# UNIVERSIDAD NACIONAL DE UCAYALI

## FACULTAD DE CIENCIAS AGROPECUARIAS

### ESCUELA PROFESIONAL DE AGRONOMÍA

# DETERMINACIÓN DE NIVELES DE CONCENTRACIÓN DE CADMIO (Cd) Y PLOMO (Pb) EN EL SUELO, HOJAS Y ALMENDRAS DE OCHO CLONES DE CACAO (*Theobroma cacao, L.*) EN EL JARDIN INTER CLONAL DE LA UNIVERSIDAD NACIONAL DE UCAYALI.

**TESIS PARA OPTAR EL TÍTULO PROFESIONAL DE**

**INGENIERO AGRÓNOMO**

**TEOFILO GERARDO CARTAGENA CACHIQUE**

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**DEDICATORIA.**

A Dios padre, que me dio la oportunidad de realizarme profesionalmente y por darme una familia maravillosa que estuvo apoyándome siempre.

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## ACTA DE APROBACIÓN.

La presente tesis fue aprobada por los miembros del jurado calificador de la Facultad de Ciencias Agropecuarias de la Universidad Nacional de Ucayali, como requisito para optar el título de Ingeniero Agrónomo.

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**ÍNDICE.**

**Pág.**

RESUMEN ..... ...ix

LISTA DE TABLAS ..... .....xiii

LISTA DE FIGURAS ..... ....xiv

I. INTRODUCCIÓN .1

II. REVISIÓN DE LITERATURA ..... ..3

2.1. Antecedentes de la investigación 3

2.2 Cultivo de Cacao (Teobroma cacao, L) .....4

2.2.1. Origen y distribución geográfica ..... 4

2.2.2. Clasificación taxonomía ..... 4

2.2.3. Raíces ..5

2.2.4. Tallo ..5

2.2.5. Hojas ..5

2.2.6. Flores ..5

2.2.7. Frutos ..6

2.2.8. Semilla ..6

2.2.9. Caracterización de clones del jardín Interclonal de la UNU 7

2.2.9.1. ISC-1 ..8

2.2.9.2. IMC-67 ..8

2.2.9.3. ICS- 6 .....9

2.2.9.4. ICS-95 9

2.2.9.5. SCA-6 9

2.2.9.6. UF-29 .....9

2.2.9.7. POUND-12 10

2.2.9.8. CCN-51 10
2.2.10. Requerimiento de suelo para el cultivo de cacao ..... ...10
2.2.11. Condiciones climáticas de cacao 11
2.2.11.1. Precipitación ..11
2.2.11.2. Temperatura ..11
2.2.11.3. Luminosidad ...12
2.2.11.4. Altitud ...12
2.2.12. Producción mundial de cacao..... ...13
2.2.13. Producción nacional del cacao ..... ...15
2.2.14. Zonas de producción de cacao..... ..17
2.3. Generalidades sobre metales pesados..... ...19
2.3.1. Metales pesados ..... ...19
2.3.2. Contenido de metales pesados admisibles en alimentos por U.E 20
2.3.3. Codex Alimentarius ...21
2.3.4. Reglamento del contenido de Cd en derivados del cacao ..... ...21
2.3.5. Peligro de exportación de cacao peruano a Europa ..... ....23
2.3.6. El cacao de Perú tiene un alto contenido en cadmio que puede afectar a la calidad del chocolate ..... ..24
2.3.7. Organización mundial de la salud ....25
2.3.8. Cadmio ..... ...27
2.3.9. Plomo .....27
2.3.10. Cadmio en el suelo agrícola 28
2.3.11. Plomo en suelo agrícola 30
2.3.12. Absorción de Cadmio (Cd) y Plomo (Pb) por la planta 32

2.3.13. Remediación de suelos contaminados con Cd y Pb 33

2.3.14. Retención de metales pesados en el suelo 34

2.3.15. Vías de contaminación por cadmio (Cd) y plomo (Pb) .....35

2.3.16. Otros factores que incrementan los metales pesados…. 36

2.3.17. Cadmio (Cd) y Plomo (Pb) en los tejidos vegetales 37

2.3.18. Determinación de metales pesados mediante el método de espectrofotometría 38

III. MATERIALES Y MÉTODOS ..... ..40

3.1. Ubicación ..40

3.2. Características climáticas ..40

3.3. Historia de campo 41

3.4. Materiales y equipos .41

3.4.1. Materiales de estudio 41

3.4.2. Materiales de campo .....42

3.4.3. Materiales de escritorio 42

3.4.4. Equipos 42

3.5. Población y muestra 42

3.5.1. Dimensión del área total 43

3.5.1.1. Del campo experimental 43

3.5.1.2. De la unidad experimental 43

3.6. Procesamiento de datos 43

3.6.1. Componentes en estudio 43

3.7. Diseño experimental 44

3.8. Ejecución del experimento 44

3.8.1. Reconocimiento de los clones evaluados .....44

3.8.2. Colecta de la muestra de suelo, hojas y almendras... 44 3.8.2.1. Colecta de la muestra de suelo... 44 3.8.2.2. Recolección de muestras de hojas... 45 3.8.2.3. Extracción de mazorcas... 45
3.8.2.4. Preparación de muestras y envío a laboratorio.... 46
IV. RESULTADOS Y DISCUSIÓN... 47 4.1. Contenido de cadmio y plomo en suelo, hojas y almendras... 47
V. CONCLUSIONES... 60
VI. RECOMENDACIONES... 61
VII. LITERATURA CITADA... 62
VIII. ANEXO... 70

## RESUMEN.

El presente trabajo de investigación se llevó a cabo en el Jardín Inter Clonal de cacao de la Universidad Nacional de Ucayali, cuyo objetivo fue determinar la concentración de cadmio (Cd) y plomo (Pb) en el suelo, hojas y almendras de ocho clones de cacao (*Theobroma cacao* L.) ICS-6, ICS-1, IMC-67, ICS-95, SCV-6, UF-29, POUND-12 y CCN-51.

Para ello, se realizó una comparación de promedios entre los datos obtenidos por los clones, usando una prueba de t al 95 % de significación, los que fueron procesados con el estadístico SAS versión 10.0 (2000), De igual forma, se realizaron los análisis de correlación de Pearson entre los contenidos de plomo y cadmio disponibles en el suelo, hoja y almendras con las variables pH, N, P y K en el suelo, hojas y almendras.

Los clones ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 y CCN-51 presentan valores de 0.39, 0.42, 0.38, 0.40, 0.36, 0.38, 0.31, 0.35 ppm de Cadmio intercambiable en el suelo por debajo de los límites permisibles es de 3 ppm. Mientras que en las hojas maduras los clones ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 y CCN-51 presentaron valores de 0.79, 0.80, 0.83, 0.54, 0.89, 0.63, 0.73, 0.59 ppm de cadmio se encuentra por debajo de los límites permisibles es de 3 ppm se concluye que los clones ICS-6, ICS-1, IMC-67, ICS-95, SCA-6 presentan valores de 0.76, 1.18, 0.62, 0.57, 0.59 ppm de cadmio se encuentra por encima de los límites permisibles es de 0.50 ppm mientras que los clones UF-29, POUND-12 y CCN-51 presentan valores de, 0.50, 0.37, 0.33 ppm se encuentra por debajo de los límites permisibles por la Unión Europea es de 0.50 ppm.

Los clones ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 y CCN-51 presentaron valores de 23.78, 6.99, 25.07, 7.25, 5.62, 8.73, 32.03, 8.69 de Plomo intercambiables en el suelo por debajo de los límites permisibles es de 300 ppm. Mientras que en las hojas maduras los clones ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 y CCN-51 presentaron valores de 2.55, 2.61, 3.43, 3.81, 3.80, 3.53, 2.48, 4.14 se encuentra por debajo de los límites permisibles es de 10 ppm se concluye que los clones ICS-95, POUND-12 y CCN-51 presentan valores de 2.30, 2.07, 2.05 ppm de Cadmio se encuentra por encima de los límites permisibles es de 2 ppm mientras que los clones ICS-6, ICS-1, IMC-67 SCA-6, UF-29, presentan valores de 2.00, 1.08, 1.71, 1.48, 1.50, ppm se encuentra por debajo de los límites permisibles por la Unión Europea es de 2 ppm.

**Palabras claves:** Cacao, metales pesados, suelo, hojas, almendras.

## ABSTRACT.

The present work was carried out in the Interclonal cacao Garden of the National University of Ucayali, whose objective was to determine the concentration of cadmium (Cd) and lead (Pb) in the soil, leaves and almonds of eight clones of (*Theobroma cacao* L.) ICS-6, ICS-1, IMC-67, ICS-95, SCV-6, UF-29, POUND-12 and CCN-51.

To do this, a comparison of averages between the data obtained by the clones, using a t-test at 95% significance, were performed with the SAS statistical version 10.0 (2000). Likewise, the analyzes were performed of Pearson correlation between the contents of lead and cadmium available in the soil, leaf and almonds with the variables pH, N, P and K in the soil, leaves and almonds.

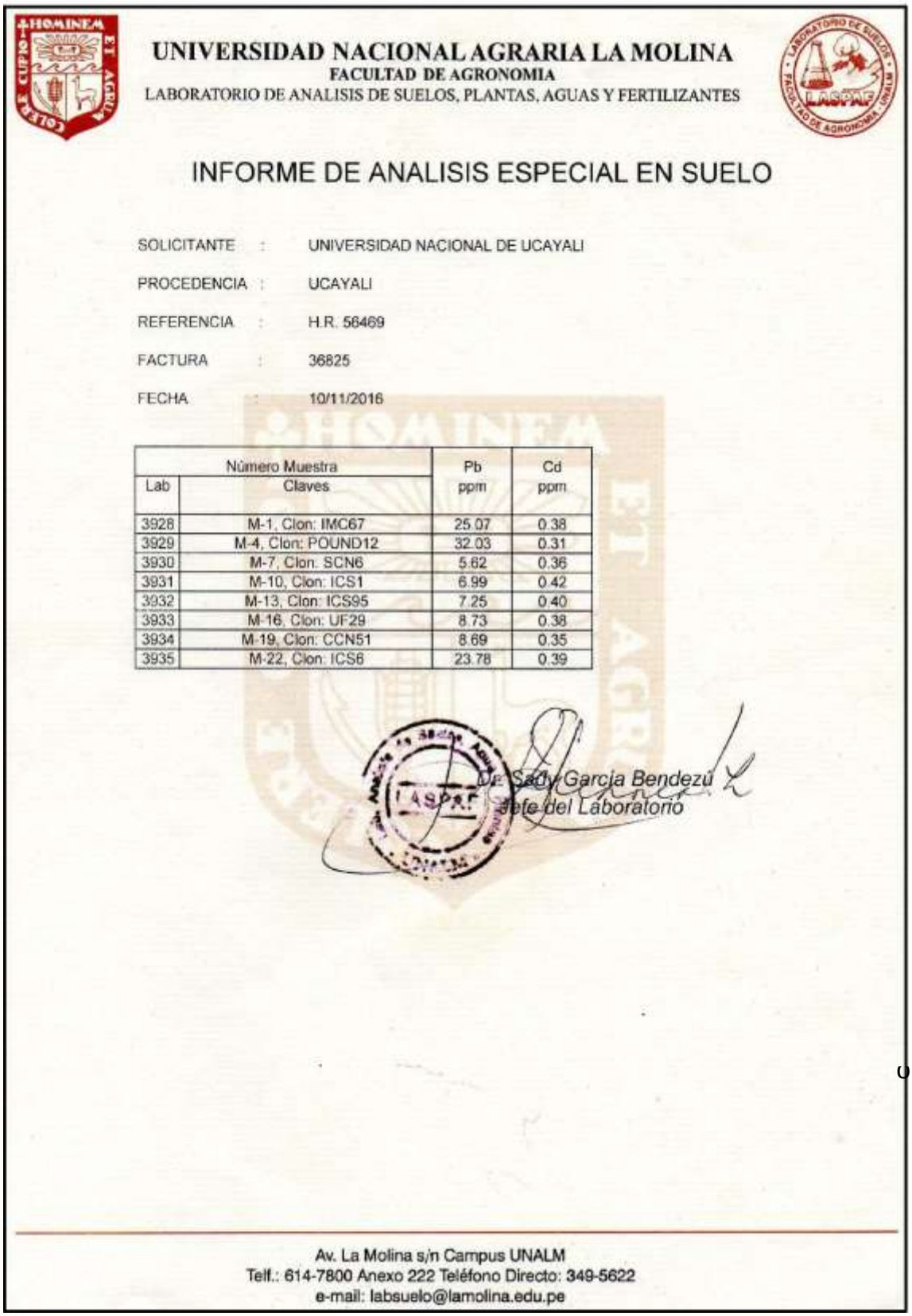
The ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 and CCN-51 clones presented values of 0.39, 0.42, 0.38, 0.40, 0.36, 0.38, 0.31, 0.35 ppm cadmium exchangeable in the soil below the allowable limits is 3 ppm. In ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 and CCN-51 clones presented values of 0.79, 0.80, 0.83, 0.54, 0.89, 0.63, 0.73, 0.59 ppm of cadmium below the permissible limits is 3 ppm, it is concluded that clones ICS-6, ICS-1, IMC-67, ICS-95, SCA-6 have values of 0.76 , 1.18, 0.62, 0.57, 0.59 ppm Cadmium is above the permissible limits is 0.50 ppm whereas the UF-29, POUND-12 and CCN-51 clones present values of, 0.50, 0.37, 0.33 ppm is found below the limits permissible by the European Union is 0.50 ppm.

The ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 and CCN-51 clones presented values of 23.78, 6.99, 25.07, 7.25, 5.62, 8.73, 32.03, 8.69

Interchangeable lead in the soil below the permissible limits is 300 ppm. The ICS-6, ICS-1, IMC-67, ICS-95, SCA-6, UF-29, POUND-12 and CCN-51 clones showed values of 2.55, 2.61, 3.43, 3.81, 3.80, 3.53, 2.48, 4.14 below the permissible limits is 10 ppm, it is concluded that clones ICS-95, POUND-12 and CCN-51 have values of 2.30, 2.07, 2.05 ppm Cadmium is above of the permissible limits is 2 ppm, while the clones ICS-6, ICS-1, IMC-67 SCA-6, UF-29, have values of 2.00, 1.08, 1.71, 1.48, 1.50 ppm below the limits permissible by the European Union is 2 ppm.

**Keywords:** Cocoa, heavy metals, soil, leaves, almonds.

# VIII. ANEXO.



UNIVERSIDAD NACIONAL AGRARIA LA MOLINA
FACULTAD DE AGRONOMIA
LABORATORIO DE ANALISIS DE SUELOS, PLANTAS, AGUAS Y FERTILIZANTES

INFORME DE ANALISIS ESPECIAL EN SUELO

SOLICITANTE : UNIVERSIDAD NACIONAL DE UCAYALI
PROCEDENCIA : UCAYALI
REFERENCIA : H.R. 56469
FACTURA : 36825
FECHA : 10/11/2016

| Número Muestra | | Pb | Cd |
|---|---|---|---|
| Lab | Claves | ppm | ppm |
| 3928 | M-1, Clon: IMC67 | 25.07 | 0.38 |
| 3929 | M-4, Clon: POUND12 | 32.03 | 0.31 |
| 3930 | M-7, Clon: SCN6 | 5.62 | 0.36 |
| 3931 | M-10, Clon: ICS1 | 6.99 | 0.42 |
| 3932 | M-13, Clon: ICS95 | 7.25 | 0.40 |
| 3933 | M-16, Clon: UF29 | 8.73 | 0.38 |
| 3934 | M-19, Clon: CCN51 | 8.69 | 0.35 |
| 3935 | M-22, Clon: ICS6 | 23.78 | 0.39 |

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**Figura 17. Análisis especiales de suelos para determinar el contenido de Cadmio y Plomo.**

UNIVERSIDADNACIONALAGRARIALAMOLINA
FACULTADDEAGRONOMIA
LABORATORIODEANALISISDESUELOS,PLANTAS,AGUASYFERTILIZANTES

# INFORMEDEANALISISESPECIALENFOLIAR

SOLICITANTE:UNIVERSIDADNACIONALDEUCAYALI

PROCEDENCIA:UCAYALI

MUESTRAHOJASDECACAO

REFERENCIA:H.R.5647

0 FACTURA36825

FECHA11/11/2016

| | N.CLAVEDEPbCd Lab.CAMPOppmppm | | |
|---|---|---|---|
| | 5614M-23.430.83 | | |
| | 5615M-52.480.73 | | |
| | 5616M-83.800.89 | | |
| | 5617M-112.610.80 | | |
| | 5618M-143.810.54 | | |
| | 5619M-173.530.63 | | |
| | 5620M-204.140.59 | | |
| | 5621M-232.550.79 | | |

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**Figura 18. Análisis especiales en Foliar para determinar el contenido de Cadmio y Plomo.**

UNIVERSIDADNACIONALAGRARIALAMOLINA
FACULTADDEAGRONOMIA
LABORATORIODEANALISISDESUELOS,PLANTAS,AGUASYFERTILIZANTES

# INFORMEDEANALISISESPECIALENFOLIAR

SOLICITANTE:UNIVERSIDADNACIONALDEUCAYALI PROCEDENCIA:UCAYALI

MUESTRAGRANOSDECACAO REFERENCIA:H.R.56471 FACTURA36825 FECHA11/11/2016

| | N.CLAVEDEPbCd Lab.CAMPOpprnpprn | | |
|---|---|---|---|
| | 5622M-31.710.62 | | |




**Figura 19. Análisis especiales en Granos para determinar el contenido de Cadmio y Plomo.**

| | | | |
|---|---|---|---|
| | 5623M-61.500.37 | | |
| | 5624M-92.070.59 | | |
| | 5625M-121.081.18 | | |
| | 5626M-152.300.57 | | |
| | 5627M-181.480.50 | | |
| | 5628M-212.050.33 | | |
| | 5629M-242.000.76 | | |

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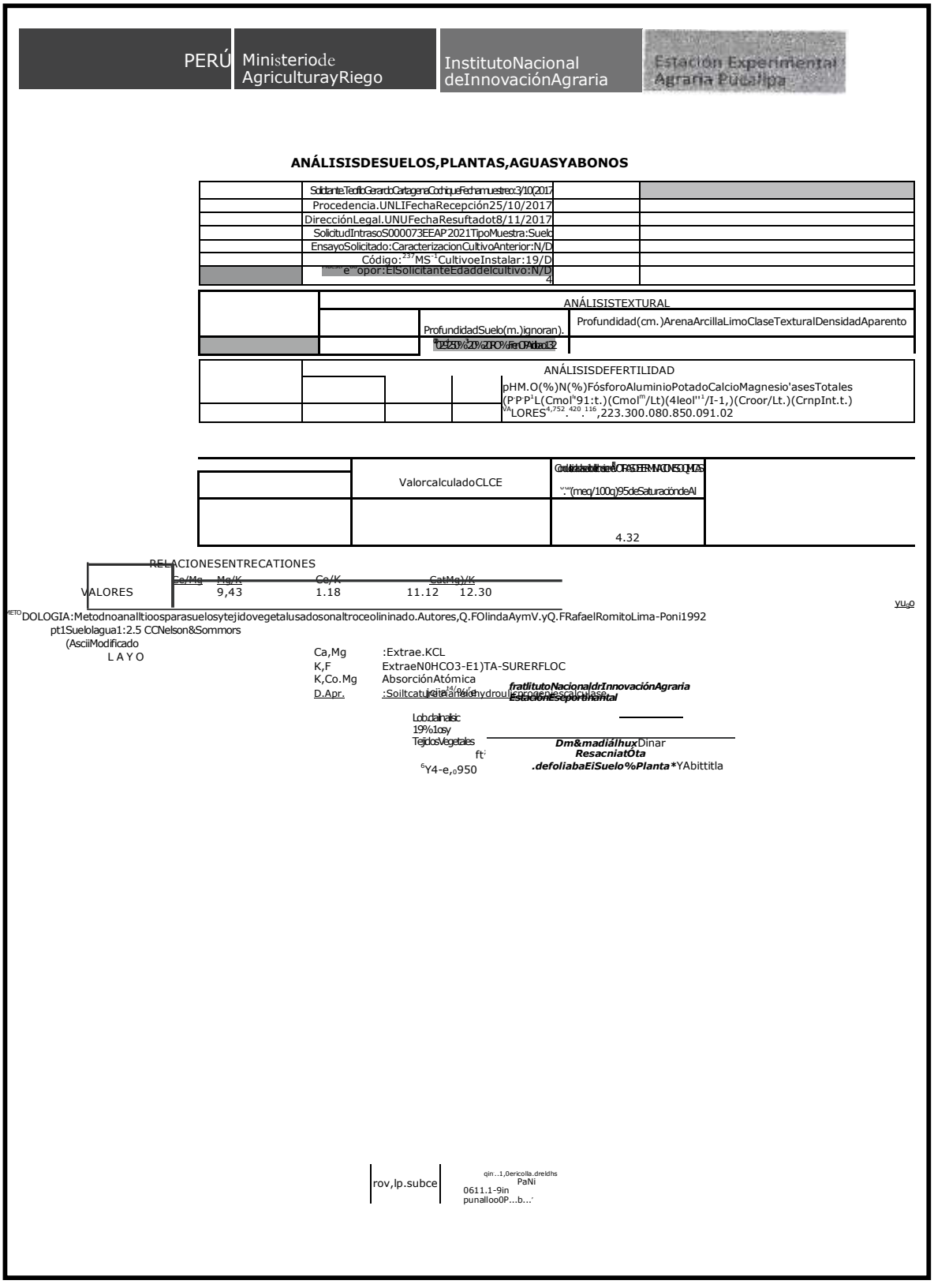



**Figura 20. Análisis de suelo.**

## Tabla 9. Corrida de SAS Cadmio Suelo.

| Obs | trt | Cd |
|---|---|---|
| **1** | **A** | **0.38** |
| **2** | **A** | **0.37** |
| **3** | **B** | **0.31** |
| **4** | **B** | **0.30** |
| **5** | **C** | **0.36** |
| **6** | **C** | **0.35** |
| **7** | **D** | **0.42** |
| **8** | **D** | **0.41** |
| **9** | **E** | **0.40** |
| **10** | **E** | **0.41** |
| **11** | **F** | **0.38** |
| **12** | **F** | **0.39** |
| **13** | **G** | **0.35** |
| **14** | **G** | **0.37** |
| **15** | **H** | **0.39** |
| **16** | **H** | **0.38** |

Class Level Information

| Class | Levels | Values |
|---|---|---|
| trt | 8 | A B C D E F G H |

Number of observations 16

Dependent Variable: Cd

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.01639375 | 0.00234196 | 34.06 | <.0001 |
| Error | 8 | 0.00055000 | 0.00006875 | | |
| Corrected Total | 15 | 0.01694375 | | | |

| R-Square | Coeff Var | Root MSE | Cd Mean |
|---|---|---|---|
| 0.967540 | 2.222194 | 0.008292 | 0.373125 |

| Source | DF | Anova SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| trt | 7 | 0.01639375 | 0.00234196 | 34.06 | <.0001 |

t Tests (LSD) for Cd

| | |
|---|---|
| Alpha | 0.05 |
| Error Degrees of Freedom | 8 |
| Error Mean Square | 0.000069 |
| Critical Value of t | 2.30600 |
| Least Significant Difference | 0.0191 |

| t | Mean | N | trt |
|---|---|---|---|
| **a** | **0.415000** | **2** | **D** |
| **a** | **0.405000** | **2** | **E** |
| **b** | **0.385000** | **2** | **F** |
| **b** | **0.385000** | **2** | **H** |
| **c** | **0.375000** | **2** | **A** |
| **d** | **0.360000** | **2** | **G** |
| **d** | **0.355000** | **2** | **C** |
| **e** | **0.305000** | **2** | **B** |

## Tabla 10. Corrida de SAS Cadmio Hojas.

| Obs | trt | Cd |
|---|---|---|
| 1 | A | 0.83 |
| 2 | A | 0.76 |
| 3 | B | 0.73 |
| 4 | B | 0.74 |
| 5 | C | 0.89 |
| 6 | C | 0.85 |
| 7 | D | 0.80 |
| 8 | D | 0.82 |
| 9 | E | 0.54 |
| 10 | E | 0.58 |
| 11 | F | 0.63 |
| 12 | F | 0.67 |
| 13 | G | 0.59 |
| 14 | G | 0.57 |
| 15 | H | 0.79 |
| 16 | H | 0.81 |

Class Level Information
Class Levels Values
trt 8 A B C D E F G H
Number of observations 16
Dependent Variable: Cd

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.18550000 | 0.02650000 | 38.55 | <.0001 |
| Error | 8 | 0.00550000 | 0.00068750 | | |
| Corrected Total | 15 | 0.19100000 | | | |

| R-Square | Coeff Var | Root MSE | Cd Mean |
|---|---|---|---|
| 0.971204 | 3.616582 | 0.026220 | 0.725000 |

| Source | DF | Anova SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| trt | 7 | 0.18550000 | 0.02650000 | 38.55 | <.0001 |

t Tests (LSD) for Cd

| | |
|---|---|
| Alpha | 0.05 |
| Error Degrees of Freedom | 8 |
| Error Mean Square | 0.000688 |
| Critical Value of t | 2.30600 |
| Least Significant Difference | 0.0605 |

| t | Mean | N | trt |
|---|---|---|---|
| a | 0.87000 | 2 | C |
| b | 0.81000 | 2 | D |
| b | 0.80000 | 2 | H |
| c | 0.79500 | 2 | A |
| c | 0.73500 | 2 | B |
| d | 0.65000 | 2 | F |
| e | 0.58000 | 2 | G |
| e | 0.56000 | 2 | E |

## Tabla 11. Corrida de SAS Cadmio Almendra.

| Obs | trt | Cd |
|---|---|---|
| 1 | A | 0.62 |
| 2 | A | 0.64 |
| 3 | B | 0.37 |
| 4 | B | 0.38 |
| 5 | C | 0.59 |
| 6 | C | 0.56 |
| 7 | D | 1.18 |
| 8 | D | 1.12 |
| 9 | E | 0.57 |
| 10 | E | 0.55 |
| 11 | F | 0.50 |
| 12 | F | 0.51 |
| 13 | G | 0.33 |
| 14 | G | 0.32 |
| 15 | H | 0.76 |
| 16 | H | 0.75 |

Class Level Information

| Class | Levels | Values |
|---|---|---|
| trt | 8 | A B C D E F G H |

Number of observations 16

Dependent Variable: Cd

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 0.92844375 | 0.13263482 | 372.31 | <.0001 |
| Error | 8 | 0.00285000 | 0.00035625 | | |
| Corrected Total | 15 | 0.93129375 | | | |

| Root MSE | Cd Mean | R-Square | Coeff Var |
|---|---|---|---|
| 0.018875 | 0.609375 | 0.996940 | 3.097368 |

| Source | DF | Anova SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| trt | 7 | 0.92844375 | 0.13263482 | 372.31 | <.0001 |

t Tests (LSD) for Cd

| | |
|---|---|
| Alpha | 0.05 |
| Error Degrees of Freedom | 8 |
| Error Mean Square | 0.000356 |
| Critical Value of t | 2.30600 |
| Least Significant Difference | 0.0435 |

| t | Mean | N | trt |
|---|---|---|---|
| a | 1.15000 | 2 | D |
| b | 0.75500 | 2 | H |
| c | 0.63000 | 2 | A |
| d | 0.57500 | 2 | C |
| d | 0.56000 | 2 | E |
| e | 0.50500 | 2 | F |
| f | 0.37500 | 2 | B |
| g | 0.32500 | 2 | G |

## Tabla 12. Corrida de SAS Plomo suelo.

| Obs | trt | Pb |
|---|---|---|
| 1 | A | 25.07 |
| 2 | A | 24.67 |
| 3 | B | 32.03 |
| 4 | B | 31.76 |
| 5 | C | 5.62 |
| 6 | C | 5.59 |
| 7 | D | 6.99 |
| 8 | D | 6.87 |
| 9 | E | 7.25 |
| 10 | E | 7.43 |
| 11 | F | 8.73 |
| 12 | F | 8.82 |
| 13 | G | 8.69 |
| 14 | G | 8.64 |
| 15 | H | 23.78 |
| 16 | H | 22.18 |

Class Level Information

| Class | Levels | Values |
|---|---|---|
| trt | 8 | A B C D E F G H |

Number of observations 16

Dependent Variable: Pb

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 1472.814500 | 210.402071 | 1180.71 | <.0001 |
| Error | 8 | 1.425600 | 0.178200 | | |
| Corrected Total | 15 | 1474.240100 | | | |

| R-Square | Coeff Var | Root MSE | Pb Mean |
|---|---|---|---|
| 0.999033 | 2.884930 | 0.422137 | 14.63250 |

| Source | DF | Anova SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| trt | 7 | 1472.814500 | 210.402071 | 1180.71 | <.0001 |

t Tests (LSD) for Pb

| | |
|---|---|
| Alpha | 0.05 |
| Error Degrees of Freedom | 8 |
| Error Mean Square | 0.1782 |
| Critical Value of t | 2.30600 |
| Least Significant Difference | 0.9735 |

| t | Mean | N | trt |
|---|---|---|---|
| a | 31.8950 | 2 | B |
| b | 24.8700 | 2 | A |
| c | 22.9800 | 2 | H |
| d | 8.7750 | 2 | F |
| d | 8.6650 | 2 | G |
| e | 7.3400 | 2 | E |
| e | 6.9300 | 2 | D |
| f | 5.6050 | 2 | C |

## Tabla 13. Corrida de SAS Plomo hojas.

| Obs | trt | Pb |
|---|---|---|
| 1 | A | 3.43 |
| 2 | A | 3.52 |
| 3 | B | 2.48 |
| 4 | B | 2.39 |
| 5 | C | 3.80 |
| 6 | C | 3.74 |
| 7 | D | 2.61 |
| 8 | D | 2.64 |
| 9 | E | 3.81 |
| 10 | E | 3.79 |
| 11 | F | 3.53 |
| 12 | F | 3.61 |
| 13 | G | 4.14 |
| 14 | G | 4.12 |
| 15 | H | 2.55 |
| 16 | H | 2.61 |

The ANOVA Procedure

Class Level Information

| Class | Levels | Values |
|---|---|---|
| trt | 8 | A B C D E F G H |

Number of observations 16

Dependent Variable: Pb

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 5.97109375 | 0.85301339 | 433.28 | <.0001 |
| Error | 8 | 0.01575000 | 0.00196875 | | |
| Corrected Total | 15 | 5.98684375 | | | |

| R-Square | Coeff Var | Root MSE | Pb Mean |
|---|---|---|---|
| 0.997369 | 1.345328 | 0.044371 | 3.298125 |

| Source | DF | Anova SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| trt | 7 | 5.97109375 | 0.85301339 | 433.28 | <.0001 |

| | |
|---|---|
| Alpha | 0.05 |
| Error Degrees of Freedom | 8 |
| Error Mean Square | 0.001969 |
| Critical Value of t | 2.30600 |
| Least Significant Difference | 0.1023 |

| t | Mean | N | trt |
|---|---|---|---|
| a | 4.13000 | 2 | G |
| b | 3.80000 | 2 | E |
| b | 3.77000 | 2 | C |
| c | 3.57000 | 2 | F |
| c | 3.47500 | 2 | A |
| d | 2.62500 | 2 | D |
| d | 2.58000 | 2 | H |
| e | 2.43500 | 2 | B |

**Tabla 14. Corrida de SAS Plomo almendra.**

| Obs | trt | Pb |
|---|---|---|
| 1 | A | 1.71 |
| 2 | A | 1.73 |
| 3 | B | 1.50 |
| 4 | B | 1.55 |
| 5 | C | 2.07 |
| 6 | C | 2.08 |
| 7 | D | 1.08 |
| 8 | D | 1.06 |
| 9 | E | 2.30 |
| 10 | E | 2.35 |
| 11 | F | 1.48 |
| 12 | F | 1.50 |
| 13 | G | 2.05 |
| 14 | G | 2.08 |
| 15 | H | 2.00 |
| 16 | H | 2.01 |

Class Level Information

| Class | Levels | Values |
|---|---|---|
| trt | 8 | A B C D E F G H |

Number of observations 16

Dependent Variable: Pb

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 7 | 2.34514375 | 0.33502054 | 734.29 | <.0001 |
| Error | 8 | 0.00365000 | 0.00045625 | | |
| Corrected Total | 15 | 2.34879375 | | | |

| R-Square | Coeff Var | Root MSE | Pb Mean |
|---|---|---|---|
| 0.998446 | 1.197058 | 0.021360 | 1.784375 |

| Source | DF | Anova SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| trt | 7 | 2.34514375 | 0.33502054 | 734.29 | <.0001 |

t Tests (LSD) for Pb

| | |
|---|---|
| Alpha | 0.05 |
| Error Degrees of Freedom | 8 |
| Error Mean Square | 0.000456 |
| Critical Value of t | 2.30600 |
| Least Significant Difference | 0.0493 |

The CORR Procedure

| t | Mean | N | trt |
|---|---|---|---|
| a | 2.32500 | 2 | E |
| b | 2.07500 | 2 | C |
| b | 2.06500 | 2 | G |
| c | 2.00500 | 2 | H |
| d | 1.72000 | 2 | A |
| e | 1.52500 | 2 | B |
| e | 1.49000 | 2 | F |
| f | 1.07000 | 2 | D |

**Tabla 15. The SAS System – Suelo.**

6 variables: Cd Pb pH N P K

**Simple Statistics**

| Variable | N | Mean | Std Dev | Sum | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Cd | 8 | 0.37375 | 0.03378 | 2.99000 | 0.31000 | 0.42000 |
| Pb | 8 | 14.77000 | 10.41583 | 118.160 | 5.62000 | 32.03000 |
| pH | 8 | 4.88250 | 0.48858 | 39.06000 | 4.25000 | 5.67000 |
| N | 8 | 0.09875 | 0.01356 | 0.79000 | 0.08000 | 0.12000 |
| P | 8 | 9.55500 | 0.60507 | 76.44000 | 8.78000 | 10.78000 |
| K | 8 | 0.23750 | 0.02659 | 1.90000 | 0.20000 | 0.27000 |

Pearson Correlation Coefficients, N = 8

Prob > |r| under H0: Rho=0

| | Cd | Pb | pH | N | P | K |
|---|---|---|---|---|---|---|
| Cd | 1.00000 | -0.49303 | 0.42262 | 0.22998 | -0.78456 | -0.09940 |
| | | 0.2144 | 0.2969 | 0.5838 | 0.0211 | 0.8149 |
| Pb | -0.49303 | 1.00000 | -0.05652 | 0.00799 | 0.50616 | 0.78464 |
| | 0.2144 | | 0.8943 | 0.9850 | 0.2006 | 0.0211 |
| pH | 0.42262 | -0.05652 | 1.00000 | 0.74866 | -0.56060 | 0.11490 |
| | 0.2969 | 0.8943 | | 0.0326 | 0.1483 | 0.7864 |
| N | 0.22998 | 0.00799 | 0.74866 | 1.00000 | -0.62585 | -0.08913 |
| | 0.5838 | 0.9850 | 0.0326 | | 0.0969 | 0.8338 |
| P | -0.78456 | 0.50616 | -0.56060 | -0.62585 | 1.00000 | 0.43505 |
| | 0.0211 | 0.2006 | 0.1483 | 0.0969 | | 0.2814 |
| K | -0.09940 | 0.78464 | 0.11490 | -0.08913 | 0.43505 | 1.00000 |
| | 0.8149 | 0.0211 | 0.7864 | 0.8338 | 0.2814 | |

**Tabla 16. The SAS System - Foliar.**

## The CORR Procedure

6 variables: Cd Pb pH N P K

### Simple Statistics

| Variable | N | Mean | Std Dev | Sum | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Cd | 4 | 5.16250 | 0.02217 | 20.65000 | 5.14000 | 5.19000 |
| Pb | 4 | 2.22500 | 0.01915 | 8.90000 | 2.21000 | 2.25000 |
| pH | 4 | 5.21750 | 0.03500 | 0.77000 | 0.15000 | 0.23000 |
| N | 4 | 1.37750 | 0.01708 | 5.51000 | 1.36000 | 1.40000 |
| P | 4 | 0.19250 | 0.01708 | 20.87000 | 5.20000 | 5.24000 |
| K | 4 | 2.26500 | 0.02082 | 9.06000 | 2.24000 | 2.29000 |

Pearson Correlation Coefficients, N = 4

Prob > |r| under H0: Rho=0

| | Cd | Pb | pH | N | P | K |
|---|---|---|---|---|---|---|
| Cd | 1.00000 | -0.27477 | 0.03221 | -0.24207 | -0.77021 | -0.18054 |
| | | 0.7252 | 0.9678 | 0.7579 | 0.2298 | 0.8195 |
| Pb | -0.27477 | 1.00000 | 0.22381 | 0.96833 | 0.76447 | -0.08362 |
| | 0.7252 | | 0.7762 | 0.0317 | 0.2355 | 0.9164 |
| pH | 0.03221 | 0.22381 | 1.00000 | 0.46007 | -0.15336 | -0.98364 |
| | 0.9678 | 0.7762 | | 0.5399 | 0.8466 | 0.0164 |
| N | -0.24207 | 0.96833 | 0.46007 | 1.00000 | 0.65714 | -0.32817 |
| | 0.7579 | 0.0317 | 0.5399 | | 0.3429 | 0.6718 |
| P | -0.77021 | 0.76447 | -0.15336 | 0.65714 | 1.00000 | 0.32817 |
| | 0.2298 | 0.2355 | 0.8466 | 0.3429 | | 0.6718 |
| K | -0.18054 | -0.08362 | -0.98364 | -0.32817 | 0.32817 | 1.00000 |
| | 0.8195 | 0.9164 | 0.0164 | 0.6718 | 0.6718 | |

**Tabla 17. The SAS System – Almendra.**

The CORR Procedure

6 variables: Cd Pb pH N P K

**Simple Statistics**

| Variable | N | Mean | Std Dev | Sum | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Cd | 8 | 0.61500 | 0.26657 | 4.92000 | 0.33000 | 1.18000 |
| Pb | 8 | 1.77375 | 0.40334 | 14.19000 | 1.08000 | 2.30000 |
| pH | 8 | 6.02750 | 0.01581 | 48.22000 | 6.01000 | 6.05000 |
| N | 8 | 2.26500 | 0.01309 | 18.12000 | 2.25000 | 2.28000 |
| P | 8 | 0.83875 | 0.01553 | 6.71000 | 0.82000 | 0.86000 |
| K | 8 | 1.83875 | 0.00835 | 14.71000 | 1.83000 | 1.85000 |

Pearson Correlation Coefficients, N = 8

Prob > |r| under H0: Rho=0

| | **Cd** | **Pb** | **pH** | **N** | **P** | **K** |
|---|---|---|---|---|---|---|
| Cd | 1.00000 | -0.48956 | -0.11524 | 0.18010 | 0.40557 | 0.35641 |
| | 0.2182 | 0.7858 | 0.6695 | 0.3188 | 0.3862 | |
| Pb | -0.48956 | 1.00000 | 0.50569 | -0.40712 | -0.51697 | -0.36341 |
| | 0.2182 | | 0.2011 | 0.3168 | 0.1895 | 0.3762 |
| pH | -0.11524 | 0.50569 | 1.00000 | -0.96609 | -0.88742 | -0.78493 |
| | 0.7858 | 0.2011 | | <.0001 | 0.0033 | 0.0210 |
| N | 0.18010 | -0.40712 | -0.96609 | 1.00000 | 0.87841 | 0.71909 |
| | 0.6695 | 0.3168 | <.0001 | | 0.0041 | 0.0444 |
| P | 0.40557 | -0.51697 | -0.88742 | 0.87841 | 1.00000 | 0.86824 |
| | 0.3188 | 0.1895 | 0.0033 | 0.0041 | | 0.0052 |
| K | 0.35641 | -0.36341 | -0.78493 | 0.71909 | 0.86824 | 1.00000 |
| | 0.3862 | 0.3762 | 0.0210 | 0.0444 | 0.005 | |

**Tabla 18. The SAS System Cd en Suelo - Foliar - Almendra.**

The CORR Procedure

3 variables: Cd suelo Cd foliar Cd almendra

**Simple Statistics**

| Variable | N | Mean | Std Dev | Sum | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Cd suelo | 8 | 0.37375 | 0.03378 | 2.99000 | 0.31000 | 0.42000 |
| Cd foliar | 8 | 0.72500 | 0.12513 | 5.80000 | 0.54000 | 0.89000 |
| Cd almendra | 8 | 0.61500 | 0.26657 | 4.92000 | 0.33000 | 1.18000 |

Pearson Correlation Coefficients, N = 8

Prob > |r| under H0: Rho=0

| | Cd suelo | Cd foliar | Cd almendra |
|---|---|---|---|
| Cd suelo | 1.00000 | 0.01183 | 0.78294 |
| | | 0.9778 | 0.0216 |
| Cd foliar | 0.01183 | 1.00000 | 0.44842 |
| | 0.9778 | | 0.2651 |
| Cd almendra | 0.78294 | 0.44842 | 1.00000 |
| | | 0.0216 | 0.2651 |

**Tabla 19. The SAS System Pb en Suelo - Foliar - Almendras.**

The CORR Procedure

3 variables: Pb suelo Pb foliar Pb almendra

**Simple Statistics**

| Variable | N | Mean | Std Dev | Sum | Mínimum | Máximum |
|---|---|---|---|---|---|---|
| Pb suelo | 8 | 14.77000 | 10.41583 | 118.16000 | 5.62000 | 32.03000 |
| Pb foliar | 8 | 3.29375 | 0.65424 | 26.35000 | 2.48000 | 4.14000 |
| Pb almendra | 8 | 1.77375 | 0.40334 | 14.19000 | 1.08000 | 2.30000 |

Pearson Correlation Coefficients, N = 8

Prob > |r| under H0: Rho=0

| | Pb suelo | Pb foliar | Pb almendra |
|---|---|---|---|
| Pb suelo | 1.00000 | -0.61026 | -0.15367 |
| | | 0.1081 | 0.7164 |
| Pb foliar | -0.61026 | 1.00000 | 0.59886 |
| | | 0.1081 | 0.1167 |
| Pb almendra | -0.15367 | 0.59886 | 1.00000 |
| | | 0.7164 | 0.1167 |




**Figura 21. Ingreso al Jardín Inter Clonal de cacao.**



**Figura 22. Clones de cacao.**



**Figura 23. Recolección de muestras de suelo en diferentes clones.**



**Figura 24. Recolección de muestras de hojas en diferentes clones.**



**Figura 25. Recolección de muestras de mazorcas en diferentes clones.**



**Figura 26. Recolección de muestras de almendras en diferentes clones.**



**Figura 27. Molido de suelo, hojas y almendras.**




**Figura 28. Muestras de suelo, hojas y almendras puestas en bolsas rotuladas.**