



ENVIRONMENTAL SUSTAINABILITY OF THE QUINOA (CHENOPODIUM QUINOA) PRODUCTION CHAIN IN THE INCLÁN-TACNA DISTRICT, PERU

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ABSTRACT

Objective: The objective of this research was to evaluate the factors involved in the sustainability of the quinoa production chain in the Inclán district, Tacna province and department.

Theoretical Framework: Various studies have addressed quinoa cultivation, but often omit critical aspects of sustainability in the production chain. Agricultural sustainability is essential for preserving natural resources and maintaining biodiversity.

Method: The research adopted a quantitative, descriptive approach using a non-experimental design. The sample included 144 quinoa producers from the project "Strengthening and Development of the Quinoa Production Chain in the Inclán District", selected for accessibility. A survey of 27 items, grouped into 9 dimensions with dichotomous responses, was used. The dimensions were organized into three sustainability criteria: soil life conservation, erosion risk, and biodiversity management.

Results and Discussion: The results showed a critical level of sustainability in soil life conservation and erosion risk, while biodiversity management showed a low level. These issues are attributed to monoculture practices, excessive use of agrochemicals and heavy machinery, and the lack of proper seed management.

Research Implications: The findings highlight the need to shift conventional agricultural practices towards more sustainable methods to mitigate negative impacts on biodiversity and natural resources.

Originality/Value: This study provides a comprehensive assessment of sustainability in quinoa production, highlighting critical areas that require attention to improve agricultural sustainability.

Keywords: Sustainability, Quinoa, Production Chain, Tacna, Ecology.

SUSTENTABILIDADE AMBIENTAL DA CADEIA PRODUTIVA DA QUINOA (CHENOPODIUM QUINOA) NO DISTRITO DE INCLÁN-TACNA, PERU

RESUMO

Objetivo: O objetivo desta pesquisa foi avaliar os fatores envolvidos na sustentabilidade da cadeia produtiva da quinoa no distrito de Inclán, província e departamento de Tacna.

Referencial Teórico: Diversos estudos têm abordado o cultivo da quinoa, mas muitas vezes omitem aspectos críticos de sustentabilidade na cadeia produtiva. A sustentabilidade agrícola é essencial para preservar os recursos naturais e manter a biodiversidade.

Método: A pesquisa adotou abordagem quantitativa, descritiva, com desenho não experimental. A amostra incluiu 144 produtores de quinoa do projeto "Fortalecimento e Desenvolvimento da Cadeia Produtiva de Quinoa no Distrito de Inclán", selecionados por acessibilidade. Foi utilizado um levantamento de 27 itens, agrupados em 9 dimensões com respostas dicotômicas. As dimensões foram organizadas em três critérios de sustentabilidade: conservação da vida do solo, risco de erosão e gestão da biodiversidade.

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Resultados e Discussão: Os resultados mostraram um nível crítico de sustentabilidade na conservação da vida do solo e no risco de erosão, enquanto a gestão da biodiversidade mostrou um nível baixo. Estas questões são atribuídas às práticas de monocultura, ao uso excessivo de agroquímicos e maquinaria pesada e à falta de gestão adequada de sementes.

Implicações de investigação: As conclusões destacam a necessidade de mudar as práticas agrícolas convencionais para métodos mais sustentáveis para mitigar os impactos negativos na biodiversidade e nos recursos naturais.

Originalidade/Valor: Este estudo fornece uma avaliação abrangente da sustentabilidade na produção de quinoa, destacando áreas críticas que requerem atenção para melhorar a sustentabilidade agrícola.

Palavras-chave: Sustentabilidade, Quinoa, Cadeia Produtiva, Tacna, Ecologia.

SOSTENIBILIDAD AMBIENTAL DE LA CADENA PRODUCTIVA DE LA QUINUA (CHENOPODIUM QUINOA) EN EL DISTRITO DE INCLÁN-TACNA, PERÚ

RESUMEN

Objetivo: El objetivo de esta investigación fue evaluar los factores involucrados en la sostenibilidad de la cadena de producción de la quinua en el distrito de Inclán, provincia y departamento de Tacna.

Marco Teórico: Diversos estudios han abordado el cultivo de la quinua, pero a menudo omiten aspectos críticos de la sostenibilidad en la cadena de producción. La sostenibilidad agrícola es esencial para preservar los recursos naturales y mantener la biodiversidad.

Método: La investigación adoptó un enfoque cuantitativo y descriptivo, utilizando un diseño no experimental. La muestra incluyó a 144 productores de quinua del proyecto "Fortalecimiento y Desarrollo de la cadena de producción de quinua en el distrito de Inclán", seleccionados por accesibilidad. Se utilizó una encuesta de 27 ítems, agrupados en 9 dimensiones, con respuestas dicotómicas. Las dimensiones se organizaron en tres criterios de sostenibilidad: conservación de vida en el suelo, riesgo de erosión y manejo de biodiversidad.

Resultados y Discusión: Los resultados mostraron un nivel crítico de sostenibilidad en la conservación de vida en el suelo y el riesgo de erosión, mientras que el manejo de biodiversidad presentó un nivel bajo. Estos problemas se atribuyen a prácticas de monocultivo, uso excesivo de agroquímicos y maquinaria pesada, y la falta de manejo adecuado de semillas.

Implicaciones de la Investigación: Los hallazgos subrayan la necesidad de cambiar las prácticas agrícolas convencionales hacia métodos más sostenibles para mitigar los impactos negativos en la biodiversidad y los recursos naturales.

Originalidad/Valor: Este estudio proporciona una evaluación integral de la sostenibilidad en la producción de quinua, destacando áreas críticas que requieren atención para mejorar la sostenibilidad en la agricultura.

Palabras clave: Sostenibilidad, Quinoa, Cadena Productiva, Tacna, Ecología.

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1 INTRODUCTION

Quinoa (*Chenopodium quinoa*) is a whole grain cereal whose cultivation, of Andean origin, has experienced domestication since pre-Inca times and then widespread its use throughout the territory included in the Inca empire and continues to this day; This is due to the great nutritional value that the crop in question has and because it is a highly beneficial alternative to contribute to food security and support in areas where there are limitations in food productivity (Calla, 2012).

Now, sustainability is a word that derives from sustainable, which in turn is defined by the Royal Spanish Academy (RAE) (s.f., definition 2) as: "That can be maintained over time without depleting resources or cause serious damage to the environment" (p. online), from which it is assumed that sustainability encompasses everything that can be done as long as it is done without depleting the resources used and, in turn, results in an eco-friendly proposal.

In this orientation, it is necessary to mention that the demand for quinoa both in the national market and, even more so in the international market, has increased significantly in recent years (Barrientos et al., 2017). The main reasons for this great growth in quantity demanded are related to the emergence of new healthy eating patterns, the recognition of the great nutritional contribution of quinoa (Cely & Ducón, 2015; Dakhili et al., 2019), its historical character and the cultural values of this Andean cereal. (Duran, 2019).

In light of the approaches presented, the enormous demand for quinoa in international markets was also reflected in the expansion of the cultivated area of this cereal in Peru (Bazile et al., 2014). Studies carried out by García et al. (2017), Ku (2017) Huillca and Segura, (n.d.) and Valdez (2019) show that, due to its high agroecological capacity, the cultivation of quinoa is no longer limited only to the high Andean areas and inter-Andean valleys and, in Consequently, the regions of the Peruvian coast that previously did not practice this activity, such as Tacna, Arequipa, Lambayeque, Lima and Ica, have begun to cultivate and market quinoa. In this way, coastal regions have become the new participants in quinoa production since 2013 (MINAGRI, 2020; MINCETUR, 2018).

Under this context, unlike the high Andean areas where traditional cultivation is predominant, cultivation on the coast has been carried out through more technical procedures, applying conventional practices such as the use of chemical inputs, which entails risks. in rural, urban and environmental health; in turn, affecting the economy of the region (Pinedo-Taco et al., 2020). To exemplify, one of the best-known events was the detention of six ships



transporting quinoa from coastal regions, with high levels of pesticide residues (MINAGRI, 2020; Rosales & Mercado, 2020; Valverde, 2015).

In relation to the aforementioned, the district of Inclán, located in the province and region of Tacna, has become one of the coastal areas dedicated to the production of quinoa; As indicated by the Regional Directorate of Agriculture of Tacna (n.d.), this district is characterized by being the main producing area of the department, concentrating most of the harvested area there with 94.3% and the highest production with 95.3%. In this way, it is important to know what agronomic management is used in the aforementioned district and thus, know what is the reality of the quinoa production chain in Inclán and its relationship with sustainability.

For this reason, the question arises: What level of ecological sustainability does the quinoa production chain present in the district of Inclán (Tacna)? Therefore, it will be the object of this research to evaluate all the sustainability factors involved in the production chain of this cereal, in the district of Inclán (Tacna).

2 MATERIALS AND METHODS

The research was developed from a quantitative perspective, being descriptive, using a non-experimental design because the data of the variable under study was not manipulated.

For the development of this research, all quinoa producers in the Inclán district were used as the study population (Condori-Ojeda, 2020) and, taking into consideration the aforementioned population, it was determined to apply non-probabilistic sampling for convenience. (Otzen & Manterola, 2017), where the sample amount was made up of 144 producers who were beneficiaries of the project "Strengthening and Development of the quinoa production chain in the district of Inclán" in the province and department of Tacna. The use of the aforementioned type of sampling is explained by the better accessibility to producers' data.

Now, to collect this data, the technique used was the survey (Muñoz et al., 2002) using a questionnaire as an instrument (Bernal, 2010). The Questionnaire was developed based on 9 dimensions: a) Crop rotation, b) Crop diversification, c) Incorporation of organic matter, d) Land preparation, e) Predominant slope, f) Plant cover, g) Conservation of varieties, h) Pest Management, i) Seed management (Table 1).



Table 1

Instrument for collecting information

DIMENSION	N°	INDICATOR	S I	N O
CROP ROTATION	1	After a quinoa harvest, do you plant another crop?		
	2	Is the crop planted on the same land?		
	3	Do you know the importance of crop rotation?		
CROP DIVERSIFICATION	4	Do you have more than two crops on your land?		
	5	Would you ever consider planting more than one variety of quinoa?		
	6	Is it profitable for you to have two or more crops other than quinoa on your land at the same time?		
INCORPORATION OF ORGANIC MATTER	7	Do you use more synthetic fertilizers than organic matter in your quinoa production?		
	8	Do you use more organic matter than synthetic fertilizers in your quinoa production?		
	9	Do you incorporate organic matter when starting to grow quinoa?		
GROUND PREPARATION	10	Do you use heavy machinery to prepare your land?		
	11	Do you use traditional methods to prepare your land?		
	12	Do you consider that the use of machinery is more profitable than traditional preparation?		
PREDOMINANT SLOPE	13	Is your quinoa production plot located in a sloping area?		
	14	If your plot is located in a sloping area, is it more difficult for machinery to access it?		
	15	Would you choose to plant in an area without slope if you had the opportunity?		
PLANT COVER	16	Do you use mulch on your plot?		
	17	Do you use any plants to cover your land in uncultivated areas?		
	18	Do you know the importance of plant cover on the soil?		
VARIETY CONSERVATION	19	Do you use native varieties of quinoa?		
	20	Do you use improved varieties of quinoa?		
	21	For you, do improved varieties of quinoa represent greater economic performance?		
PEST MANAGEMENT	22	Do you use an organic pest control treatment?		
	23	Do you use synthetic insecticides to eradicate pests on your plot?		
	24	Is the use of insecticides your first option compared to tasks such as pruning, traps, biological control?		
SEED MANAGEMENT	25	Do you use the seeds produced in your field to plant?		
	26	Would you prefer to use seeds produced in your field than certified seeds due to cost issues?		
	27	Do you think it is important to use and preserve the seeds of native varieties?		

Source: self made

The instrument was subjected to a validation process in the judgment of 105 experts on the subject, university professors and agricultural engineers, who were contacted through LinkedIn and universities such as the Universidad Agraria la Molina and Universidad Jorge Basadre, who approved the instrument with approval. an average of 98.05%. Subsequently, a pilot test was applied to evaluate internal consistency through Cronbach's Alpha method, resulting in 0.942, which is why it is considered a highly reliable instrument.



In order to establish a relationship between the dimensions studied and sustainability, three sustainability criteria indicated in table 2 were established, based on the characteristics of strong sustainability, in which natural resources are considered irreplaceable to realized human capital, characterizing the activities that are carried out as not only viable and socio-culturally acceptable, but also adequate to safeguard the environment (Pinedo-Taco et al., 2020).

Table 2

Sustainability criteria to group dimensions

Dimension	Sustainability criterion
Crop rotation Crop diversification Incorporation of organic matter Land preparation	Conservation of soil life
Predominant slope Plant cover	Erosion risk
Conservation of varieties Pest Management Seed Management	Biodiversity Management

Source: self made

2.1 PROCEDURE

Prior to data collection, permission was requested from the Regional Directorate of Agriculture of Tacna to obtain information from the beneficiaries of the project “Strengthening and Development of the quinoa production chain in the district of Inclán”, explaining the objectives and scope of the project. the investigation. Once the requested request was granted, the informed consent of the participating producers was given, where the complete anonymization of the data and responses obtained was ensured, based on the principles of bioethics (Molina, 2013).

For the processing of the collected data, basic descriptive statistics were used, for the systematization of data, and construction of respective tables and graphs, using Microsoft Excel and Spss.

Now, for the interpretation of the results, it was decided to develop a sustainability scale based on the methodology proposed by (Sarandon & Flores, 2014), which establishes a scale from 0 to 4, with 0 being the lowest level of sustainability. and 4 the highest level; However, a modification of the scale was established where the values vary from 0 to 100%, with 0 being the lowest value and 100 the optimal value for each sustainability criterion and, in turn, the sustainability levels for each criterion were established accordingly. according to what is



indicated in table 3. Likewise, to locate the results in the scales mentioned in table 3, a simple average of the results obtained in the indicators was carried out, for the level of sustainability of the dimensions located in table 1 and a simple average of the weighted means for each dimension, for the criteria located in table 2 (Abraham et al., 2014).

Table 3

Scales for the interpretation of sustainability levels

Scale in percentage (%)	Interpretation
Positive responses less than 25	Critical sustainability level
Positive responses between 25.1 to 50	Low level of sustainability
Positive responses between 50.1 to 75	Medium level of sustainability
Positive responses between 75.1 to 99	High level of sustainability
Positive responses between 99.1 to 100	Optimal level of sustainability

Source: self made

3 RESULTS

Below are the results obtained for each criterion evaluated in this research:

Table 4

Results by evaluated criterion

Criterion	SI		NO	
	f	%	f	%
Conservation of life in the soil	30	20,5	115	79,5
Erosion risk	26	18,3	118	81,7
Biodiversity Management	56	38,7	88	61,3

Legend: The numbers that identify the frequency and percentage of each criterion correspond to the simple average of the weighted averages for each dimension integrated into them.

Source: self made

According to what is observed in table 4, the criterion of conservation of life in the soil is located at a critical level of sustainability. Likewise, the erosion risk criterion is also at a critical level of sustainability and, finally, the biodiversity management criterion is at a low level of sustainability.

In this same context, the data obtained for each of the dimensions evaluated in this research are presented:



Table 5

Average results per dimension evaluated

Criterion	Dimension	Si		No	
		f	%	f	%
Conservation of life in the soil	Crop rotation	44	30,6	100	69,4
	Crop diversification	30	20,8	114	79,2
	Incorporation of organic matter	18	12,5	126	87,5
	Land preparation	26	18,3	118	81,7
Erosion risk	Predominant slope	15	10,4	129	89,6
	Plant cover	38	26,2	106	73,8
Biodiversity management	Conservation of varieties	28	19,7	116	80,3
	Pest management	15	10,2	129	89,8
	Seed management	124	86,1	20	13,9

Legend: The numbers that correspond to the frequency and percentages for each dimension belong to a dichotomous scale and are the result of the simple average of the weighted averages of the indicators attached to that dimension.

Source: self made

According to what was observed in Table 5, in relation to the crop rotation dimension, it is evident that 30.6% of those surveyed responded affirmatively while 69.4% responded negatively. In this way, the crop rotation dimension is located at a low level of sustainability.

Regarding the crop diversification dimension in table 5, it can be seen that 20.8% of those surveyed stated that they carry out activities related to it, while 79.2% mentioned that they do not carry them out. Regarding the level of sustainability, the crop rotation dimension is located at a critical level of sustainability.

Regarding the dimension incorporation of organic matter in table 5, 12.5% stated that they had carried out tasks that contribute to this dimension, while 87.5% of those surveyed denied doing them. Likewise, the incorporation dimension of organic matter is established at a critical level of sustainability.

In relation to the soil preparation dimension in table 5, 18.3% expressed using forms of preparation that do not affect the soil structure, while 81.7% expressed that they do not do them; For this reason, the land preparation dimension is located at a critical level of sustainability.

Concerning the predominant slope dimension in Table 5, 10.4% mentioned that their plots do not present characteristics related to this dimension, while 89.6% did so in a negative way, which is why the dimension in question is located at a critical level of sustainability

Regarding the vegetation cover dimension in Table 5, 26.2% of those surveyed stated that they had carried out activities that supported this characteristic, while 73.8% stated that they had not carried out them. In this way, the vegetation cover dimension is located at a low level of sustainability.



Regarding the conservation of varieties in table 5, 19.7% responded affirmatively to this dimension, while the remaining 80.3% did so negatively; This dimension is located at a critical level of sustainability.

In this same orientation, regarding pest management in Table 5, 10.2% of respondents expressed having carried out mitigation work that helps sustainability, while 89.8% of respondents did so negatively; The pest management dimension is located at a critical level of sustainability.

Finally, in relation to seed management in table 5, 86.1% stated that they carried out activities concerning this dimension, while 13.9% did not carry them out.

Now, with the purpose of thoroughly interpreting the results presented in the previous paragraphs, each of the dimensions evaluated independently is presented.

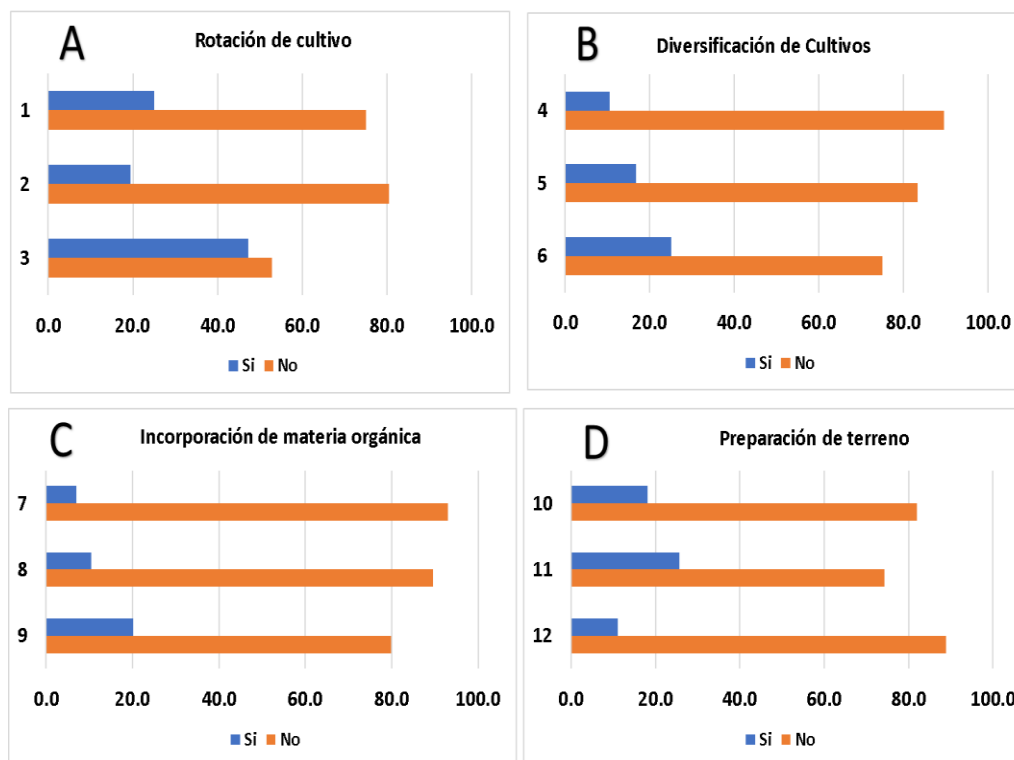
3.1 CONSERVATION OF LIFE IN THE SOIL

Figure 1 shows the general results of the dimensions related to the criterion of conservation of life in the soil: Crop rotation, crop diversification, incorporation of organic matter and land preparation.



Figure 1

Results of the dimensions that make up the soil conservation criterion: Crop rotation (A), crop diversification (B), incorporation of organic matter (C) and land preparation (D).



Legend: The numbers on the Y axis correspond to the number of questions indicated in table 2.

Source: self made

In figure 1, referring to the crop rotation dimension, it is evident that the respondents stated that in 25% of the cases, they had planted another crop apart from quinoa, while the remaining 75% indicated that they did not do so. Likewise, 19.4% of those surveyed indicated that they would plant another crop on the same land as quinoa, while 80.6% indicated that they would only plant quinoa. Finally, 47.2% of the participants show that they are aware of the importance of crop rotation while 52.8% are unaware of the importance of this work.

Regarding the diversification of crops referred to in figure 1, 10.4% of those surveyed stated that they did have more than two established crops apart from quinoa, while the remaining 89.6% did not. Likewise, 16.7% of those surveyed consider planting other varieties of quinoa on their land, while 83.3% consider that they would not do so. Finally, 25% consider it profitable to plant more than one variety of quinoa, while 75% consider that it would not be.

Regarding the dimension incorporation of organic matter indicated in figure I, 6.9% stated that they use more organic matter than synthetic fertilizers, while 93.1% stated that they do not. Likewise, 10.4% of those surveyed stated that they obtained more profits by applying



organic matter than synthetic fertilizers, while 89.6% stated the opposite. Finally, 20.1% expressed having applied organic matter at another time, apart from land preparation, during quinoa production, while 79.9% did not do so.

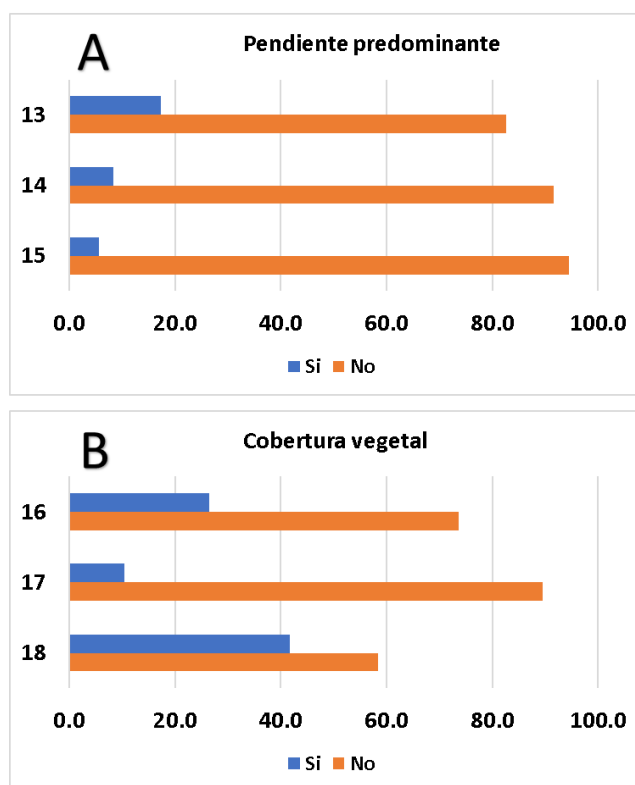
In relation to the land preparation dimension indicated in figure 1, 18.1% of those surveyed expressed their preference for traditional planting methods, while 81.9% opted for the use of heavy machinery. Additionally, 25.7% of those surveyed avoid the use of a subsoiler on the land, while 74.3% use a subsoiler. Finally, 11.1% consider that preparing the land by traditional methods is more profitable than the use of machinery, while 88.9% consider the opposite.

3.2 EROSION RISK

Figure 2 shows the general results of the dimensions related to the erosion risk criterion: Predominant slope and vegetation cover.

Figure 2

Results of the dimensions that make up the erosion risk criterion: Predominant slope (A) and vegetation cover (B).



Source: self made

Legend: The numbers on the Y axis correspond to the number of questions indicated in table 2.



In figure 2, referring to the predominant slope dimension, 17.4% indicated that their crop land was located in a slope area, while the remaining 82.6% indicated the opposite. Likewise, 8.3% of those surveyed stated that they would acquire land if it had a slope, while 91.7% stated the opposite. Finally, 5.6% consider that in sloping areas there would be better quinoa production than in areas without it, while 94.4% consider the opposite.

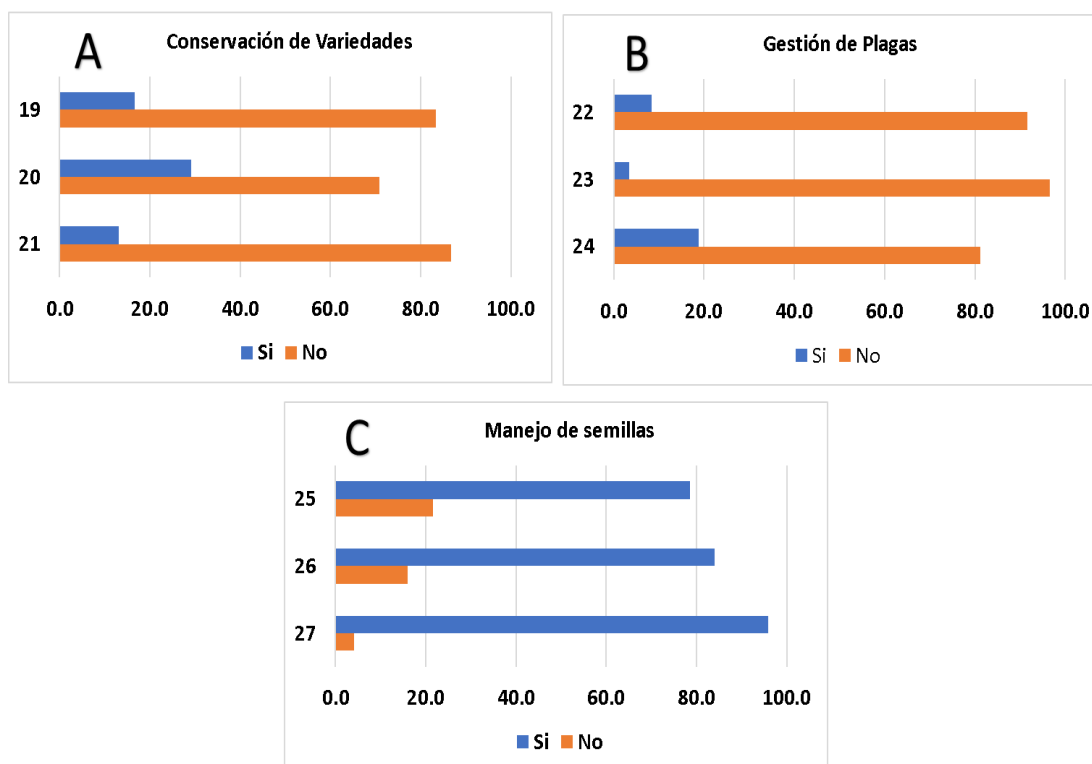
Regarding the vegetation cover dimension indicated in Figure 2, 26.4% of those surveyed resort to using mulch as soil cover, while 73.6% do not. In turn, 10.4% use green plant material for soil cover, while 89.6% do not use it. Finally, 41.7% are aware of the importance of soil cover, while 58.3% are unaware of its importance.

3.3 BIODIVERSITY MANAGEMENT

Figure 3 shows the general results of the dimensions related to the biodiversity criterion: Variety conservation, pest management and seed management. }

Figure 3

Results of the dimensions that make up Biodiversity Management: Variety Conservation (A), Pest Management (B) and Seed Management (C).



Source: self made

Legend: The numbers on the Y axis correspond to the number of questions indicated in table 2



Figure 3 shows that, regarding the variety conservation dimension, 16.7% stated that they used native varieties of quinoa, while 83.3% stated the opposite. Likewise, 29.2% of those surveyed expressed using more native varieties than improved ones, while 70.8% responded negatively. Finally, 13.2% indicated that native varieties represent a greater economic performance, while 86.8% stated the opposite.

In relation to the pest management dimension indicated in figure 3, 8.3% of those surveyed stated that they had applied an organic treatment for pest control, while 91.7% stated that they had opted for conventional treatments. In turn, 3.5% of the participants avoided using synthetic insecticides in crop management, while 96.5% did use them. Finally, 18.8% preferred to carry out tasks that prevent the appearance of pests rather than opting for synthetic insecticides, while 81.3% did not carry out the aforementioned tasks.

With reference to the seed management dimension indicated in figure 3, 78.5% of respondents expressed using seeds produced in their field, while 21.5% expressed the opposite. Likewise, 84% of the participants indicated that, if possible, they would use quinoa seeds obtained on their plot, while 16% indicated the opposite. Finally, 95.8% recognize the importance of using native seeds, while 4.2% do not consider it this way.

4 DISCUSSIONS

Environmental sustainability covers multiple aspects of which, as far as the production of a crop is concerned, only agriculture would be resolved (FAO, 2015). With reference to the results of this research, they reveal that quinoa production in the Inclán district located in the province and department of Tacna, Peru, is characterized by having a critical level of sustainability for the most part and, to a lesser extent, a low level. For this reason, what was expressed by the Ministry of Agriculture and Irrigation (2015) must be taken into consideration, which considers that the great biodiversity that Peru has is affected by harmful practices in crop management, threatening with this deterioration to wildlife; Desertification, through which millions of tons of arable soil layer are lost each year, is the result of the aforementioned practices (Quispe, 2013).

In this aspect, it is important to recognize that, within the criterion of conservation of life in the soil located at a critical level of sustainability, the crop rotation dimension is located at a low level, unlike the three remaining dimensions that are at a low level. critical. This is based on the fact that, although an important part of the producers feel they know the importance of crop rotation, they do not practice such work even though it can mean an adequate extraction



of nutrients without wearing down the soil and conserving its biota (Reginatto, 2018). Likewise, regarding the crop diversification dimension, the level of sustainability is presented at a critical scale in response to what was expressed by the producers, who do not consider the possibility of establishing more than two crops on their plots, based on low profitability. that they perceive when carrying out such practices even though, as far as economic factors are concerned, they may have considerably positive margins (Landeros-Sánchez et al., 2011).

Regarding organic matter, producers have intensified the use of synthetic products for fertilization and, as evidenced in the results, the amount of organic matter used is minimal throughout the production process of quinoa cultivation, affecting both the soil as the water table and having an impact on the ecological dynamics of the area (de Luna et al., 2014). In this orientation, during the period included in the preparation of the land, producers claim to use heavy machinery for agricultural work; This leads to a loss of soil structure, causing soil degradation due to the unnatural disturbances it experiences (Espinosa et al., 2011).

According to the aforementioned, the erosion risk criterion presents a critical level of sustainability; This is explained by the practices carried out in the field, where the majority of producers stated that they had plots located in areas with little or no slope; Likewise, they do not consider the possibility of acquiring a plot with these characteristics because they do not find them productively attractive and this translates into greater accessibility of heavy machinery to the land, which would cause compaction thereof (Polanco, 2007), and, in addition to the little use of soil cover material by producers, the number of macropores is reduced, which reduces the infiltration capacity of water into the soil and produces subsequent runoff that would trigger erosion (Sánchez-Sáenz et al., 2010).

It should be added that, regarding the biodiversity management criterion, the level of sustainability is low; This level responds to the results related to the dimensions that make up this criterion, where two of them show a critical level of sustainability and one a medium level. The critical level of sustainability that is designated to the dimension of variety conservation is explained by the little use of native varieties of quinoa compared to improved varieties and, in turn, because the majority of producers consider it unprofitable. The use of the first, the improved varieties are displacing cultivation areas for the native varieties (Paisajismo Digital, 2019).

Regarding the pest management dimension, with critical level classification, the results show the majority use of chemically formulated insecticides compared to other treatments that exclude the former, due to the high effectiveness that agrochemicals offer and, for this reason, They become a quick and easily accessible alternative, thus responding to market demand



(Devine et al., 2008).; On the contrary, as mentioned by Del Puerto et al. (2014), its use has negative effects on the preservation of ecosystems, as well as on the health of rural and urban communities. Finally, regarding the dimension of seed management that was located at a medium level of sustainability, the majority of respondents indicated that they were currently using seeds produced in their field, due to the high cost that would result from the acquisition of improved varieties and, additionally, , express knowledge of the importance of preserving native varieties, which would translate, as Saburido (2021) mentions, into a positive effect on the preservation of seed diversity, as a key piece and meaning of resilience against the climate changes that we are going through and that, in the future, could mean a food crisis.

Indeed, sustainability in the district of Inclán, located in the province and department of Tacna, shows a critical level as a consequence of the demanding production tasks that characterize the current market, affecting rural and urban health and wildlife; Additionally, the soil and water resources of the water table are affected.

5 CONCLUSIONS

The quinoa production chain in the district of Inclán, located in the province and department of Tacna, presents critical levels of sustainability, affecting biodiversity due to the practices carried out in a production characteristic of conventional agriculture that, annually, is expressed in significant losses. of arable soil layer.

It is appropriate to mention that, in reference to the conservation of life in the soil, the classification levels are critical for all dimensions because crop rotations and diversification, although perceived as important, are not tasks that are carried out. To the aforementioned, is added the use of heavy machinery for land preparation and the little use of organic matter, which translates into a smaller number of macropores that allow air flow in the soil and losing its structure, causing , in the long term, desertification effects.

Regarding the risk of erosion, classified as a critical level, it is necessary to highlight the absence of coverage to avoid the adverse effect of activities on production affecting the soil, as well as the location of the producers' plots, established mainly in areas without slope. or with very little; Added to this is the little interest in acquiring new land with a certain slope, which leads to the greater use of machinery in the field, affecting the soil.

Regarding biodiversity management, the level presented is low as a consequence of the little use of native varieties and, although they recognize their importance and even use seeds produced in their fields, affecting the biodiversity of plant species; This would have a negative



effect related to the resilience of plant species to climate change. Likewise, the preference for chemically formulated insecticides over organic pest control seriously affects ecological diversity, soil fauna, and the soil's water table.

Additionally, it is recommended to carry out more research in other coastal areas where quinoa production activities are carried out, to obtain data on the management of this crop and to contrast it with the results obtained in this research; Thus, collect information on the productive chain at the coastal level and its ecological sustainability.

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