Supplementary material

Table 1S. Key elements for the Sacha Inchi productive model

Variables	Sub-variables	References	Objective	Conclusions
Geographic area	Crop distribution	Flores & Lock (2012)	Re-evaluate key aspects of the species and its production system.	• This species extends from the Lesser Antilles, Suriname, and the northwestern sector of the Amazon basin of Venezuela and Colombia to Ecuador, Peru, Bolivia, and Brazil. From 100 meters above sea level in lowland forests up to 2,000 m.a.s.l. in highland forests of the Amazon.
	Edaphological aspects/ requirements	Flores & Lock (2012)	Re-evaluate key aspects of the species and its production system.	• It grows in clay loam to loam soils with a pH range from 5.5 to 7.5 but tolerates well-drained acid soils. • It may be affected by light intensity and water availability.
		(Yang et al., 2016)	Analyze the plant compartment against different growth promoters.	• Optimum soil conditions are of a dark red type with a pH of 5.42 in its upper layer (0-20 cm); organic carbon 5.65% (w/v); total nitrogen 0.34 g kg^{-1}; available nitrogen 46.0 mg kg^{-1}; available phosphorus 14.1 mg kg^{-1}; and available potassium 22.0 mg kg^{-1}. • Influence on the final nutritional content of the seed.
	Climatic aspects/ requirements	Alayón & Echeverri J (2016)	Identify and evaluate the health benefits of sacha inchi consumption.	• Required temperature 10-26 °C, altitude range from 30 to 2,000 meters above sea level, and relative humidity of 78%.
		Avila-Sosa et al. (2019)	Establish the antioxidant properties of Amazonian fruits.	• Hot climates, Andean rain forests in the Amazonian lowlands of Peru.
		Lei, Y et al. (2014)	Determine the effects of cold stress on photosynthetic activity and yield.	• Yield decreased progressively and drastically after treatment with cold and moderate light by combining photoinhibition and low temperatures. Recovery occurs at 18°C.
	Approach: determination of the most suitable areas	Alayón & Echeverri J (2016)	Identify and evaluate the health benefits of sacha inchi consumption.	• Warm areas and Andean rain forests in the departments of Amazonas, Cusco, Junín, Pasco, San Martín, Loreto, and Madre de Dios in Peru.
Social environment	Sociocultural conditions	Wang et al. (2018)	Analyze and identify the nutritional and biological characteristics of the species.	• Oil and nuts are part of the traditional Peruvian diet.
	Socio-environmental conditions	Flores & Lock (2012)	Re-evaluate key aspects of the species and its production system.	• The methods used for bio trade and agroforestry avoid applying chemical pesticides for agricultural use.
		Barter (2016)		• In the absence of commercial cultivars, vegetative propagation techniques are valuable to multiply superior genotypes rapidly.
		Kodahl et al. (2018)		• The multiplication of high-quality plants can infer benefits for the local population in the native area range where the plant thrives, e.g., by generating sustainable income and shifting cultivation of illicit crops, such as *Erythroxylum coca* Lam.
		Solis et al. (2019)		• The establishment of commercial plantations generates positive environmental impacts because they can be installed on degraded soils.
	Socioeconomic conditions	Salinas & Villaba (2014)	Carry out a productive and economic study of Sacha Inchi cultivation that allows identifying the occupied area, the production, and the limitations of this crop as an ecological, sustainable, and productive option, as well as determining economic viability through financial indices.	• The crop is being adapted to a technical agricultural system to gain access to international markets. • In the Jambelí Parish, 27 Sacha inchi producers are distributed in an area of approximately 50 ha of land, with an average of 1.8 ha per producer and a monthly production of 176 kg of seed. This means that in the sector, there is a monthly harvest of 17,000 kg and an annual production of 204,000 kg, or 224 t per year. • The annual cost of the crop has an average of 3,757.00 USD per ha, and its structure is comprised of fixed investments (28%) over five years, represented by crop infrastructure. Twenty-nine percent of the components are represented for the inputs used from tillage to harvest and 43% for the family-based workforce (mostly).
		Del-Castillo, Gonzalez-Aspajo, de Fátima Sánchez-Márquez, & Kodahl, (2019)	Identify the current ethnobotanical knowledge of the oilseed plant Sacha Inchi (*Plukenetia volubilis* L.) in the regions of San Martin and Loreto in Peru.	• Respondents valued the crop highly and considered it important in traditional medicine with health benefits. The most important were cholesterol control and general and cardiovascular health improvement. • Sacha Inchi is grown mainly on plots owned by farmers, and their production is sold to intermediaries at a fixed price.

Information on the species	Origin, taxonomy, classification	Chirinos et al. (2016)	Establish the potential use of the shell as a good biocomposites active.	• Oil-bearing plant of the Euphorbiaceae family, native to the Amazon basin, perennial vines with staminate flowers located above one or a few pistillate flowers.
	Botanical description and crop life cycle	Yang et al. (2016)	Establish grafting techniques in sacha inchi for its propagation as planting material.	• Flowering occurs five months after planting. Capsule-shaped fruits (4-7 cm in diameter) contain between 4 to 7 seeds. • The use of grafting techniques contributes to constructing a protocol focused on domestication and reduces quality and loss.
		Kodahl (2020)	Develop a review of information focused on the different aspects of the production system.	• Fruit development between 8-9 months after planting.
		Chen et al., 2022	Determine the photosynthetic responses of sacha inchi seedlings to short-term waterlogging and their morphological changes after long-term waterlogging stress	• Seedlings produce adventitious roots (AR) survive after two weeks of waterlogging. Adventitious root development is one of the morphological adaptation traits that enable Sacha inchi to survive under long-term waterlogging stress. Improvement in waterlogging tolerance has considerable potential for increasing the sustainable production of Sacha inchi
	Genetic resources and varieties	Fu, Q., et al. (2018)	Analysis of the effect of applying cytokinin's on the gene expression of flowering in *P. volubilis*.	• Candidate genes provide a basis for new studies on the molecular mechanisms they regulate. • Floral development and sexual differentiation in *P. volubilis*. Further research is needed to investigate the biological role of these genes and their expression in the sex change of flowers.
		Valente, Chaves, Lopes, Oka, & Rodrigues (2017)	From the analysis of 37 accessions of *P. volubilis*, a characterization employing genetic parameters was performed, seeking fruit and seed production and quality and aiming at identifying superior accessions for reproduction purposes.	• There was no significant correlation between oil yield and fatty acid composition with any biometric trait and fruit and seed yield. This result indicates that it is possible to select both traits independently. • High heritability estimates for yield traits based on the average of accessions showed favorable conditions for selection, allowing a selective precision of 85% • There is a high genetic variability for the leading commercial traits of interest in sacha inchi, which can result in significant gains, depending on the selection procedure adopted. • Accessions with higher genotypic values are indicated for clonal propagation, as these capitalize on additive and dominance effects. These are fully transmitted to the next generation only through vegetative propagation.
		Valente, M.; Lopes, M.; Chaves, C.; Oliveira, A.; Freitas, D. (2017)	Estimate the repeatability coefficient of biometric and yield traits related to sacha inchi (*Plukenetia volubilis*) fruits and seeds and define the number of evaluations required for an efficient selection and evaluation of the species' genotypes.	• The results indicate that the principal components analysis based on the covariance matrix is the most appropriate strategy to estimate the repeatability of sacha inchi due to the cyclical behavior of the crop. The evaluation of five monthly harvests for yield traits and a minimum of five, 25, and 39 evaluations for mean fruit weight, number of seeds per fruit, and biometric seed traits, respectively, allows selecting superior genotypes with an accuracy of about 90%.
		Cardinal-McTeague, W.; Wurdack, K.; Sigel, E.; Gillespie, L. (2019)	Develop a comprehensive phylogeny for *Plukenetia* and closely related genera in the subtribe Plukenetiinae to investigate seed size, evolution, and biogeography patterns.	• *Plukenetia* was divided into two main groups, pinnate and palmate-veined. • Analyzes suggest that *Plukenetia* originated in the Amazon or Atlantic forest of Brazil during the Oligocene and migrated/dispersed between those regions and Central America/Mexico throughout the Miocene. • Transoceanic dispersals explain the pantropical distribution of *Plukenetia* from the Amazon to Africa in the Miocene, followed by Africa to Madagascar and from Africa to southeast Asia in the late Miocene and Pliocene, respectively. • A single origin of large seeds is inferred from the ancestor of *Plukenetia*. • Seed size fits a Brownian motion model of trait evolution and is moderate to strongly associated with plant size. • Changes in the biome were not determinants of seed size, although there was a weak association with a transition to fire-prone semi-arid savannas.
		Valente, M.; Lopes, M.; Chaves, F.; Pantoja, M.; Sousa, F.; Chagas, E. (2017)	Evaluate the genetic diversity between and within sacha inchi progenies and determine the rate of outcrossing using AFLP molecular markers to provide information for conservation and breeding programs.	• AFLP markers revealed a high degree of polymorphism and proved to be a useful and reliable tool to characterize genetic diversity in sacha inchi progenies. • AFLP markers were very informative for evaluating the reproductive system of sacha inchi. • The results highlight the need to apply biometric models that consider the existence of different relationships within the progenies and the need for large samples to conserve genetic variability. • *P. volubilis* exhibited a low level of self-fertilization, leading to the expectation that natural populations retain high genetic variability.
		Ocelák, M.; Hlásná, P.; Viehmannová, I.;	Evaluate genetic variability within the species using ISSR markers	• The cluster analysis and a PCoA successfully identified diversity between samples from different locations.

		Dvořáková, Z.; Huansi, D.; Lojka, B. (2015)		• The study revealed differences between samples from abandoned or older growing sites and new plantations regardless of geographic distance. • Presumably, genetic diversity is strongly influenced by the anthropological effect, and the forms of distribution are connected with the activities. • Knowing the current level of genetic variability in the place of origin of the crop is essential for future research, crop breeding, and adequate conservation management.
		Kodahl (2020)	Develop a review of information focused on the different aspects of the production system.	• Recently created breeding programs based on selecting seeds by size for new plantations or restoring others.
		Delgado et al. (2022)	Increase the efficiency of genetic improvement programs through the estimation of indirect genetic gains	• Progenies with a greater number of fruits per plant and total fruit weight provide greater genetic gain and can be used in the establishment of open-pollinated clonal systems to achieve an improved population.
		Kodahl & Sørensen (2021)	Re-evaluate key aspects of the species and its production	• Use of vegetative propagation through cuttings and grafting to reduce the time for flowering and obtaining genetically identical plants
		Villanueva-Corrales et al. (2021)	Generate molecular methods to characterize species and recognize ecotypes.	• A useful molecular marker was found to differentiate interspecific relationships between cultivars, contributing to the knowledge of the genetic diversity of ecotypes and thus to the genetic improvement of the species.
		Bataller et al. (2023)	Evaluate the ozonation effects on germination and disinfection of Sacha inchi seeds.	• The applied treatments did not cause negative effects on seed quality or germination. The lower the ozone concentration, the higher the percentage of germination and vigor. Disinfection allowed the microbial load to be reduced.
		Flores & Lock (2012)	Re-evaluate key aspects of the species and its production system	• Availability of the Germplasm Collection of Peru (41 ecotypes) and the Germplasm Bank of Brazil in the custody of Embrapa.
Nutritional value	Oil quality	Xiaojuan et al. (2012)	Perform transcriptome assembly and gene expression profiling for the identification of genes involved in high accumulation of unsaturated fatty acids (FA)	• Images that may be involved in the *de novo* biosynthesis of FA and triacylglycerol were identified. In particular, several unigenes encoding desaturases for the formation of unsaturated fatty acids were identified, with high levels of expression at the fast oil accumulation stage compared to the early stage of seed development. • This study provides the first comprehensive dataset characterizing gene expression in Sacha Inchi at the transcriptional level. • The analysis facilitates understanding the molecular mechanisms responsible for the high accumulation of unsaturated fatty acids (especially α-linolenic acid) in Sacha Inchi seeds. • The data provide the basis for further studies on the molecular mechanisms underlying oil accumulation and polyunsaturated fatty acids (PUFA) biosynthesis in Sacha Inchi seeds.
		Avila-Sosa et al. (2019)	Profile analysis	• Content of linoleic and linolenic acids, tocopherols, phytosterols, stigmasterol, phenolic compounds, flavonoids, and tannins. • Percentages of omega 3 and 6 fatty acids in the seed of 45.2 and 36.8, respectively.
		Kong et al. (2023)	Oil extraction techniques to achieve a high oil recovery. Heat-based methods, which led to compromised oil quality and reduced nutritional values. Hydraulic cold-pressed extraction (HCPE) technique for extracting SIO aiming to enhance oil yield while preserving its nutritional integrity	• Constant temperature of 25 +/- 1 °C, pressures and pressing times were varied within the range of 30–50 MPa and 10–30 min. • Highest oil recovery of 86.31 wt.% on a wet basis achieved at 50 MPa for 30 min. • HCPE exhibited similar efficiency in extracting SIO, offering additional advantage in terms of its cold-pressed condition vs. thermal and solvent extraction methods.
		Rodríguez-Cortina et al. (2022)	Sacha inchi oil microcapsules Spray and freeze-drying technologies. Reduce oxidation processes	• The droplet size is of vital importance for an emulsion since it influences the texture and stability, associating a uniform and small particle size. • All the factors and their interactions had a significant effect on the droplet size, especially the velocity of emulsion. • Both spray- and freeze-drying are regarded as efficient tools to design controlled release delivery systems for sacha inchi emulsions encapsulation. • Its greater scalability and lower operating costs, spray-drying proved more versatile than freeze-drying

Technical recommendations for management	Multiplication of plant material	Kodahl (2020)	Develop an information review focused on the different aspects of the production system.	• It is multiplied by cuttings or seeds; seeds germinate at temperatures between 25 and 30°C. Exogenous applications of cytokinin or 6-benzyl adenine are used to increase inflorescence by 26.9%
		Henao-Ramírez et al. (2022)	Evaluation of a protocol for germination and in vitro micropropagation of Plukenetia volubilis (sacha inchi) seeds.	• The in vitro germination protocol allowed obtaining high germination percentages, reducing the seedling production time. The authors report a possible usefulness to overcome seed dormancy. The micropropagation protocol is considered feasible for inducing explants from axillary buds.
		Van Q.V et al. (2022)	Evaluate seeds of sacha inchi (Plukenetia Volubilis L.) of the S18 variety copyrighted by the Ministry of Agriculture and Rural Development of Vietnam, collected in different ecological regions of the country.	• Based on agronomic, health and performance evaluation parameters, they indicated that this variety takes between 108 and 125 days from sowing to flowering and fruiting; and 123 to 125 days between fruiting and ripening and between 244 and 250 days from sowing to harvest. The evaluation results showed that sacha inchi lines collected in Thanh Hoa and Tuyen Quang provinces are the best
		Luna Murillo & Bustamante Castillo (2011)	Check the action of the Naphthalene Acetic Acid (NAA) hormone in Sacha Inchi seed germination.	• The best benefit/cost ratio was achieved with the concentration of 50 and 100 mg of ANA. The highest plant height was obtained with 100 mg of ANA. The best root weight and the number of leaves were recorded with a concentration of 750 mg of ANA. The highest root length was recorded with 1,500 mg of ANA. The number of roots and the weight of leaves obtained the highest values with 2,000 mg of ANA. The control treatment reported the highest stem weight.
		Kodahl, N.; García-Dávila, C.; Cachique, D.; Sørensen, M.; Lütken, H. (2018)	Development of an *in vitro* germination protocol for *P. volubilis* aimed at facilitating the production of material from interspecific crosses, accelerating plant regeneration after crossing, and increasing germination rates.	• The protocol developed in the study was successful and allowed 100% *in vitro* germination of *P. volubilis* seeds without the presence of contamination in the growth medium. The plants obtained were transferred to the field 12 weeks after inoculation, establishing themselves completely.
		Solis, R.; Gonzales, N.; Pezo, M.; Arévalo, L.; Vallejos-Torres, G. (2019)	Evaluation of rooting methods for juvenile cuttings of the species in micro tunnels to obtain plants with superior genetic traits and shorten production cycles.	• The use of Jiffy pellets, a nebulized irrigation per day, 8 cm long stakes with 75 cm^2 of leaf area, and 2,000 ppm of indole-3-butyric acid (IBA) induce high rooting percentages (93.3%) and the best root development in the vegetative propagation of sacha inchi.
		Cardoso, De Obolari, e Borges, Da Silva, & Rodrigues (2015)	Evaluation of seed germination, seedling survival, and growth of this species under different substrate, light, and temperature conditions.	• Germination is stimulated by substrates with greater surface contact with the seeds, the presence of light, and temperatures between 25 and 35°C. Vermiculite, continuous light, and a temperature of 30°C favor initial seedling growth. These conditions allow rapid and uniform germination of seeds and better establishment and development of seedlings.
		Da Silva, G.; Vieira, V.; Boneti, J.; Melo, L.; Martins, C. (2016)	Evaluation of the effect of temperature and substrate on the germination of *P. volubilis* seeds	• The ideal temperature range for the germination of *P. volubilis* is between 25 and 30°C. The temperature of 20°C is the minimum for germination, and temperatures above 35°C, are lethal for these seeds. The most favorable substrate for the germination *of P. volubilis* seeds is fine or micronized vermiculite.
		Kodahl et al. (2018)	Evaluate viability in *P. volubilis* grafts and determine the most efficient grafting method and protection system.	• There were no significant differences in the percentage of graft unions formed, mortality percentage, number of shoots, length of shoots, and diameter of shoots between the grafting techniques. • The protection systems showed significantly different results. The protection of grafted plants with a plastic bag resulted in 100% graft union success and 0% mortality, significantly different from the 42.5 and 22.5% graft union success from plants without protection or with the graft union covered by paraffin, respectively. In addition, the plants protected with a plastic bag had an average of 2.23 shoots, which were, on average, 8.17 cm long, compared to 1.36 and 1.66 shoots of 5.21 and 2.77 cm in length of unprotected and paraffin-protected plants, respectively.
	Land preparation	Yang et al. (2016)	Establish grafting techniques in sacha inchi for its propagation as planting material.	• The type of soil where the experiment was carried out was a Lithosol. Before planting, the soil was processed with hoes, and mounds were made.
		Vitar et al. (2023)	Determine the response to light intensity and the effect of soil water availability on the rate of photosynthesis of P. volubilis	• Tolerance to drought, that allowed them to still be alive for several weeks with a reduced water level in the soil (0.033 m3 m-3). • Adaptability to dry seasons, also resistance to water deficit, and a suitable reaction of the photoinhibition mechanism to prevent the photosynthetic apparatus from being damaged.

		Nur Suraya et al. (2023)	Determine the ideal medium composition through the application of NPK and biochar as soil amendments in the planting medium	• The use of biochar is also one of the alternatives to reducing the negative impact of inorganic fertilizer use and is beneficial to the environment. • 2.47g NPK+99.92g biochar. • Additional research is required on the examination of the nutritional composition of oil and nutrients in soil and leaves
	Planting: times and systems	Yang et al., 2014	Determine the effect of different planting densities and NPK fertilizer doses on yield.	• A planting density of approx. 4,444 plants per ha were necessary to guarantee the maximum yield of seeds and oil, regardless of the level of fertilizer. *P. volubilis* plants require relatively high fertilizer application rates to achieve their maximum seed and oil yields.
		Fu et al. (2014)	Determine the effect of the application of cytokinin's on the flowering of *P. volubilis*	• Cytokinin's may play an essential role in developing female flowers of *P. volubilis*. Therefore, there is great potential to use this plant growth regulator to improve the fruit yield of *P. volubilis* by increasing the number of female flowers.
		Pezo et al. (2019)	Evaluate the effect of gibberellic acid on the yield of adult sacha inchi plants.	• The treatment of 60 mg L^{-1} of gibberellic acid and 5 ml L^{-1} of TRIGGRR showed the highest number of fruits and the highest weight of capsules and seeds. In addition, the highest yield per hectare (1,278) and a difference of 437 kg ha^{-1} with the control was registered.
		Yang et al. (2016)	Investigate the effects of growth regulators on plant physiology, growth, and yield of *P. volubilis* plants during a growing season.	• Growth regulators significantly affected seed size (weight) and seed oil content with gibberellic acid (GA_3), kinetin (KIN), and indole acetic acid (IAA), while high seed oil content was found with abscisic acid (ABA) and salicylic acid (SA) on different sampling dates. • The specific leaf area was reduced for all treatments without a statistical difference; the stomatal opening was lower for ABA, KIN, and SA and higher for GA_3 and IAA.
		Cai et al. (2013)	Investigate the effects of plant density on the growth, fruit yield, and seed quality of *P. volubilis* during a growing season.	• The three plant densities did not affect photosynthesis, stomatal conductance, respiration, and water use efficiency (WUE). • Low densities decrease leaf area and leaf area ratio. The number of fruits per unit area and the dry matter (DM) of fruits and flowers per plant (males and females combined) decreased, while the estimated source: sink ratio increased at high planting density. • Fruit size (DM per fruit) in *P. volubilis* plants did not differ between the three plant densities in different samplings. Therefore, increasing the number of fruits produced by hectare may be one of the most effective ways to increase fruit yield and oil production in *P. volubilis* plants. • As plant density increases, the number of fruits and yields on the plot increases. In general, the oil content of seeds increases with increasing population density.
		Cai et al. (2012)	Develop a comparative analysis of sacha inchi leaf physiology, growth, and chemicals by the combined effects of altitude and season.	• Altitude and seasons influenced leaf photosynthesis, biomass, seed yield, and quality. The photosynthetic rate decreased with altitude increase in the cold and dry season. Plant biomass production and fruit yield were highest at lower altitudes and decreased dramatically above 900 m.a.s.l. However, the seeds presented more linolenic and unsaturated fatty acids at higher altitudes. Similar behavior was expressed in the cold season. • Further studies should be conducted to determine the environmental factors that affect plant growth and development to predict and simulate yield and oil quality interactions.
		Cai (2011)	Investigate the variation in the flowering phenology of *P. volubilis* during eight months regarding the light gradient and relate the results to growth, fruit yield, and photosynthetic activity.	• *P. volubilis* plants grown in low light (20-52% of full sunlight) required more time to achieve initial flowering than those grown in high light (75–100% of full sunlight). The photosynthetic rate (A_{max}) of plants grown in the open site was 1.4 times higher than that of plants grown in 20% full sunlight. Their maximum photosynthetic capacity and relative growth rate (RGR) were very similar to those of pioneers with strong phenotypically plastic responses to light variation; photosynthetic capacity, RGR, and total biomass increased continuously with increasing irradiance, differing from the results of most shadow studies. It is similar to many other woody shade plants, significantly. • Increase in specific leaf area and proportion of leaf area. Shading did not affect apparent quantum efficiency (AQY), dark respiration rate (Rd), and light compensation point (LCP); AQY is high, and, therefore, it was suggested that *P. volubilis* is strongly adapted to high light conditions.
	Fertilization	Perez Caro et al. (2018)	Evaluate the response of *Plukenetia volubilis* L. to the application of vermicompost (bio input) and vesicular-arbuscular mycorrhizal fungi in the municipality of Ciénaga de Oro, Córdoba, Colombia.	• The application of commercial vesicular-arbuscular mycorrhizae increased growth and stimulated the emission of female, fertilized, and male flowers in *P. volubilis* plants. • Applying vermicompost to *P. volubilis* plants is not an efficient alternative to promote growth, development, and flowering.

		Solis et al. (2019)	Evaluate the growth characteristics of legume species for their use as cover crops and determine their influence on sacha inchi yield.	• *Canavalia* and *Centrosema* can be established when cultivating sacha inchi because they cover the soil in less time, control weed growth from the third month after their establishment, protect the soil from erosion, and protect sacha inchi plants from hydric stress. • *Centrosema* showed better results in improving soil fertility through nutrient cycling, higher foliar biomass, and adequate root development. The N content in the soil was higher, positively influencing sacha inchi yield. It has higher efficiency in N_2 fixing capacity, representing an extra supply of N, and contributes to the N cycle. It is better adapted to the tropical region and has greater specificity with bacteria of the *Rhizobium* genus. • The higher biomass production and nutrient concentration in cover crops facilitate the recovery of soil fertility in various agricultural systems. • The main agricultural crops associated with cover crops are a viable alternative, compared to monocultures, considering that the yield of sacha inchi increased by 18.2% when associated with *Centrosema* and compared to the control treatment.
		Corazon-Guivin et al. (2022)	Identify changes in the species composition of the arbuscular mycorrhizal (HMA) community in various substrates mixed with soil.	• The species composition of the AMF community varied among the substrates; however, there were no differences in species richness.
		Yamuangmorn et al. (2022)	Determine the response of early vegetative growth of sacha inchi to boron supply, to identify boron deficiency symptoms, and to define leaf boron concentrations for optimum growth	• Boron deficiency strongly inhibited root and shoot development causing stunting and organ malformation. Inadequate boron supply retarded root and shoot growth in sacha inchi. The leaf boron concentration for 90% maximum yield was 27–29 mg by Kg dry weight.
		de la Sota Ricaldi et al. (2023)	To study the beta diversity patterns of arbuscular mycorrhizal (AM) fungal communities associated with sacha inchi (Plukenetia volubilis) after crop establishment.	• Beta diversity increased in older plots, but no temporal effect was found on alpha or phylogenetic diversity and that AM fungal composition was determined by factors such as altitude and soil. A recovery of the microbiota in the soil is observed after the establishment of the crop, which could be associated with low-impact management.
		Nur Suraya. Et al (2023)	Determine the ideal medium composition through the application of NPK and biochar as soil amendments in the planting medium	• The use of biochar and NPK fertilizers in medium planting improved most of • the growth parameters of Sacha inchi. Soil medium supplemented with 99.92g biochar and 2.47g NPK fertilizer was found effective in increasing and promoting the growth of Sacha inchi
	Irrigation: sources and type	Gong et al. (2018)	Evaluate the response of seedlings and adult plants to different types of irrigation	• Seedlings were more sensitive to water deficit than adult plants. • Full irrigation is optimal for faster seedling growth at the expense of water use efficiency. • The magnitude of the increase in total seed and seed oil yield per type of fertilization was similar under different irrigation regimes.
		Geng et al. (2017)	Provide a better understanding of irrigation and fertilizer management for this species both locally and regionally, and, thus, increase seed and oil yields for commercial-scale oil production.	• Irrigation of up to 100% crop evapotranspiration in the dry season might be advisable to achieve high yield and efficiency in agricultural nutrient use at the expense of water use efficiency. • The number of seeds (fruits) per unit area was largely responsible for the total seed oil yield of Sacha Inchi plants. • Carbon storage may be an active process that occurs at the expense of growth, while carbon and N shortages during periods of reproductive growth affect final seed yield under drought conditions. • Water deficit can save water but reduces yield and requires more fertilizer, compared to irrigation of up to 100% crop evapotranspiration and full irrigation, which had higher total seed oil yield and agricultural nutrient use efficiency, but reduced water use efficiency. Moderate and severe water deficit applied in the dry season is not successful in increasing total seed yield or total seed oil yield during the growing seasons of Sacha Inchi plants in tropical humid monsoon areas.
		Jiao et al. (2012)	Provide a better understanding of the water and fertilizer management needs of this species both locally and regionally.	• Natural drought reduced photosynthetic leaf rate, flower, and fruit production and increased fruit abortion in *P. volubilis* plants, reducing seed yield, although effects on leaf traits seemed to be short-term. • Irrigation and NPK fertilization during the dry season did not significantly affect the seed quality of a season. However, natural drought is the main factor that progressively limited plant growth and reduced immediate and subsequent season seed yields.

				• Irrigation during the dry season is one of the critical management strategies in southeastern Yunnan province to obtain high yields of *P. volubilis* plants.
		Wang et al. (2018)	Addressing the questions: How does the cultivation of sacha inchi in areas with different land use histories affect the abundance and diversity of soil microbes? What environmental factors are related to changes in the structure of the soil's microbial community?	• Considering the five fields with different land use in which sacha inchi was later planted, it was identified that the previous crops had an important impact on the microbial community of the soil. The highest abundance of bacterial and fungal genes was observed in sacha inchi soils previously cultivated with maize. The total number of copies was higher in rhizosphere soils than in bulk soils. • The structure of the soil microbial community was affected by the chemical properties of the soil. Total N and pH were significantly related to the composition of the bacterial and fungal communities.
		Wiriya et al. (2020)	Investigate the abundance and diversity of viable bacteria and Arbuscular mycorrhiza (AM) fungi that inhabit the rhizospheres of dried fruits and sacha inchi.	• The number of AM spores is affected by plant species and soil characteristics. • Two classes of rhizobacteria were identified in the rhizosphere of physical dried fruits of sacha inchi: Alphaproteobacteria (*Ensifer* sp. and *Agrobacterium* sp.) and Gammaproteobacteria (*Raoultella* sp. and *Pseudomonas* spp.), and three classes in the rhizosphere: Actinobacteria (*Microbacterium* sp.), Betaproteobacteria (*Burkholderia* sp.), and Gammaproteobacteria (*Pantoea* sp.). • Four genera were identified in sacha inchi rhizospheres (*Acaulospora*, *Claroideoglomus*, *Glomus*, and *Funneliformis*) and two genera in dry rhizospheres (*Acaulospora* and *Glomus*). • Microbial treatments increased stem length and diameter and chlorophyll content in both crops. CM1-RB003 and CR1-RB056 also increased the number of leaves in sacha inchi. In physical nuts, the consortium increased root colonization by AM fungi and the number of spring AM spores compared to those observed in sacha inchi. • The abundance and diversity of AM fungi probably depend on plant species and soil characteristics. Pot experiments showed that rhizosphere microorganisms were the key players in developing and growing physical nuts and sacha inchi.
		Cai et al. (2021)	Elucidate physiological and yield traits in response to defoliation (reduce source) or desolation (reduce sink), applied in an intensively cultivated *P. volubilis* plantation at the beginning of the rainy season.	• Carbohydrate reserves buffer sink-source imbalances that may result from a temporary adjustment in demand for assimilates or deficiencies in carbon assimilation. • Defoliation is disadvantageous for the yield and accumulation of carbohydrates and lipids in fruits of *P. volubilis* plants.
		Tian et al., 2013	Investigate the effects of arbuscular mycorrhizal fungi (AMF) inoculation on plant growth and drought tolerance in seedlings of a promising oilseed crop, Sacha Inchi (*Plukenetia volubilis* L.), under well-irrigated or drought conditions.	• AMF colonization significantly improved the growth of Sacha Inchi seedlings, and the highest development was achieved in double-inoculated plants under well-irrigated conditions. • *G. versiforme* was more efficient than *P. occultum.* Plants inoculated with both symbionts had significantly higher specific leaf area, leaf area ratio, and root volume than uninoculated control treatments, *G. versiforme*, and *P. occultum* alone, indicating a synergistic effect on the inoculation of two AMF. • Photosynthetic rate and water use efficiency were stimulated by AMF but not by stomatal conductance. • AM fungus inoculation increased the activities of antioxidant enzymes, reducing hydrogen peroxide accumulation and oxidative damage, especially under drought-stress conditions. • The accumulation of proline might not serve as the main compound for the osmotic adjustment of the studied species. • AMF inoculation stimulated growth and improved tolerance to drought in Sacha inchi seedlings through alterations in morphological, physiological, and biochemical traits. This microbial symbiosis could be an effective cultivation practice to improve the yield and development of Sacha Inchi plants.
	Weed	Solis et al. (2019)	Evaluate the growth characteristics of legume species for their use as cover crops and determine their influence on sacha inchi yield.	• *Centrosema* and *Canavalia* were the most appropriate legume cover crops to control weed growth and protect soil from erosion
	Pests	Nisa et al. (2018)	Study the diversity and role of arthropods in Sacha inchi cultivation.	• The arthropods found in the sacha inchi plantations consisted of 75 families from 13 orders: Araneae, Ephemeroptera, Odonata, Orthoptera, Blattaria, Isoptera, Hemiptera, Homoptera, Thysanoptera, Coleoptera, Diptera, Lepidoptera, and Hymenoptera. • The arthropods present in sacha inchi crops are 8% pests, 10% natural enemies (predators and parasitoids), and 82% others (decomposers and pollinators).

				• The diversity of arthropods in sacha inchi plantations is in the low category with a Shannon diversity index value of 0.692 and a uniformity index of 0.164, i.e., uniformity is low (high dominance). • Identifying arthropods down to the species level is necessary to identify their more profound roles in Sacha inchi cultivation.
		Rodríguez Hernández & Hernández-Ochandía (2020)	Determine the existence of root-knot nematodes in mulberry (*Morus alba* L.) and sacha inchi (*Plukenetia volubilis* L.) plantations, and establish the presence of *Meloidogyne* in *Vernonia cinerea* L.	• The morphological characteristics of the perineal patterns suggest the presence of *Meloidogyne incognita* (Kofoid and White) Chitwood and *Meloidogyne arenaria* (Neal) Chitwood in mulberry; *M. arenaria* in sacha inchi and *M. incognita* and *Meloidogyne enterolobii* Yang & Eisenback (syn. jun. *Meloidogyne mayaguensis* Rammah and Hirschmann) in *V. cinerea*.
		Márquez-Dávila, K.; González, R.; Arévalo, L.; Solís, R. (2013)	Determine the response of five accessions of sacha inchi (*Plukenetia volubilis* L.) to the infestation of the nematode *Meloidogyne incognita* under controlled conditions.	• The Mishquiyacu and Chazuta accessions show tolerance to *M. incognita* and can be used in future studies on integrated management of sacha inchi cultivation.
		Guerrero-Abad et al. (2021)	Combined infection of the root knot nematode *Meloidogyne incognita* and two *Fusarium* species led to high plant mortality of Inka nut	• The synergistic interaction of M. incognita and especially F. verticillioides demonstrates a lethal outcome for inka nuts. • *M. incognita* creates favorable conditions that lead to enhanced effect and damage by the Fusarium species. • Meloidogyne incognita inoculum were removed from galled inka. • Isolation and multiplication of Fusarium spp from roots collected from inka nut plants showing typical symptoms of the disease complex. nut roots. • The combination of *M. incognita* and *F. verticillioides*, however, appears to be particularly deadly, with half of test plants killed after just three months growth,
		Nie et al. (2021)	Effects of strip intercropping of Sacha Inchi/Chinese leek of 3-4 years on the seasonal dynamics of plant and soil traits in tropical China	• Intercropping greatly suppressed *M. javanica* populations which may be associated with the indigenous microbe induced-suppressiveness. • Intercropping did not affect microbial richness and α-diversity in the rhizosphere, except for the decreased fungal richness. • Intercropping suppressed *M. javanica* populations and shifted microbial compositions (especially decreased pathogen-containing *Fusarium*)
	Diseases	Yang, L. Y., et al. (2017)	Identify the causal agent of vascular wilt	• First report of grapevine wilt disease caused by *Fusarium solani* in Sacha Inchi in China
		Wang, G, F. et al, 2018	Identify the causal agent of the sacha inchi wilt symptom	• First report of *R. pseudosolanacearum* phylotype I sequevar 34 causing bacterial wilt of Sacha inchi in China and around the world. These findings of disease strains may help develop effective strategies for disease control in sacha inchi.
		Wang et al. (2019)	Identify the causal agent of stem rot in Sacha inchi.	• First report on stem rot by *M. phaseolina* of Sacha inchi in China. The Sacha inchi pathogen library was enriched, and the development of disease management strategies was promoted.
	Harvest	Chirinos et al. (2016)	Establish the potential use of the shell as a good source of biocomposites	• Manual harvest of ripe fruit from all *P. volubilis* plants during the fruit ripening period.
		Supriyanto et al. (2022)	Find the right cultivation conditions to develop Sacha Inchi. Determine the adaptability of Sacha Inchi to different cultivation conditions and the effects of these conditions on seed production and oil quality	• Seed production in the open area was higher than in mixed culture or agroforestry systems. • Highest oil yield from monthly harvesting was found in mixed cultures. • Omega-3 content in the agroforestry condition was higher compared to other conditions. Omega-6 and Omega-9 content in the open area was higher compared to other conditions. • The cultivation of Sacha Inchi under open areas is recommended due to its seed productivity which will affect the total oil production.
		Van et al. (2022)	Variety S18 was copyrighted by Ministry of Agriculture and Rural Development of Vietnam in 2019 as a special medicinal plant variety	• Collected sacha inchi lines have a time from sowing to flowering and fruiting of 108–125 days, a fruiting to ripening of 123–125 days, and a time from sowing to harvesting the first batch of 244–250 days. • Annual harvest is carried out at two main times: May–June and November–January. • Yield of the first two periods is high (2.66–3.07 tons per hectare)

		Flores & Lock (2012)	Re-evaluate key aspects of the species and its production system	• Seed harvest is done manually not to affect plant integrity.
	Postharvest	Wang et al. (2018)	Analyze and identify the nutritional and biological characteristics of the species	• Specific techniques to determine phenolic compounds, antioxidant capacity, lignin, flavonoids, free tannins, and gualatins (tocopherols)
		Sharma et al. (2023)	Deep eutectic solvents (DESs) have been regarded as potential green alternatives to conventional organic solvents for protein extraction from press cake biomass Sacha inchi seed meal (SIM).	• High number of protein-rich precipitates was obtained from the SIM biomass by sequential ultrasound-ChCl/glycerol and ultrasound-NaOAc/urea. • Ultrasound-DES is an environment friendly protein extraction method from sacha inchi oilseed cake with the potential for reprocessing of by-products in the food industry. • Extracted protein showed high solubility at alkaline pH and better in-vitro enzyme digestibility
		Cruz-Tirado et al. (2023)	Low-cost and portable Near Infrared (NIR) spectrometer to authenticate pure sacha inchi oil from adulterated one with cheaper oils	• Chemometric tools are necessary to analyze multivariate NIR signals and developing classification/authentication models. • Data Driven Soft Independent Class Analogy (DD-SIMCA)) for data analysis. • Regions associated with unsaturated fatty acids promote the differentiation between pure SI oil samples and blends.
		Chirinos et al. (2016)	Establish the potential use of the shell as a good biocomposites active	• Use of the nutshell as biomass, for the extraction of bioactive compounds (polyphenols and tannins) and the formulation of nanoemulsions. • Fractions of bioactive compounds such as condensed tannins indicate potential antioxidant activity. • Potential for use in the food and pharmaceutical industries. • Variation in the lipid composition of seeds depends on several factors, including genetics and growing conditions (e.g., suitability and temperature), processing (e.g., roasting before extraction), and extraction conditions (e.g., subcritical extraction temperature and pressure with n-propane)
	Commercialization and Marketing	Alayón & Echeverri (2016)	Identify and evaluate the health benefits of sacha inchi consumption	• A productive system with an agro-industrial orientation, alternative cultivation, and a valid option for developing peasant communities.
		Kodahl et al. (2018)		• Commercialization as peanuts and oil with nutraceutical properties and health benefits in its consumption, in addition to differential sensory properties. • Approximate distribution of oil products (42.34%), powder (12.73%), snacks (5.37%), toasted (2.85%), capsules (1.79%), and cosmetic (0.10 %). • *Plukenetia volubilis* has excellent commercial potential, but until now, reproduction and genetic breeding have been extremely limited.
		Solis et al. (2019)		• Its commercial exploitation is still incipient because no varieties have been developed, it is susceptible to the root-knot nematode (*Meloidogyne incognita*) –the main disease– and it has a broad genetic, morphological, and phytochemical variability.
		Ramos-Escudero et al. (2021)	Authenticity evaluate of the Sacha inchi oil by means of characterization of phenols, volatile compounds, and sensory profile	• Liquid chromatography-electrospray ionization-time of flight/mass spectrometry (HPLC-ESI-TOF/MS) and headspace solid phase microextraction combined with gas chromatography and mass spectrometry (HS-SPME/GC-MS). • 16 volatile compounds may have a significant influence upon overall perceived flavor and odor of the commercial Sacha inchi oils.
		Preciado Ramírez et al. (2021)	Analyze the conditions presented by the market for vegetable oil from oleaginous seeds	• Turbulence, gross entry, gross exit and net entry, incur as market conditions for the national demand for Sacha Inchi. • Sacha Inchi its prioritized as an alternative source of African palm oil derivatives.
		Ocelák et al. (2015)		• It is a potential crop, economically efficient, with great possibilities for industrialization.