Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Ambiental

Tesis

Degradation of Organic Matter and pH in Agricultural Soils by the Species of *Zingiber Officinale* R. (Ginger) within the Native Community the Milagro, Marankiari, Satipo, 2022

Jazmín Rios Aliaga
Edith Eva Quintana Alania
Jhon Emerson Torres Ricse
Steve Dann Camargo Hinostroza

Para optar el Título Profesional de
Ingeniero Ambiental

Huancayo, 2024

INFORME DE CONFORMIDAD DE ORIGINALIDAD DE TESIS: EN FORMATO ARTÍCULO CIENTÍFICO

A : Felipe Néstor Gutarra Meza
Decano de la Facultad de Ingeniería

DE : Steve Dann Camargo Hinoztroza
Asesor de tesis en formato artículo científico

ASUNTO : Remito resultado de evaluación de originalidad de tesis en formato artículo científico

FECHA : 17 de Febrero de 2024

Con sumo agrado me dirijo a vuestro despacho para saludarlo y en vista de haber sido designado asesor de la tesis en formato artículo científico titulada: **"Degradation of Organic Matter and pH in agricultural soils by the species of *Zingiber officinale r.* (Ginger) within the Native Community the Milagro "Marankiari", Satipo-2022"**, perteneciente al/la/los/las estudiante(s) **JAZMÍN RIOS ALIAGA, EDITH EVA QUINTANA ALANIA Y JHON EMERSON TORRES RICSE**, de la E.A.P. de **Ingeniería Ambiental**; se procedió con la carga del documento a la plataforma "Turnitin" y se realizó la verificación completa de las coincidencias resaltadas por el software dando por resultado 7 % de similitud (informe adjunto) sin encontrarse hallazgos relacionados a plagio. Se utilizaron los siguientes filtros:

• Filtro de exclusión de bibliografía	SI	X	NO	
• Filtro de exclusión de grupos de palabras menores (N° de palabras excluidas:)	SI	X	NO	
• Exclusión de fuente por trabajo anterior del mismo estudiante	SI	X	NO	

En consecuencia, se determina que la tesis en formato artículo científico constituye un documento original al presentar similitud de otros autores (citas) por debajo del porcentaje establecido por la Universidad.

Recae toda responsabilidad del contenido la tesis en formato artículo científico sobre el autor y asesor, en concordancia a los principios de legalidad, presunción de veracidad y simplicidad, expresados en el Reglamento del Registro Nacional de Trabajos de Investigación para optar grados académicos y títulos profesionales – RENATI y en la Directiva 003-2016-R/UC.

Esperando la atención a la presente, me despido sin otro particular y sea propicia la ocasión para renovar las muestras de mi especial consideración.

Atentamente,

La firma del asesor obra en el archivo original
(No se muestra en este documento por estar expuesto a publicación)

DECLARACIÓN JURADA DE AUTORÍA

El presente documento tiene por finalidad declarar adecuada y explícitamente el aporte de cada estudiante en la elaboración del trabajo de investigación a ser utilizado para la sustentación de tesis: formato de artículo científico.

Yo: Jazmín Rios Aliaga, con Documento nacional de identidad (DNI) N° 75270073; teléfono 916464290; estudiante de la Escuela Académico Profesional de Ingeniería Ambiental.

Yo: Edith Eva Quintana Alania, con Documento nacional de identidad (DNI) N° 74804230; teléfono 913579911; estudiante de la Escuela Académico Profesional de Ingeniería Ambiental.

Yo: Jhon Emerson Torres Ricse, con Documento nacional de identidad (DNI) N° 73188291; teléfono 935691098; estudiante de la Escuela Académico Profesional de Ingeniería Ambiental.

Ante Usted, con el debido respeto me presento y expongo:

Declaramos que hemos participado en la ideación del problema, recolección de datos, elaboración y aprobación final del artículo científico.

La firma del autor y del asesor obra en el archivo original
(No se muestra en este documento por estar expuesto a publicación)

DEGRADATION OF ORGANIC MATTER AND PH IN AGRICULTURAL SOILS BY THE SPECIES OF ZINGIBER OFFICINALE R. (GINGER) WITHIN THE NATIVE COMMUNITY THE MILAGRO "MARANKIARI

ORIGINALITY REPORT

7%	4%	3%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	banglajol.info Internet Source	2%
2	Submitted to Ana G. Méndez University Student Paper	1%
3	Submitted to Fundación Universitaria CEIPA Student Paper	1%
4	Submitted to Universidad Continental Student Paper	1%
5	mafiadoc.com Internet Source	1%
6	Submitted to Universidad San Ignacio de Loyola Student Paper	<1%
7	Geraldi Milagros Tomas Ruiz, Erick Teodoro Cristobal Chihuan, Steve Dann Camargo Hinostroza. "Chapter 11 Analysis of Dispersion of the Pollutant PM2.5 by the "La	<1%

Leña" Poultry Shop with the Langrangian Model in the Province of Huancayo 2020", Springer Science and Business Media LLC, 2023
Publication

8	Submitted to University of Texas at Tyler Student Paper	<1%
9	dokumen.pub Internet Source	<1%
10	Islamic Azad University–Isfahan Branch Publication	<1%

Exclude quotes On
Exclude bibliography On
Exclude matches < 5 words

Degradation of Organic Matter and pH in agricultural soils by the species of *Zingiber officinale r.* (Ginger) within the Native Community the Milagro "Marankiari", Satipo-2022

Jazmín Rios Aliaga[1*]; Edith Eva Quintana Alania[1], Jhon Emerson Torres Ricse[1] and Steve Dann Camargo Hinostroza[1]

[1]Professional Academic School of Environmental Engineering. Faculty of Engineering. Continental University, Huancayo, Peru

***Email:** 75270073@continental.edu.pe; 74804230@continental.edu.pe; 73188291@continental.edu.pe; scamargo@continental.edu.pe

Abstract.

Soil degradation is caused by different types of crops in recent times, being one of the most relevant problems observed. Within the group of crops that are considered extractive is the species *Zingiber Officinale r.* (Ginger), since this species directly degrades the percentage of Organic Matter and the pH level. The development of this article aims to estimate the loss of chemical properties of the soil under cultivation of the species *Zingiber Officinale r.* (Ginger) within the Native Community the Milagro "Marankiari". For this study the following procedures were performed: preparation of a schedule, identification, and location of the area to be studied, survey of the land, collection of samples, drying, sieving, and packaging, finally, the samples were labelled and then sent to two different laboratories where the respective analysis was performed. The method used to develop this study was based on the search for information in the following journals: Scopus, ScienceDirect, etc. which reveal the direct influence of the species *Zingiber officinale r.* The results obtained in the analysis of the soil, shows that this crop reduced the percentage of organic matter 29.3% and increased the level of pH 0.1. It was seen that cultivating the species *Zingiber officinale r.* does degrade the organic matter and increase the pH of agricultural soils.

Keywords: Degradation of agricultural land, Organic Matter, pH, *Zingiber officinale r*. (Ginger).

1 Introduction

It is known that man began to cultivate the land for thousands of years, thus establishing the beginning of agriculture, but the history of fertilization began when early farmers managed to discover that certain soils ceased to have acceptable yields if they were grown continuously, and that the addition of manure or plant residues would restore [1].

The study carried out in 1980 on the degradation of the soil by the cultivation of Zingiber *Officinale r.* (Ginger) revealed that this crop causes the degradation of agricultural soils [2]. It is

also considered an extractive plant, suggesting that the cultivation should be cultivated with a rotation system with other crops [3]. The best soils for the cultivation of *Zingiber Officinale r.* (Ginger), require that they have the following characteristics, either rich in organic matter or with a pH ranging between 5.5 - 7.5 [4].

According to the authors According to Salahin, Begum, Hossain, Ullah & Alam, in his article Titled Degradation of Soil Properties under the Ginger, Turmeric, Aroid and Jhum Rice Crop in Hilly Areas of Bangladesh, had as objective "estimate soil loss and changes in soil properties under indigenous cultivation methods of ginger, turmeric, aroid and jhum rice on hillsides. Indigenous cultivation methods were used for each crop. As a result of the four crops, the largest annual soil loss (22.68 t/ha) occurred in ginger cultivation, which was statistically similar to turmeric (16.52 t/ha), followed by aroid (12.02 t/ha) and the lowest soil loss (7.92 t/ha) because of jhum rice [5].

According to reports, in the years 2009 to 2010, Peru increased its ginger export by 65% and in the years 2013 to 2014 it increased by 23.7%. Ginger is currently grown in 9 districts, including Chanchamayo and Satipo provinces. These provinces are between 500 and 1930 meters above sea level, with a tropical climate, warm and humid with intense rains from November to March with temperatures above 25 °C. Leading to an increase and competition among producers to obtain productive land, But this large production brings with it several negative effects, such as deforestation of primary forests for planting and soil degradation, because it reduces organic matter and soil pH [6].

Considering that soils store a wide variety of biodiversity and that these are threatened by different unsustainable farming practices such as land rental, as, these will be completely felled, then burned. This practice is commonly used to cultivate ginger, adding that the method most used for this type of crop is the migratory one, they are not re-sown in the same place and they are moved to other lands after this cycle of felling and burning [7].

The development of our research project will help us to know much more the importance of the impact on agricultural soils by planting the species *Zingiber officinale r.* (Ginger), as this crop requires a large amount of nutrients for better and optimal production, the following values obtained by the laboratories to which the samples were taken for analysis shall be identified, Regarding the chemical properties of the soil before planting and after harvest, this will allow us to compare the results obtained and know what nutrients were lost.

2 Materials

Zingiber officinale r. **(Ginger).** This plant belongs to the family zingiberáceas, has the following characteristics: reaching between 1-1.5 meters in height, having twenty centimeters long in each of its leaves, has an underground rhizome, branched in its fingered form and in turn the stems are covered by pods on each leaf. The leaves are alternate, smooth, and pale green and lanceolate. The flowers usually have three yellowish sepals and three cherry petals with light spots, having a minimum of flowers. The flower has an asymmetrical structure and has a tubular calyx. For the optimal growth of ginger an annual precipitation of 1800 to 2000 masl is needed, its development depends on sandy loam that facilitate its free development and contain higher percentage of organic matter and pH level in soils [8].

Figure N°1: The species *Zingiber officinale r.* (Ginger).

Chemical properties of the soil: It expresses the quality of the soils, has a quantity of water and nutrients necessary for the development of different plants, within the chemical properties that we can find: pH, organic matter, phosphorus, nitrogen, potassium and electrical conductivity. It also has a relationship with the quality and availability of water that provides nutrients for plants [9].

pH: The pH level depends on the amount of nutrients in the soil. The pH has a scale of 0-14, whose values below 7 indicate that the soil is acidic, the value of 7 indicates that the soil is neutral and the values above 7 indicate that the soil is alkaline [10]. The pH level, being one of the most important variables to evaluate the different analyses such as: Water, Soil, and one of these analyses to evaluate were agricultural soils, since there are alterations that affect the soil as in the absorption of nutrients caused by agricultural plants, also all the investigations carried out gave a resolution to the chemical processes that occur in them. In general, the pH should be optimal for soils where it should have a variation between 6.5 and 7.0 to obtain the best yields and the highest productivity in a soil [11].

Ph level	Assigned value	Indicator

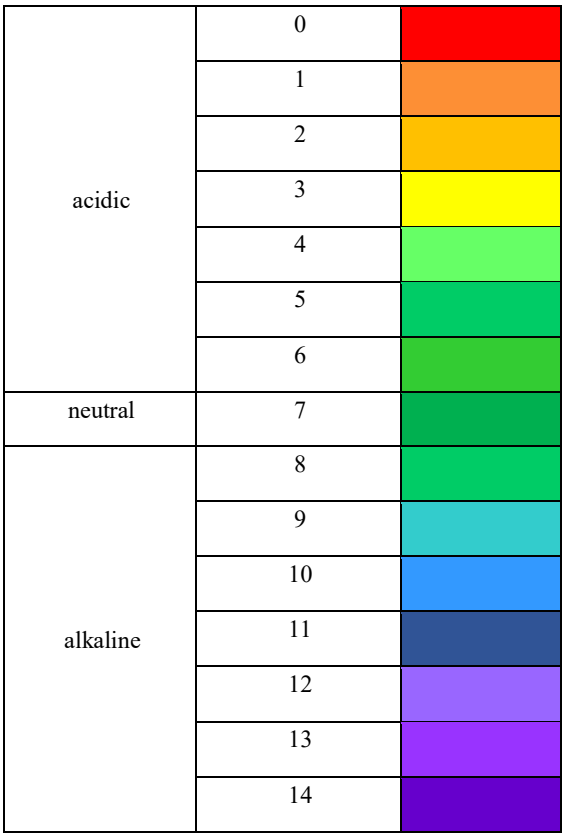


Figure N°2: pH measurement scale

The pH scale ranges from 0 to 14. For example, substances with a pH=0 value are the most acidic (least basic), those with a pH=7 value are neutral, and those with a pH=14 value are the least acidic (most basic).

Organic matter: Organic matter is part of the chemical properties of the soil, it is considered necessary and important. In agricultural soils, the organic matter content ranges between 1% and 5%, but these are 25 centimeters deep [8]. Being an important component for the soil that contributes to the development of plants in its effect on their chemical properties, helping to improve stability in agriculture knowing that it contains essential elements for plants and that it is mainly composed of carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur and micronutrients, although it may contain other essential macro and micronutrients, all this will give us a higher productivity of plants. These generate positive feedback processes that maintain fertility and balance in soils or virtuous cycles in ecosystems [12].

Degradation of agricultural soils: It is considered the loss or decrease of properties present in the soil and has an impact on the reduction of productivity. The changes present in the degradation of agricultural soils are: erosion, low nutrient content, organic matter, high pH, etc. That is, the soil loses its capacity and becomes poor soil with limits on its productivity [13]. Soil degradation is defined as an abrupt behaviour within soil quality, Current and future changes that trigger the preservation of such agricultural soils and soil health resulting in a large decline and deterioration

of the capacity of soils and ecosystems facing serious problems that make a situation much worse than that which would face the production of goods or services for its beneficiaries. The degradation of agricultural soils is the extraction of nutrients and organic matter that contains, eliminating all this loses its fertility of production and consecutive vegetation that will be very difficult to stop in the development of production [14].

3 Methodology

3.1 Method

The method used for the development of this research is non-experimental deductive because it begins with a theoretical description, which generates questions and results. In other words, the collection of samples is used for laboratory analysis and finally a description of the results is made using comparative statistical graphs [15]. In the non-experimental design the researcher has a direct intervention in the variables from which he will also work with a transversal or transactional approach, where he will observe the phenomena or events that will arise and then be analyzed, by being able to go to the site located by the group for its measurement corresponding to what is to be done, whether its initial or final scope is exploratory, descriptive, correlative or explanatory, so that such research has the purpose of knowing variables that may be related. The research focuses on studying how one or more variables evolve or the relationships between them, or analyzing these changes over time in an event, community, processes, phenomenon, context, among others. In these situations, like these the appropriate design in a non-experimental approach is the longitudinal one where you will analyze changes that are going to take place through different time and period, with data collection to make inferences to change determinants and consequences at the time of performing the method [16].

3.2 Place of Study

Currently ginger is produced in the region of Junín, in the provinces of Chanchamayo and Satipo, these provinces have the following characteristics: they have a rainfall ranging between 500-1930 masl, have a tropical climate, Rainfall between November and March exceeds the temperature of 25°C [6].In the province of Satipo the population is engaged in the following activities such as: hunting, fishing, crops and crop harvesting, opting to generate various economic income, where summer times are short, warm, dry and mostly cloudy and winters are hot and cloudy. During the course of the year, the temperature usually varies from 21 °C to 33 °C and rarely falls to less than 19 °C or rises to more than 35 °C. its boundaries adjacent to the province of Satipo are: north with the province of Chanchamayo; Oxapampa, south with the province of Tayacaja, To the east with the province of Atalaya and thus to the west with the province of Chanchamayo; Jauja;
Concepción and Huancayo. It is also characterized by having short and long slopes, its soils are moderately deep, its soils are yellowish in turn has the difficulty of absorbing water, it is a place where reforestation of vegetation is extensive [17].The Native Community the Milagro "Marankiari", is located in the Satipo District, Junín Region. This community belongs to the high forest, which has a warm and humid climate, its soils are rich in organic matter and optimal levels of pH, and other nutrients, for the efficient development of its various crops.

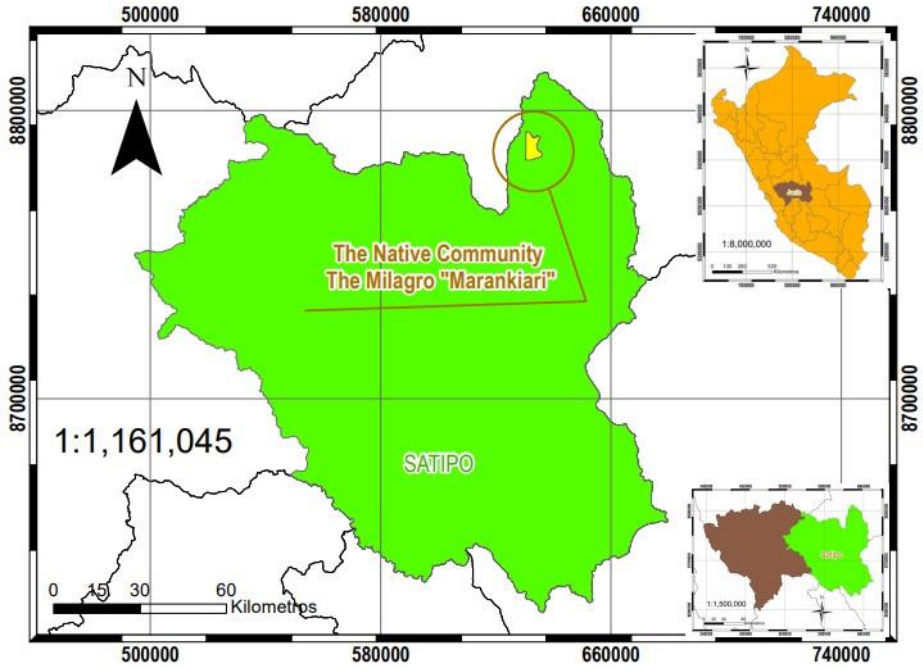


Figure N° 3: Location of the Satipo District of the Marankiari Native Community

3.3 Sampling and Chemical Parameters

According to Sampieri's methodology, it indicates that the method or design has 2 aspects, which, for the development of the research, was worked with the longitudinal or evolutionary type, with the purpose of analyzing changes over time. Non-probabilistic sampling is to be used, making a choice of the different elements that do not depend on the probability for the collection of samples, this depends on the researcher to relate the causes and so the purposes he wants to demonstrate [16] . An in-situ visit was made to the determined area, where the total land averaged 2 hectares, the samples were collected before sowing and after the harvest of the species *Zingiber officinale r.*, (Ginger) taking into account that this crop took 9 months to develop for harvesting and/or harvesting. In each collection 5 random points were taken, each extraction point of the sample had an excavation depth of 20-25 cm, for this use was made of the peak, hoe and phlegm. At each point 2 kg of sample were extracted, in total 10 kg of sample was obtained for each stage chosen. The samples collected before sowing and after harvesting the crop were dried at room temperature for 3 sunny days and then sifted to obtain 2 kg for each sample mentioned and separated 1 kg for each sample. Each sieved sample was filled in 4 bags of polyethylene with hermetic closure, then labeled to be later sent to the RCJ Labs Universal Laboratory for pH analysis and thus for organic matter to the JHACC GROUP, to be subsequently analyzed.

3.4 Analysis of results

For the analysis of the results obtained by the laboratories, they were tabulated in Excel software, in order to visualize the degradation of organic matter and pH of agricultural soils by the species *Zingiber officinale r.*(Ginger), which will allow us to see through graphs the variations obtained in vector diagrams.

3.5 Techniques

The technique applied for data collection is the medicion, because samples taken before sowing and after harvesting, they are dried at room temperature for 3 sunny days and then sieved to obtain 2 kg for each sample mentioned and separated 1 kg for each sample. Each sieved sample was filled in 4 polyethylene bags with an airtight seal, then labeled and then sent to the RCJ Universal Laboratory for pH analysis and therefore for organic matter to the JHACC GROUP for further analysis.

3.6 Instrument

To carry out the pH analysis, we followed the methods established by the RCJ Labs UniversalHuancayo and for the soil organic matter for each sample, we followed the methods established by the JHACC-GROUP Huancayo, which is specified in table N°1.

Table N° 1

Chemical analysis of soil- Organic matter.

Soil Analysis		
Ítem	**Analysis**	**Methodology**
1	Matter Organic	Mexican Official Standard NOM-021-RECNAT-2000. Second Section (December 31, 2002). Item 7.1.7, AS 07. 2000, subject content organized by the Walkley method and Black Organic Matter

Source: Soil Analysis Laboratory, GRUOP JHACC-Huancayo

4 Results

Organic matter. According to the data obtained after the analysis of the sample by the JHACC GROUP Laboratory, it can be inferred that the percentage of the Organic Matter content decreased in the soil of the Native Community the Milagro "Marankiari", with a difference of 29.3%, being a margin of more than 50% decrease in the chemical properties that are within the composition of Organic Matter, see Table N°2 and Graph N°1.

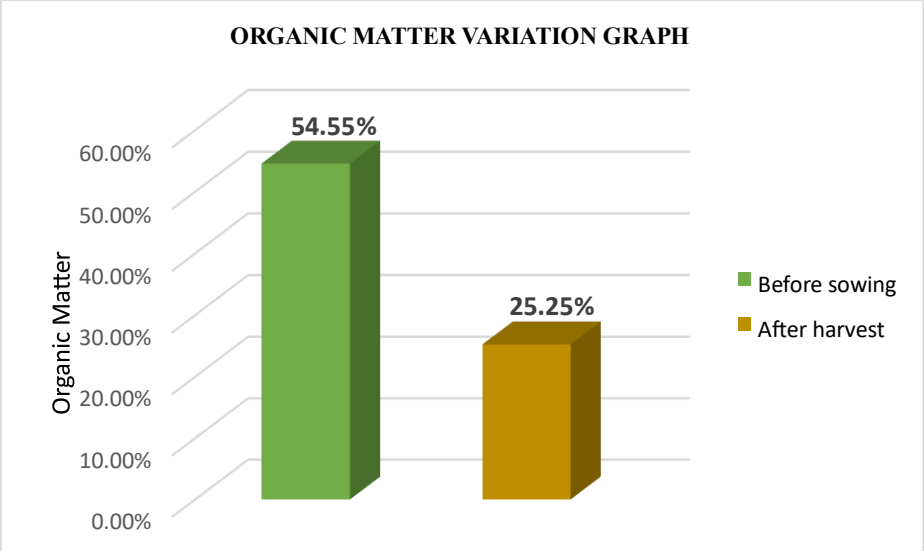
Table N°2. Organic Matter Analysis of the soil sample of the Native Community the Milagro "Marankiari"

Specie	**Chemical property**	**Sampling season**	**Organic Matter (%)**	**Percentage reduction (%)**

		Before sowing	54.55	29.3
Zingiber officinale r. (Ginger)	Organic Matter	After harvest	25.25	

Source: *Laboratory of the ENVIRONMENTAL ANALYSIS JHACC GROUP -Huancayo*

Graph N°1. Variation of the Organic Matter of the soil of the Native Community the Milagro "Marankiari"



Source: *Own production*

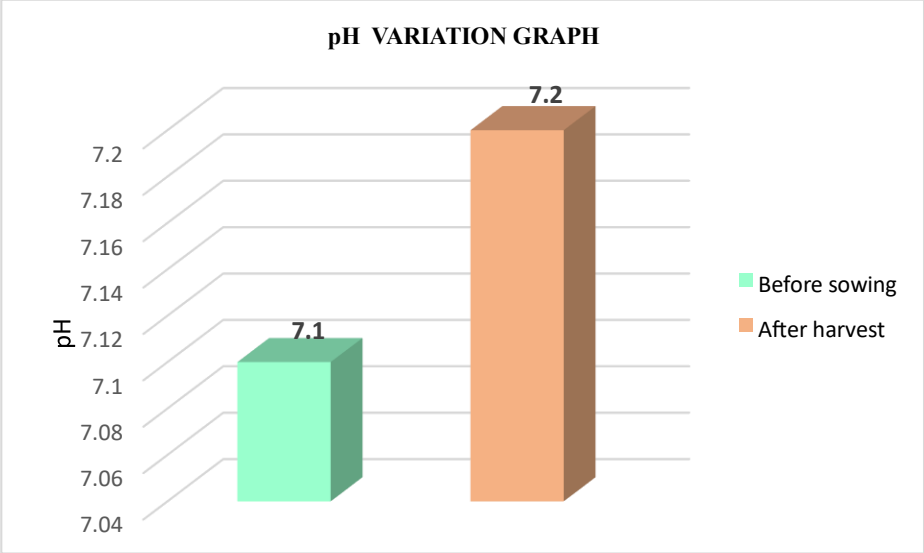
At the pH level. The results obtained based on the RCJ Labs Universal Laboratory, show that the pH level in the soil of the Native Community increased the Milagro "Marankiari", from 7.1 to 7.2, which increased 0.1, see Table N°3 and Graph N°2.

Table N°3. Analysis of the pH of the soil sample of the Native Community the Milagro "Marankiari"

Specie	Chemical property	Sampling season	pH(N°)	Level of increase
Zingiber officinale r. (Ginger)	pH	Before sowing	7.1	0.1
		After harvest	7.2	

Source: *RCJ Labs Universal-Huancayo*

Graph N°2. Variation in soil pH of the Native Community the Milagro "Marankiari"



Source: *Own production*

5 Discussion

The development of this research project shows that one of the main problems caused by the degradation of agricultural soils is by the species Zingiber officinale r. (Ginger), because there is a great effect on the growth of several crops, that generates that the soil has a lower yield and production capacity in the Native Community of the Miracle "Marankiari" -Province of Satipo.

The chemical properties of the two samples analysed, shown in Table N°2 and Figure N°1, do show significant changes in organic matter. The soil cultivated with the species *Zingiber officinale r.* (Ginger) showed a considerably lower percentage of decrease to the initial soil, going from an initial content that oscillated with a percentage of 54.55% having a final variation of 25,25%, this shows great variation. Affecting proportionally the recovery of the soil and resorting to more conventional methods such as the use of natural and chemical fertilizers or the search for other lands to continue cultivating.

The pH results obtained in the two analyzed samples, observed in Table N°3 and Graph N°2, show that initially it was 7.1 and presenting a final increase of 0.1. Also, this result indicates that the species *Zingiber officinale r.* (Ginger) if it influences the pH levels, due to its increase we can say

that this species does degrade the soil, since it takes away from its optimal and efficient levels for the development of other crops.

To know the results obtained on the two chemical properties and with their corresponding analysis between organic matter and pH, where both analyses made by different laboratories, demonstrate that there was a greater effect on the organic matter belonging to the chemical properties of the soil and indicate that the species *Zingiber officinale r.* (Ginger) affects more agricultural soil in the province of Satipo, This, in turn, affects the expansion and deterioration of current and future agriculture.

6 Conclusions

The development of this work allowed us to know more about the influence of the cultivation of *Zingiber officinale r.* (Ginger) on the chemical properties of the soil of the Native Community the Milagro "Marankiari", as evidenced by the results obtained in the laboratories, Organic Matter was the chemical property that showed the greatest decrease, it showed more than 50% decrease with respect to its initial content, but in the case of pH there was no great change with respect to the initial level.

As for the characteristics of the species *Zingiber officinale r*. (Ginger), it is of Asian origin, being well known for its aromas, flavors, and flowers, what can be highlighted is the use of its rhizome. It also has healing properties and popular use to fight diseases. This indicates that their production of the species *Zingiber officinale r.* (Ginger) is continuous and in great quantity, also this species is characterized by being an extractive crop, which requires a rotary cultivation method, migration, or use of fertilizers to recover lost nutrients from the soil.

Taking into account the results obtained, we can see the variations based on the pH, which before the cultivar had a level of 7.1 and after the harvest the soil had a level 7.2, but in case of Organic Matter, a great decrease can be recorded , since before being cultivated the species of *Zingiber officinale r.* (Ginger) had a percentage of 54.55% and after the harvest a percentage of 25.25% was recorded, thus having a clear decrease after the cultivation of the *Zingiber officinale r.* (Ginger) in the chemical properties of the soil as its pH of 0.1 and Organic Matter 29.3%, This indicates that the species decreases the chemical properties of the soil and especially the organic matter reducing more than half the content of organic matter that was obtained before the cultivation of the *Zingiber officinale r.* (Ginger).

References

[1] L. A. Hembra Parraga, Chemical fertilization in the cultivation of Ginger (Zingiber officinale), in the area of Buena Fe, Quevedo, 2015, p. 4.

[2] Ja y T. J. P, «The hidden economic costs of soil erosion: a case study of the ginger industry in Fiji,» p. 1, January 1998.

[3] L. Maraví y Y. Jazmín, Characterization of farms producing Kion, Pineapple and Banana in the micro-watershed Cuyani-Pichanaki (Junín, Peru), 2018, p. 3.

[4] J. A. Brunner Rioja, Sowing Density in the Yield of Zingiber officinale Rosc. "kion" in Zungarococha, Iquitos, 2019, Iquitos, 2019, p. 14.

[5] N. Salahin, R. Begum, S. Hossain, M. Ullah y M. Alam, «Degradation of soil Properties under Ginger, Turmeric, Aroid, and Jhum Rice cultivation in Hilly areas of Bangladesh,» vol. 38, nº 2, June 2013.

[6] A. C. Ancco Acuña, Organic ginger sub-system in the Junín-Peru region, Buenos Aires, 2018, pp. 8-26.

[7] I. Bravo Aliano, 5 March 2022. [En línea]. Available: https://vientosalisios.net/historias-finales/las-tierras-alquiladas-de-satipo/. [Último acceso: 15 September 2022].

[8] R. Orellana Alas, Evaluation of the effect of two sources of fertilizers on the Yield of Ginger (Zingiber officinale R.), in the Bulbuxya farm, San Miguel Panan, Suchitepequez, Guatemala, 2004, p. 22.

[9] C. Calderón Medina, G. Bautista Mantilla y S. Rojas Gonzáles, «Chemical, physical and biological properties of the soil, indicators of the state of different ecosystems in a high terrace of the department of Meta,» 2018.

[10] M. Kluepfel y B. Lippert, «Home & Garden information Center,» 22 October 2012. [En línea]. Available: https://hgic.clemson.edu/factsheet/cambiando-el-ph-delsuelo/#:~:text=El%20pH%20del%20suelo%20afecta,mayores%20a%207%20indican%20alcalinidad. [Último acceso: 2 May 2022].

[11] G. Catalán Salas, «AGROPAL,» 8 November 2016. [En línea]. Available: http://www.agropal.com/es/el-ph-del-suelo/. [Último acceso: 24 November 2022].

[12] P. López, «GACETA UNAM,» 18 May 2022. [En línea]. Available: https://www.gaceta.unam.mx/indagan-la-composicion-de-la-materiaorganica-del-suelo/#:~:text=La%20materia%20org%C3%A1nica%20est%C3%A1%20compuesta,micronutrientes%20esenciales%20para%20las%20plantas. [Último acceso: 24 November 2022].

[13] G. Cartes Sánchez, «Agricultural Soil Degradation and SIRSD-S,» *ODEPA,* 2013.

[14] FAO, «Food and Agriculture Organization of the United Nations,» 2022. [En línea]. Available: https://www.fao.org/soils-portal/soil-degradationrestoration/es/. [Último acceso: 25 November 2022].

[15] R. Hernández Sampieri, C. Fernández Collado y P. Baptista Lucio, Research Methodology, Fourth ed., Mexico, 2006, p. 15.

[16] R. Hernández Sampieri, C. Fernández Collado y P. Baptista Lucio, Research Methodology, Sixth ed., Mexico, 2014, pp. 153-208.

[17] Weather Spark, «Weather Spark,» [En línea]. Available: https://es.weatherspark.com/y/23283/Clima-promedio-en-Satipo-Per%C3%BA-durante-todo-el-a%C3%B1o. [Último acceso: 25 November 2022].