

Estimate the Potential in the Harvest of the Sacha Inchi Seed in A 12-Hectare Crop, Using the Decision-Making Model Under Uncertainty.

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Abstract

Sacha Inchi (*Plukenetia volubilis*) is a crop with great agro-industrial potential since it contains omega 3, 6, 9 and a high value in unsaturated fatty acids, so it can be used to transform it into different products with high nutritional content; In the present work, a bibliographic review was carried out in countries such as Peru, Ecuador and Colombia where the information on the production of the crop was determined in kilogram per hectare for the first 5 years, the data were taken from existing documents and interviews carried out in Colombia to companies that work with Sacha Inchi, in order to know the productive behavior and the yield capacity of the crop. It was obtained that the production of sachá Inchi seed at the international level presents a grouped deviation of 718,31 kilos with an R^2 of 64,94% and an average of 2.541 kilos for year 3 of production, in the same way and through the national review made it possible to show a deviation of the data for each period of time from 490 to 1.001 kilos and a grouped deviation of 638,65 kilos with an R^2 of 65,39% and an average of 3.411 kilos for year 3 of production.

Keywords

Decision-making, crop, sachá inchi, seed, uncertainty.

1. Introduction

The Sacha Inchi seed is a non-traditional crop, originally from the Peruvian, Colombian and Ecuadorian Amazon and that has been cultivated by their indigenous communities for centuries (Palacio, 2018), being used as a source of food, whose nutritional contribution according to The study "Compositional analysis of the cake and oil of seeds of sachá inchi (*plukenetia volubilis*) cultivated in Colombia" presents a proximal composition with a crude fiber content $4,79 \pm 0,02\%$, fat $4,84 \pm 0,02\%$ and protein $51,23 \pm 0,10\%$. The protein fraction presented a content of total essential amino acids (TEAA) 45,3% and total amino acids (TAA) 99,3%. (Z. Adriana and H. Ordoñez, 2020).

At present, the planting of Sacha Inchi has played a fundamental role in the substitution of illicit crops, as it presents a high potential for commercialization in national and international markets given the nutritional benefits, especially those from the oil extract. According to the Ministry of Agriculture and Rural Development of Colombia, the area planted with this plant in the national territory has increased by 300% during the last three years, going from 111 hectares in 2015 to 463 in 2017.

Due to the above, the interest arises in knowing how the productivity of the plant grows to measure during the first 5 years of life, and thus understand the minimum resources necessary for an adequate exploitation of the crop, the planning of the resources and the commercialization of the same. In this way, it is expected to demonstrate the impact

that the crop has on farmers and thus determine the number of hectares to be planted according to the marketing capacity to which they wish to apply.

1.1 Objectives

Estimate the potential in the harvest of the Sacha Inchi seed in a 12-hectare crop, using the decision-making model under uncertainty.

- Review articles and research related to the research project in databases.
- Determine by the Hurwicz method the estimate of harvest by extension of the crop.

2. Methods

In the present study, an analysis of the information related to the annual production kilogram per hectare of Sacha Inchi was carried out, the information consulted was using primary and secondary sources. The primary sources of information were obtained with structured interviews carried out with Sacha Inchi growers in different departments of Colombia, who through their experiences narrated the practice of their crops, these data were structured for the analysis of the behavior of the crop. On the other hand, information was collected with secondary sources of works consigned in databases such as: SCOPUS, Google Academic, and SciELO, among which are works from Peru, Ecuador, Colombia and from which information could be extracted regarding the Behavior of the crop with data of Kilogram of the Sacha Inchi nut per hectare between the first year of harvest until the fifth year, with this information a statistical method is established to analyze the data.

2.1. International

According to the information obtained through the bibliographic review carried out, studies were found in Peru in the cities of Tarapoto, Lama and in the department of San Martin; In Ecuador, a study was found that can be related to the information on the production per annual hectare of Sacha Inchi walnut.

2.2. National

The data handled in Colombia were obtained through a bibliographic review of different documents related to the cultivation of Sacha Inchi, found for the departments of: Putumayo, Valle del Cauca, Meta, Boyacá. Additionally, interviews were conducted with companies dedicated to the sowing and harvesting of sachá Inchi in Colombia, the contacts were obtained from the page of the ministry of environment and sustainable development, who made a call to demonstrate the progress regarding green agriculture and where there were companies related to the cultivation of Sacha Inchi, with the interviews the information regarding the annual production per hectare of the crops of Sacha Inchi was supplemented for departments such as Santander, Córdoba, Antioquia, Caldas, Putumayo, Meta.

3. Data Collection

3.1. Review articles and research related to the research project in databases.

3.1.1. Perú

In several studies carried out in Peru, in animals and in humans, it has been shown that the consumption of products based on Sacha Inchi is safe and reliable, which is also deduced from the fact that it is a food consumed by numerous indigenous American tribes that make it used to generate oil and flour (A. N. Alayón and I. Echeverri J, 2016)

According to (D. Flores and O. Lock, 2012) in Peru, the sachá Inchi plant grows from 100 meters above sea level in the Low Forest and 2.000 meters above sea level in the High Forest of the Amazon, in the departments of Amazonas, Cusco, Junín, Pasco, San Martín, Loreto and Madre de Dios, generally in the high and low Peruvian jungle. Sacha Inchi has different forms of commercialization, among which it stands out, just like Table 1 and Table 2:

Table 1 - List of products marketed from sachá inchi seed

Product	Percentage
Oil	42,34%
Dust	12,73%
Snacks	5,37%
Toasted	2,85%
Capsules	1,79%

Cosmetic	0,10%
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The main destination markets are:

Table 2 - Main buyers of sacha inchi seed

Country	Percentage
Canada	31,78%
USA	23,33%
Japan	14,73%
Spain	6,97%
France	6,23%
Mexico	4,59%
Belgium	3,44%
Australia	2,66%

3.1.2. San Martín

The regional government of San Martín in Peru has implemented a project to harvest 6.000 k of Sacha Inchi per hectare in that region, informed the coordinator of the Project of the Regional Directorate of Agriculture, Raúl Gonzales Alegría. In some places, Sacha Inchi is still produced in an artisanal way, which does not allow increasing the amount in kilograms per hectare, where technical assistance will also be inserted to improve and increase production. Currently the production of Sacha Inchi in San Martín amounts to 1.100 kilos per hectare (Agronegocios Peru, 2020)

The sowing of Sacha Inchi in San Martín is conditioned to the rainfall regime (December to March), generally sowing at the beginning of the rains, since adequate soil moisture is necessary for germination. For direct sowing, 1 to 1,7 kg / seed / ha is used, with a monoculture spacing that varies from 3,0 to 2,5 m between plants and rows, with a density of 1.111 to 1.333 plants / ha. The preparation of the land is carried out in a traditional way under the system of grazing, grave, picking and joint. The control of weeds, particularly grasses, which compete strongly with the plants sown in the growth phase, is carried out manually. The use of live stakes is not generalized, when they do use rods 1,5 m long x 0,10 m in diameter. The pruning practice carried out by the farmer in this crop is unusual, generally limited to the tutors and terminal buds. The harvest of the product is carried out in a traditional way, with an average yield in monoculture of 2.000 to 2.200 k of dry seed / ha (Instituto de investigaciones de la and amazonía peruana, 2020). See Figure 1.

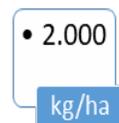


Figure 1 - Yield in monoculture mode

According to the study of L. Aguirre (2020), the evolution of the sacha inchi cultivation in the San Martin Region is evidenced during a period between 2010 and 2014, in which variables such as: planted and harvested area, yield and production are monitored.

As shown in Table 3, for the year 2010 the seed harvested per hectare shows amounts similar to those obtained in the previous studies of this research, however, in the period 2011 - 2013 there is a decrease in production due to hectare given that the price per kilogram of sacha inchi seed decreased, generating an abandonment of crops by the producer, as of 2014 there is a reactivation because in that same year the commercial barriers to entry to the markets of Europe and the United States were overcome for Sacha Inchi oil.

Table 3 - Evolution of sacha inchi cultivation in the San Martin region

Year	Area sown (ha)	Area harvested (ha)	Yield (kg/ha)	Production (tn)
2010	1.639	767	2.145	2.412
2011	997	628	3.293	2.068

2012	1.369	608	3.122	1.896
2013	852	533	3.859	2.055
2014	740	447	4.036	1.802

3.1.3. Tarapoto

According to L. Santillán (2018), it is estimated that the level of productivity per hectare of Sacha Inchi planted amounts to 1 ton of similla, however, there are records of yields in crops with three years or more between 1,5 and 3,0 tons. The variations are mainly due to aspects such as: care in the maintenance of the crop, number of plants per hectare, control of weeds and pests and the availability of water. See Table 4.

Table 4 - Evolution of sacha inchi cultivation in the Tarapoto region

Year	Yield (kg/ha)
1	1.000
2	N.D.
3	1.500
4	3.000
5	N.D.

3.1.4. Lama

According to the report Shanantina SAC (2009) which is part of the Perubiodiverso Project (PBD), which aims to contribute to the improvement of the quality of life of the rural population through the sustainable use of biodiversity, there is a data table on the production of Sacha Inchi (kg / ha) which is listed in Table 5.

Table 5 - Evolution of sacha inchi cultivation in the Lama region

Year	Yield (kg/ha)
1	700
2	2.000
3	3.000
4	3.000
5	3.000

3.2. Ecuador

According to E. Vera, E. Yagual, and R. Paz (2020) at present, Ecuador is potentiating the cultivation of Sacha Inchi seed in various areas nationwide, especially in areas where passion fruit crops are found, since this crop requires to be sown under similar conditions.

According to Briones Mora and Marcos Ismae (2014) and data from official pages of Ecuador, by 2013 an approximate of 813 hectares of the seed of Sacha Inchi was estimated, of which the provinces of El Oro, Manabí, Pichincha, Esmeraldas and Morona Santiago had the highest participation, knowing until then that there was an annual yield of 3.500 kilos per hectare, thus giving 2.845,5 tons per year, of which around 0,30 liters were obtained per kilo, which represented a production of 853,65 liters of Sacha Inchi oil yearly (E. Vera, E. Yagual, and R. Paz, 2020). See Figure 2.

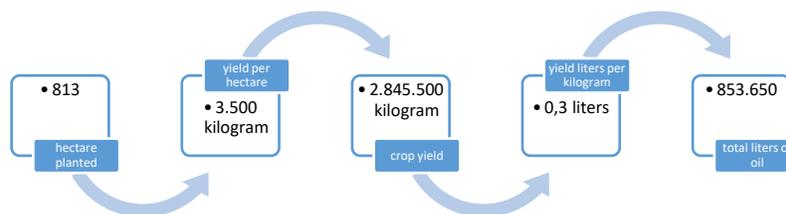


Figure 2 - Estimated crop yield sacha inchi seed

Based on the above, it is possible to deduce that the harvest potential of the sacha Inchi seed ranges between 1.200 kg / ha and 2.000 kg / ha per year, varying according to the climatic characteristics of the area.

The number of seedlings sown per hectare is around 1.000 to 1.200, with a maximum separation of 3 mx 3 m and assisted by tutors to facilitate their growth and subsequent harvest, the amount of seeds necessary for handling per hectare is only 2 kilogram in the same extension of land, this supposes a high productivity, since there are references that indicate to provide productivity from 8 months of sowing, increasing annually with registration until 10 years old, starting with a production of 50 kg per plant per year and reaching records of 800 kilograms.

This is a benefit for the farmer since the rotation of the sowing will not be necessary until reaching a minimum of 10 years old.

Regarding the obtaining of oil, it is found that there is a ratio of 0,3 liters per kilo of seed, showing a high potential for use, since the 250 ml presentation has a market price of around the € 22,00 to € 40,00 depending on its omega content. (oil.org.es, 2020).

4.4 National review of sacha Inchi crop

4.4.1 Agronet

Pioneer crops of Sacha Inchi are established in Colombia, in the departments of Meta, Putumayo in Sopenrán, Liborina, Barbosa and Bajo Cauca in Antioquia and currently in almost all departments of Colombia, with thermal levels that vary from 0 to 2.600 meters above sea level. The natural oil of the Sacha Inchi seed is characterized by having in its chemical composition the highest content of unsaturated fats 92,7% and the lowest content of saturated fats 6,5%.

Due to the diversity that the thermal floors in Colombia promote and because it is found in this area of the Ecuador line, Sacha Inchi has established itself as a non-traditional crop with potential for the country; According to the Ministry of Agriculture and Rural Development, the area planted with this plant in the national territory has increased by 300% during the last three years, going from 111 hectares in 2015 to 463 in 2017, the agricultural evaluations (EVAS) of that entity reveal that 1.100 tons of Sacha Inchi were produced in 2017 and the main producers were Putumayo, Valle del Cauca, Amazonas and Antioquia, where 85% of the country's total is concentrated. (La Nota Economica, 2020)

Colombia, being a country that has an Amazon basin, the product has existed in the wild; But when speaking of Sacha Inchi as a crop, it can be said that it is "native" to Putumayo, since this department is bordering Peru, the country of which it is native. This is how the seed entered through Putumayo and was received in this sector of the Colombian Amazon. A national production of 685 hectares planted with Sacha Inchi can be estimated mainly in the departments of Putumayo, Antioquia and Cauca, without ignoring that it is found in the wild in the Orinoquia region, Amazonia and to a lesser extent in Choco.

According to the previous graph (Sacha Inchi production in Colombia) taken from Agronet, it is evident that Sacha Inchi crops have been growing in Colombia, having higher production in the municipalities of Putumayo, Antioquia, Valle del Cauca, Cauca and Amazonas.

Currently there is little production of Sacha Inchi oil in Colombia, however, the product is marketed in Colombia directly through the National firm, Omega Oils de Colombia, Agroindustrias La Dorada and Prome SAS, Biorefineria SAS (Grupo Sacha Colombia). The price of the Sacha Inchi almond, being this one of the primary link in the chain, has a fluctuating price according to the dynamics and interest of the industrialists and traders who determine the price for the producers; currently counting with a paid price of \$ 6.000 Kilo

This changing with the projection of initially cultivating 10 hectares of Sacha Inchi and knowing that a cultivated hectare (according to data provided by Asoproagro) produces in the first year of cultivation, from 1.200 to 1.400 kilos / grain, and in the second year it is 2.000 kilos / grain, therefore, the share will be 12 tons in the first year and 20 tons in the second, this being the market share in volume in the first two years of production, for the 10 base hectares available. See Figure 3.

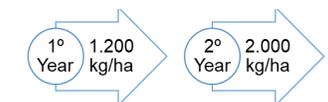


Figure 3 - Estimated Sacha Inchi production per hectare

4.4.2 Valle del Cauca

Taking into account the performance of the sacha Inchi crops in the Cauca Valley, it is possible to affirm that collections are made from the eighth month and constantly every 15 days, whose production peaks are generated between July and September.

The Figure 4 - Estimated Sacha Inchi production per hectare in the Valle del Cauca, resume the expected yield for this area of the country:

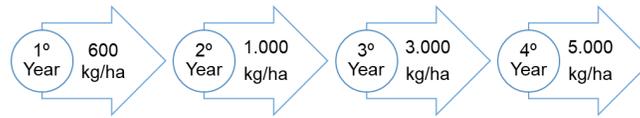


Figure 4 - Estimated Sacha Inchi production per hectare in the Valle del Cauca

According to N. Gomez (2018) the productivity of the crop stabilizes after the third year of sowing and remains constant for up to seven more years, being 12 years the maximum time of use, time in which there is a decrease of up to 35% of the seed.

In another investigation with a sample of Sacha Inchi seeds collected in Colombia, an oil content of 41,4% and proteins of 24,7% are reported, with the percentages of fatty acids in the oil being 50,8% of alpha-linolenic and 33,4% linoleic acid. The lipid fraction showed mainly neutral lipids (97,2%), a very low amount of free fatty acids (1,2%) and phospholipids (0,8%). The main minerals present in the seed, in ppm, were potassium (5.563), magnesium (3.210) and calcium (2.406), it also contains iron and zinc to a lesser extent (D. Flores and O. Lock, 2012).

4.4.3 Boyacá

According to the study [14] it is established that the Moniquirá – Boyacá, has a Sacha Inchi production in the San Cristóbal farm with a size of 2 hectares with the following behavior in kilograms.

The projection in the Table 6 made in the previous study of annual kilograms (first 5 years) for 2 hectares, using certified Sacha Inchi seeds:

Table 6 - Kilograms / Year for 2 hectares of star fruit in Boyacá

Period	Description	Harvest in 2 years (Kg/ha)	Harvest in 1 year (Kg/ha)
Year 1	Star fruit	2.250	1.125
Year 2		6.750	3.375
Year 3		7.850	3.925
Year 4		8.550	4.275
Year 5		9.000	4.500

4.4.4 Meta

Within the work D. Gómez and E. Montaña (2019) which was carried out by the research seedbed for the municipalities of (Villavicencio, Puerto López, San Martín and Granada) in Meta, the information in the Table 7 and Table 8 is established regarding the yield of Sacha Inchi per hectare per year:

Table 7 - Kg / ha per year star fruit in Meta

Period	Description	(Kg/ha)
Year 1	Star fruit	3.500
Year 2		3.700
Year 3		3.700
Year 4		4.200
Year 5		4.200

Table 8 - Kg/ha per year grain seed

Period	Description	(Kg/ha)
Year 1	Seed grain	1.750
Year 2		1.850
Year 3		1.850
Year 4		2.100
Year 5		2.100

4.4.5 Putumayo

According to the experience of most of the already established crops, in the different parts of Colombia and especially in the Putumayo area, in 1 hectare with 1.111 plants, 4,5 tons of grain are obtained per year, of 4,5 kilos of seed you get 2,3 kilos of almond and from that almond you get 1 liter of oil. For each sown plant, approximately one kilo of seed is obtained per month. (D. Castellanos and M. Mendoza, 2016).

According to the study conducted by the Cooperativa Sacha Colombia, historical data were obtained on the behavior of seed production for 5 years of cultivation sown in a field of one hectare, which are shown in Table 9 (L. F. Arias, 2019)

Table 9 - Kg / ha per year star fruit in Putumayo - Sacha Colombia.

Period	Description	(kg/ha)
Year 1	Fruto estrella	800
Year 2		2.000
Year 3		3.000
Year 4		3.000
Year 5		3.000

Additionally, a telephone survey was carried out with 11 companies dedicated to the planting and harvesting of sacha inchi in Colombia, the contacts were obtained from the website of the Ministry of Environment and Sustainable Development, who made a call to demonstrate progress in Regarding green agriculture, this document is a portfolio in which, initially, 979 Green Business producers were identified in 29 Departments, of which 22 have the management of sacha inchi in their processes, which have been previously verified by the Authorities Environmental and Green Business Office, as producers that generate positive environmental impact through their goods and services, and whose products are in demand in the framework of the health emergency generated by the COVID-19 coronavirus pandemic according Minambiente (2020).

The Table 10, show the data obtained from the companies that were in the disposal of answering the questions formulated:

Table 10 - Summary National historical sacha Inchi productivity of star fruit.

Company name	Department	Year 1 (Kg/ha)	Year 2 (Kg/ha)	Year 3 (Kg/ha)	Year 4 (Kg/ha)	> Year 5 (Kg/ha)
Aspromacarena	Meta	1.300	2.500	N.D.	N.D.	N.D.
Sainsa s.a.s	Santander	1.000	3.000	3.500	N.D.	N.D.
Asociación de frutos amazónicos de puerto Caicedo – asofrupc	Putumayo	600	2.000	N.D.	N.D.	N.D.
Serranía sacha Inchi	El Carmen de Chucuri	1.000	2.200	3.000	N.D.	N.D.
Cooperativa agroindustrial del alto Sinú	Córdoba	1.500	3.000	3.000	3.000	N.D.
Sacha moniquira	Boyacá	1.500	2.500	3.000	N.D.	N.D.
Natural sacha zomac	Antioquia	1.500	2.500	3.000	3.000	N.D.
Asoinchi oro verde-mama Inés	Putumayo	2.500	3.000	3.500	N.D.	N.D.
Amazónica de Colombia	Putumayo	1.000	2.500	3.200	N.D.	N.D.

Cooperativa de sachicultores de Colombia “sachacoop”	Manizales	800	2.000	3.000	3.500	3.500
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According to the documents at the national level reviewed above, a summary of the information is consolidated, in order to analyze a behavior in the yield of the Sacha Inchi crop in Colombia, the information is shown in kilograms per hectare according to age (year) of the crop, data were found in some documents from the first year to the fifth year as related in the Table 11:

Table 11 - National historical sachá Inchi productivity summary of star fruit.

Estudios revisados	Año 1 (Kg/ha)	Año 2 (Kg/ha)	Año 3 (Kg/ha)	Año 4 (Kg/ha)	> Año 5 (Kg/ha)
Asoproagro	1.200	2.000	N.D	N.D	N.D
Valle del Cauca	600	1.000	3.000	5.000	N.A
Boyacá	1.125	3.375	3.925	4.275	4.500
Meta	1.750	1.850	1.850	2.100	2.100
Putumayo - Sacha Colombia	800	2.000	3.000	3.000	3.000
Meta - Negocios Verdes	1.300	2.500	N.D.	N.D.	N.D
Santander - Negocios Verdes	1.000	3.000	3.500	N.D.	N.D
Putumayo 1 - Negocios Verdes	600	2.000	N.D.	N.D.	N.D
Santander 2 - Negocios Verdes	1.000	2.200	3.000	N.D.	N.D
Córdoba - Negocios Verdes	1.500	3.000	3.000	3000	N.D
Boyacá - Negocios Verdes	1.500	2.500	3.000	N.D.	N.D
Antioquia - Negocios Verdes	1.500	2.500	3.000	3.000	N.D
Putumayo 2 - Negocios Verdes	2.500	3.000	3.500	N.D.	N.D
Putumayo 3 - Negocios Verdes	1.000	2.500	3.200	N.D.	N.D
Manizales - Negocios Verdes	800	2000	3.000	3.500	3.500
Average	1.212	2.362	3.081	3.411	3.275
DesVest	495	597	490	958	1.001

Reviewing Table 11, it can be established that there is an upward behavior regarding crop productivity from year 1 to year 4, having a variability in behavior according to the region where the study is carried out, this may be due to different conditions of crops as well as the different environmental factors to which they are exposed.

5. Results and Discussion

5.1 Numerical Results

Taking into account that in the databases consulted, there is no information that allows understanding the behavior of the Sacha Inchi cultivation in the department of Cauca, the data obtained from the international and national analysis will be used to estimate the potential of cultivation in the 12 hectares.

To determine the harvest potential and given the variability of the process, the absence of data and taking into account that the above will be done under the decision-making method under uncertainty where according to Taha (2012) Decision-making under uncertainty, as well as low risk, implies alternative actions whose rewards depend on the states of nature. The Hurwicz method will be applied, which is designed to represent different decision attitudes ranging from the most optimistic to the most pessimistic, defining an α between $0 \leq \alpha \leq 1$, where the value of α is 1 It is because the level of optimism regarding the proposed scenario is high, if on the contrary and the α is close to 0, it indicates that the level of optimism regarding the model is low.

Where:

$$\begin{aligned} & \max_{a_i} \{ \alpha \max_{s_j} v(a_i, s_j) + (1 - \alpha) \min_{s_j} v(a_i, s_j) \}, \text{ if } v \text{ is a profit} \\ & \min_{a_i} \{ \alpha \min_{s_j} v(a_i, s_j) + (1 - \alpha) \max_{s_j} v(a_i, s_j) \}, \text{ if } v \text{ is a loss} \end{aligned}$$

For the above and taking into account the behavior of the crop at the international, national and departmental level listed in Table 12, as well as the visits made to the pilot crops of the ancestral territory of Kite Kiwe, an $\alpha = 0,8$ is proposed, since optimism regarding the behavior of the crop in these lands is moderately high.

Table 12 - Summary of international, national and departmentar historical sachá Inchi productivity model

		Year 1 (Kg/ha)	Year 2 (Kg/ha)	Year 3 (Kg/ha)	Year 4 (Kg/ha)	> Year 5 (Kg/ha)
		S1	S2	S3	S4	S5
International	A1	1.261	2.647	2.541	3.286	0,0
National	A2	1.212	2.362	3.081	3.411	3.275
Departmental	A3	0,0	2.000	3.000	0,0	0,0

For the purposes of calculations, we proceed to change the N.D. (Information not available), by 0.0.

In this way:

$$\alpha = 0,8$$

$$(1 - \alpha) = 0,2$$

$$H_{A2} = 2.971,20$$

$$H_{A1} = \{0.8 * (\text{máx} (1.261, 2.647, 2.541, 3.286, 0.0) + ((1 - 0.8) * \text{mín} (1.261, 2.647, 2.541, 3.286, 0.0)))\}$$

$$H_{A1} = 2.628,80$$

$$H_{A2} = \{0.8 * (\text{máx} (1.212, 2.362, 3.081, 3.411, 3.275) + ((1 - 0.8) * \text{mín} (1.212, 2.362, 3.081, 3.411, 3.275)))\}$$

$$H_{A2} = 2.971,20$$

$$H_{A3} = \{0.8 * (\text{máx} (0.0, 2.000, 3.000, 0.0, 0.0) + ((1 - 0.8) * \text{mín} (0.0, 2.000, 3.000, 0.0, 0.0)))\}$$

$$H_{A3} = 2.400,00$$

In accordance with the above and taking into account the result of each of the scenarios, A1, A2 and A3, the estimate for the harvest potential for each hectare planted with Sachá Inchi from the third year is $H_{A2} = 2.971,20$ kilograms, if the project covers an area of 12 hectares, we have to:

$$\text{Total kilogram} = H_{A2} * \text{Number of hectares to be harvested}$$

$$\text{Total kilogram} = 2.917,20 * 12$$

$$\text{Total kilogram} = 29.172$$

In this way, the processes, people and machinery necessary to process a total of 29 tons of Sachá Inchi seed per year must be estimated.

5.2. Graphical Results

5.2.1 International

Taking into account the data collected through the consultations made in the bibliographic sources and technical studies of Lama, San Martín, Tarapoto in Peru and Ecuador, Table 13 is made to show the productivity of the sachá Inchi seed from year 1 to year 1. year 4 in kilos per hectare sown.

Table 13 - Summary of international historical sachá Inchi productivity

Studies reviewed	Year 1 (Kg/ha)	Year 2 (Kg/ha)	Year 3 (Kg/ha)	Year 4 (Kg/ha)
Lama – Perú	700	2.000	3.000	3.000
San Martín – Perú	2.145	3.293	3.122	3.859
Tarapoto – Perú	1.000	N.D.	1.500	3.000
Ecuador	1.200	N.D.	N.D.	N.D.
Average	1.261	2.647	2.541	3.286
DesVest	624	914	903	496

In this way, it is possible to appreciate that there is a variability in the behavior between the different mentioned localities, mainly associated with environmental conditions and the lack of information in years 3 and 4. However, it is possible to show that the crop shows an ascending behavior in the amount of seed harvested from its first year and up to the last data for which there is reference.

On the other hand, it is evident that the studies reviewed in this regard have not focused their attention on consolidating information regarding the behavior of the crop in an annualized manner, which makes it difficult to estimate a trend for the harvest of said crop.

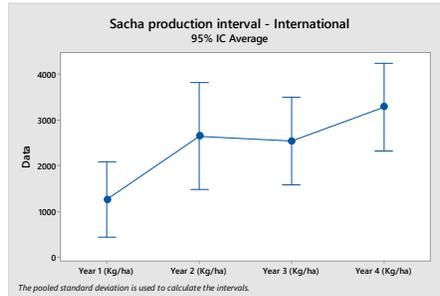


Figure 5 - Sacha production interval – International

Summary international data

S	R-cuad.	R-cuad. (ajustado)	R-cuad. (pred)
718,313	64,94%	51,79%	13,37%

Average

Factor	N	Average	Desv.Est.	IC de 95%
Year 1 (Kg/ha)	4	1.261	624	(433; 2.089)
Year 2 (Kg/ha)	2	2.647	914	(1.475; 3.818)
Year 3 (Kg/ha)	3	2.541	903	(1.584; 3.497)
Year 4 (Kg/ha)	3	3.286	496	(2.330; 4.243)

Desv.Est. agrupada = 718,313

As evidenced in Figure 5, it is possible to evidence a deviation of the data for each period of time from 496 to 914 kilos and a grouped deviation of 718,31 kilos with an R² of 64,94%.

5.2.2 National summary

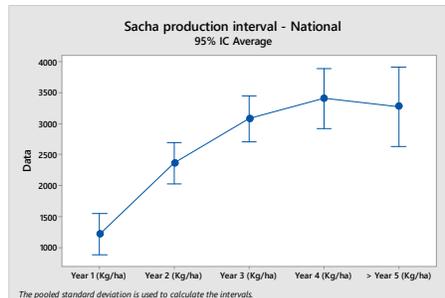


Figure 6 - Sacha production interval - National

Summary international data

S	R-cuad.	R-cuad. (ajustado)	R-cuad. (pred)
638,657	65,39%	62,50%	54,65%

Average

Factor	N	Average	Desv.Est.	IC de 95%
Year 1 (Kg/ha)	15	1212	495	(880; 1543)
Year 2 (Kg/ha)	15	2362	597	(2030; 2693)
Year 3 (Kg/ha)	12	3081	490	(2711; 3452)
Year 4 (Kg/ha)	7	3411	958	(2925; 3896)
> Year 5 (Kg/ha)	4	3275	1001	(2633; 3917)

Desv.Est. agrupada = 638,657

In the national information (figure 6) there are 54 data of total kilos per hectare from year 1 to year 5, a greater R² adjustment compared to international and departmental data of 65,39% and a lower accumulated standard deviation of 638,65 kilogram.

6. Conclusion

- Through the international review it was possible to determine the behavior per hectare that the crop presents from the beginning of its productive stage at 8 months and up to 10 years, which start with 50 kg per tree up to 800 kg per tree planted per year.
- It was also possible to establish a relationship of 1 to 3 in terms of the amount of oil extracted per kilo of seed, it should be taken into account that the above depends on the extraction method and quality of the seed.
- Through the international review it was possible to show a deviation of the data for each period of time from 496 to 914 kilos and a grouped deviation of 718,31 kilos with an R² of 64,94%.
- Through the national review it was possible to show a deviation of the data for each period of time from 490 to 1.001 kilos and a grouped deviation of 638,65 kilos with an R² of 65,39%.
- The information in the department of Cauca is scarce and does not allow a quantitative analysis to be carried out and correlate the behavior of productivity vs. the number of hectares vs. the cultivation time.
- According to the estimation of the mathematical model and the productivity forecast, a potential harvest of 29 tons of seed per year is estimated from the third year and for the rest of the useful life of the plant.

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