physicochemical composition of the biodiesel of *J. curcas* cultivate 'Doña Aurelia'.

Properties	Biodiesel	Norm[a]	
		USA (ASTM D6751-08)	European (EN 14214)
Specific Density (g cm^{-3})	0.862 ±0.001	Unmentioned	0.860 -0.900
Viscosity 40 C (mm^2 s^{-1})	4.472 ±0.115	1 - 6	3.5 - 5
Acidity index (mg KOH g^{-1})	0.559 ±0.002	< 0.8	< 0.5
Iodine index (mg I_2/100 g)	116.51 ±1.13	Unmentioned	< 120
Freezing point (°C)	1.351 ±0.65	Specific for each city	
Cetane number (minimum)	59.56 ±0.897	47	51
Calorific value (HHV) (MJ kg^{-1})	40.99 ±0.654	-	-
Theoretical yield of biodiesel (L ha^{-1})	1 492 ±1.254	-	-

[a]= Quality standards for Biodiesel B100 (Hoekman *et al*., 2012); [b]= Low temperature properties are not strictly specified but must be agreed by the fuel supplier or the buyer.

The clonal cultivar 'Doña Aurelia', was officially registered for protection in September 2014 in the national catalog of plant varieties (CNVV) with provisional registration number 3055-JAT-002-260914/C, of the inspection and certification service of Seeds (SNICS) belonging to the Ministry of Rural Development (SADER), with definitive registration number JAT-003-050615 and obtaining the title of breeder number 1541 in the month of July 2016 for its use and exclusive exploitation until the month July 2034.

Conclusions

The use of the clonal cultivar 'Doña Aurelia' of INIFAP will allow to increase the production of raw material to guarantee a sustainable production of biofuels. This cultivar can be sown in tropic areas identified as environments with high and medium productive potential, with an altitude of 0 to 900 m, temperature between 18 °C and 28 °C and rainfall between 900 and 1 500 mm per year, of the states of Chiapas, Tamaulipas, Michoacán, Yucatán, Veracruz, Oaxaca and Guerrero, excluding areas currently occupied by natural forests and forests, this variety could be grown not only to increase current yields but also to address current concerns and problems related to climate change.

The development of *J. curcas* as a crop through the use of cultivars generated by INIFAP for the production of biofuels will have a favorable impact on the environment, since according to studies conducted by INIFAP, Mexican Bioenergy Network (REMBIO) and the National Autonomous University of Mexico (UNAM), data not shown in this description, produce biodegradable compounds, with positive energy balances of 1:5.1 and reduces pollutant gas emissions by more than 70% with respect to the fossil diesel reference which is equivalent to 83.8 kg CO_2eq GJ.

The propagation of this cultivar is carried out asexually by means of stakes, with this method the genetic identity of the cultivar "Doña Aurelia" is maintained. Stakes 40 to 50 cm in length and 3 cm in diameter have high percentages of field yield. Currently, there are lots of multiplication

(clonal gardens) in four INIFAP Experimental Fields: CE Rosario Izapa, in the municipality of Tuxtla Chico, Chiapas; CE Valle de Apatzingán, in Michoacán, CE Las Huastecas, in the municipality of Altamira, Tamaulipas and CE Mococha, in the municipality of Uxmal, Yucatan, available to producers and companies that are interested in the production and marketing of inputs for the production of biofuels.

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