# Ecophysiological studies in "quinoa" varieties in Argentinean Northwest.

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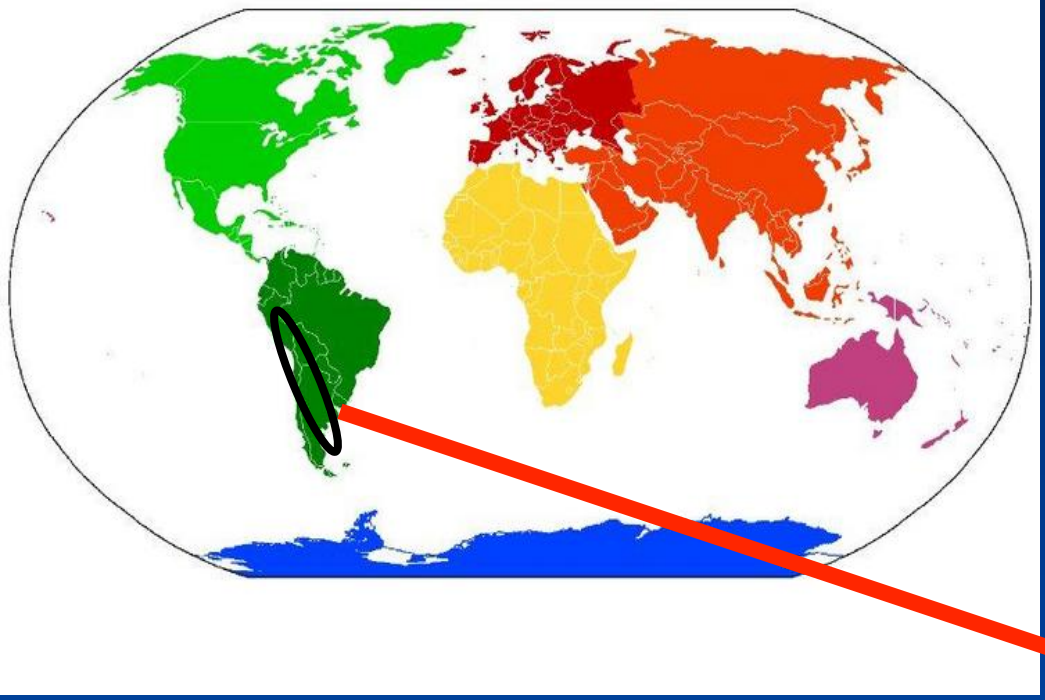
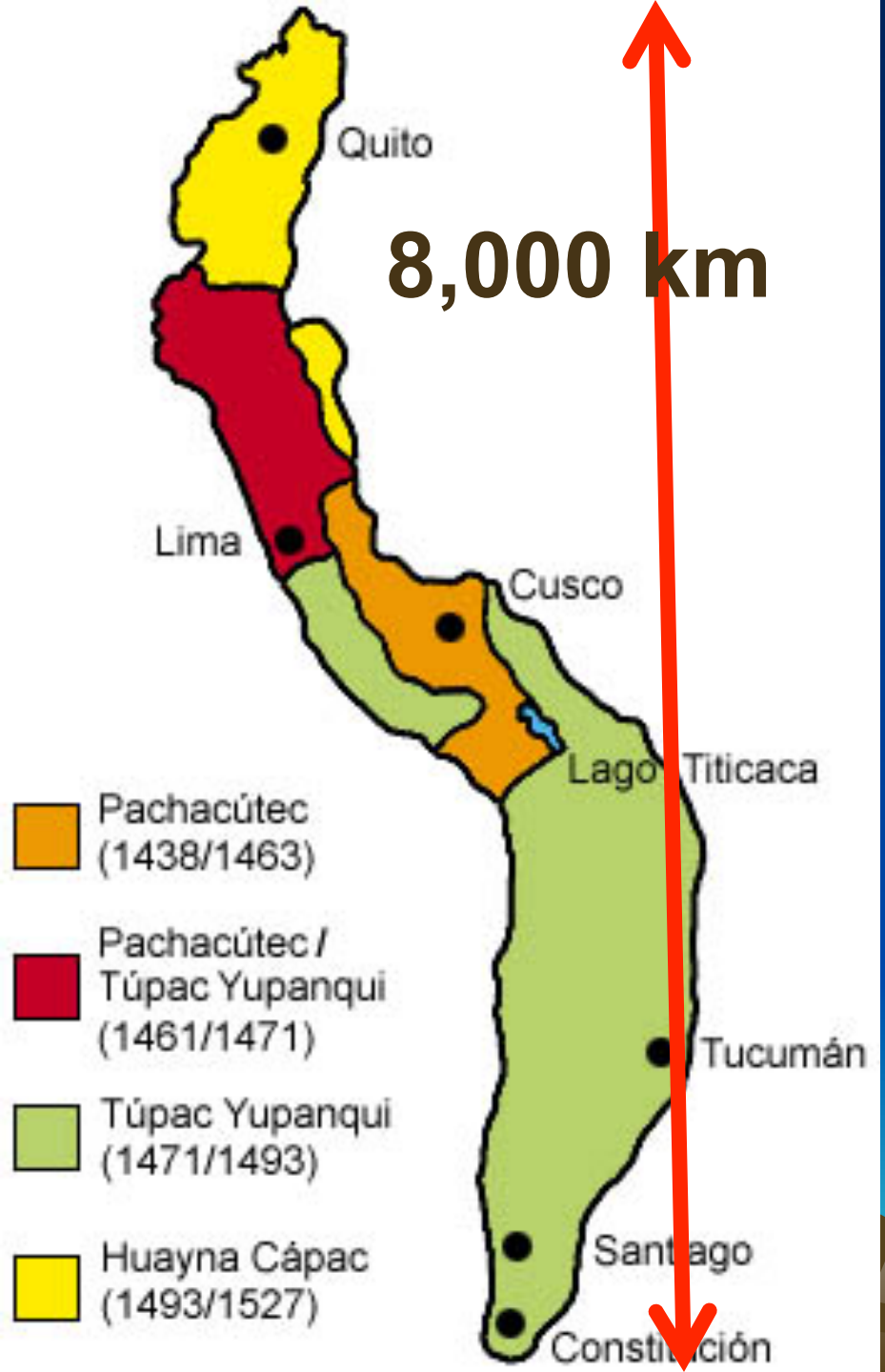
# Quinoa origin




**Quinoa is an south american crops. Origin center in the area of Titicaca lake ).**

# Inca empire




## Altitude:

**Between 400 to 7,000 m asl**

## Latitude:

**Near the Ecuator (0 º lat) to 40 ª lat S**

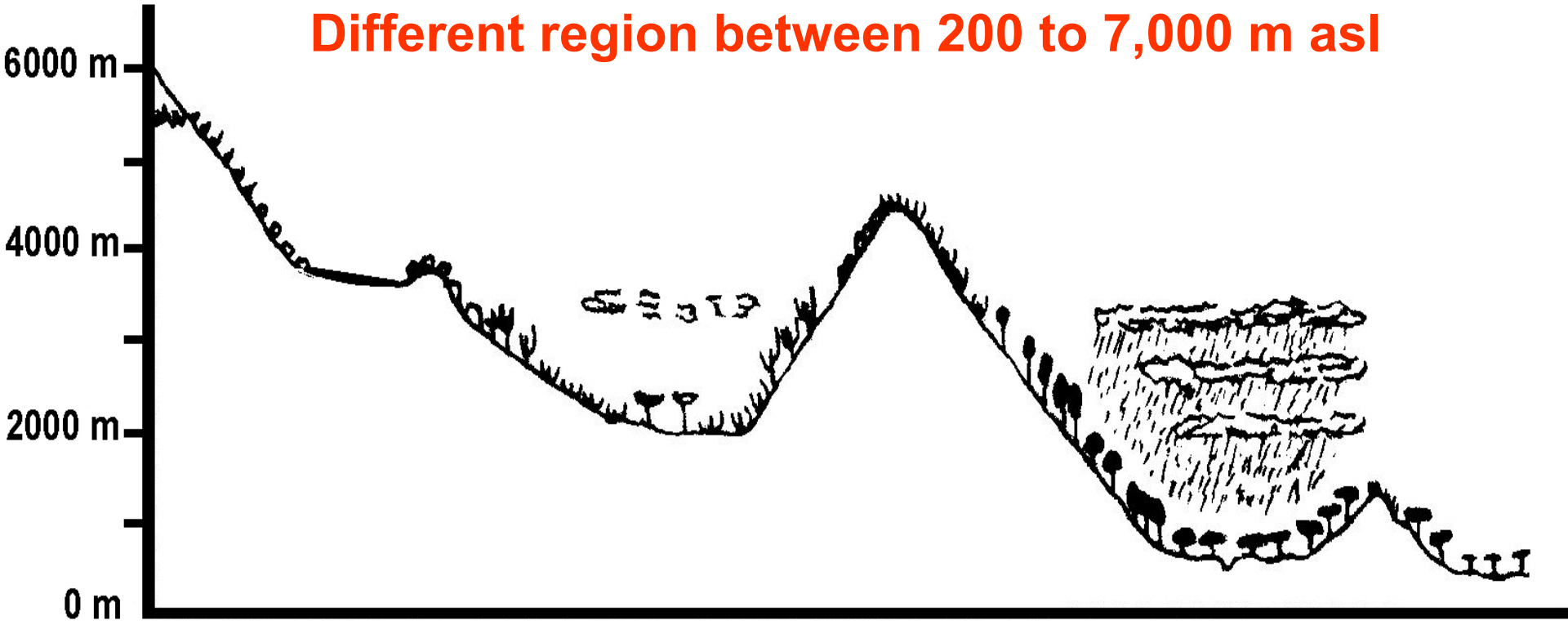
- In this altitudinal and latitudinal transect quinoa was grown (from sea level to 4,000 m asl)

Actually near 30 commercial varieties exist but only in Bolivia 3,600 quinoa accessions are deposited

# Argentinean Northwest

South América


# Altitudinal levels and vegetation in the Argentinean Northwest Region

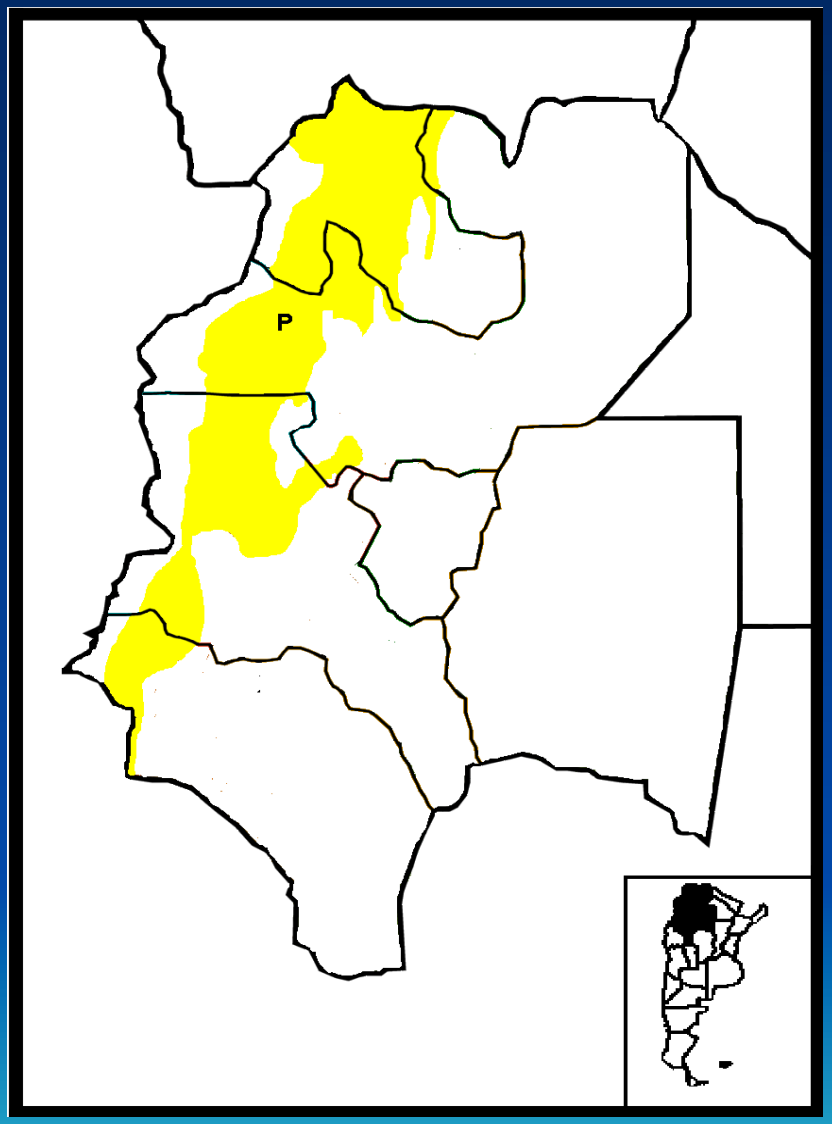



"Chaco" vegetation (> 200 m asl)
"Selva basal" (400 – 700 m asl)
Mountain forest (700 – 1,500 m asl)
Cloud forest (1,500 – 3,000 m asl)
Prepuna, Puna (> 3,000 m asl)
High andean vegetation (> 4,200 )

**A lot of microclimate in medium and high mountain (between 2,000 to 4,200 m asl) exist.**

**These are considered “marginal lands”, for soil types and climatic condictions.**

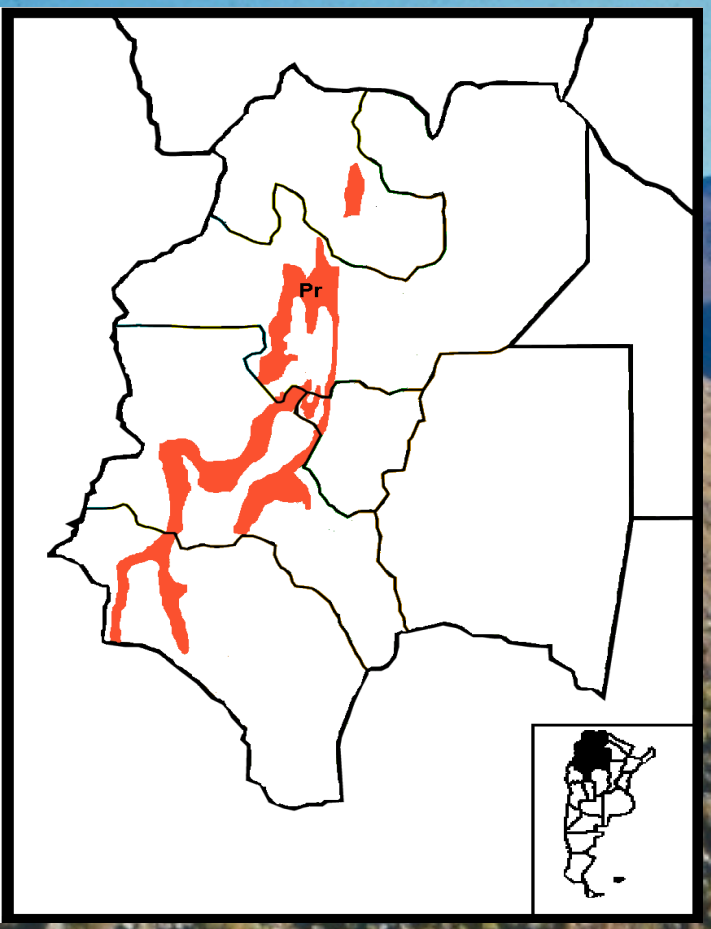
# Puna Region




It is a high plateau, between 3,300 and 4,300 m asl. Shrub vegetation.

87,000 Km2

# Prepuna Region
# Between 2,000 and 3,300 asl

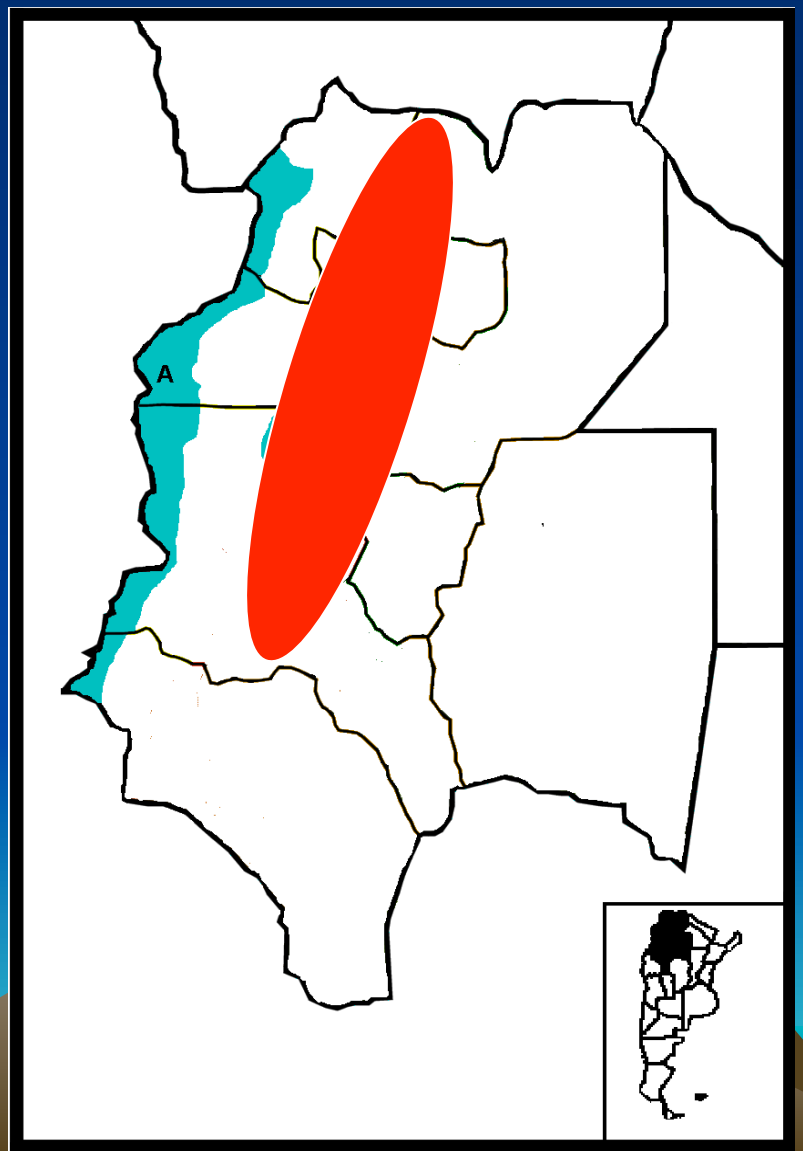



39,000 km2

**Presence of shrub vegetation and columnar cacti and bromeliaceae**

# Valle Calchaquí Region (Calchaquí Valley) between 1,800 to 2,500 m asl

Near
40,000 km2



# Calchaquí Valley: some crops like:

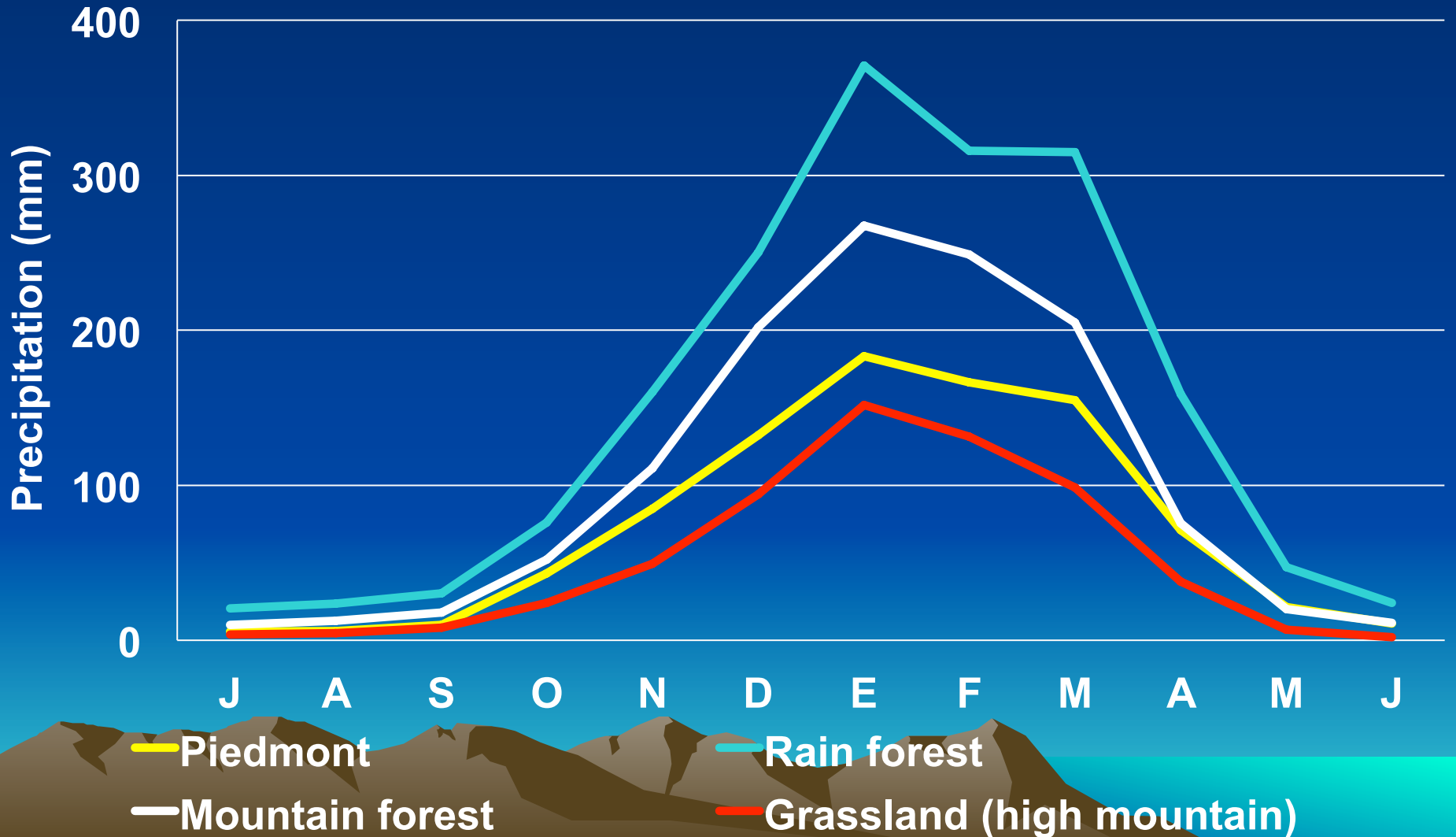
- Lettuce
- Tomatoes
- Chilli
- Grapes
- Peach

- and very few indigenous crop species (like maize, andean potatoes or quinoa)

# Crops, water and environment

All the mentioned crops are demanding a lot of water in a region where the rain distribution is very different along the year and along the altitude. Another environment problem is the use of pesticides.

# Distribution of precipitation in different altitudinal levels



# Exist  some camelids but it is neccesary fodde


FUENTE: GUIA PARA EL RECONOCIMIENTO DE MAMIFEROS CHILENOS, S.MILLER Y J.ROTTMANN

**In this context it is necessary to look for new alternative crops**

**The other point to take into account is climatic change (especially drought) and marginal soils.**

# Our goals…

**We are trying to recover and developed the clasical andean crops: quinoa, amaranthus, algarrobo ("mesquite tree), cactaceae ("tuna"), andean potato ("papines") with emphasis in "quinoa" due to rusticity.**


# Proposal

**Selection of "quinoa" varities for high valley (2,000 – 3,000 m asl) in order to obtain:**

## A multipurpose species

# Quinoa studies

Growth analysis (biomass distribution)

Photosynthetic assimilation and pathway (C13/C12)

Grain yield

Nutritional value (proteins and total and essential aminoacids)

Mineral contents (Fe, Ca and others)

Quinoa vegetables as fodders

Saponin content

Foliar pigments (red pigment)

- Lab Experiments: Germination (water ,salt, heavy metals and UVB stress)

# Field experiments

**Tucumán - Encalilla - Amaicha del Valle**
**(1,995 m asl; 22º 31´S, 65º 59´W)**

# Sandy and alkaline soil

**Table 2.** Soil classification, chemical and physical properties of Encalilla and Patacamaya topsoils

| Parameter | Encalilla | Patacamaya |
|---|---|---|
| Soil order | Entisol | – |
| Type | Xeric Torriorthent | Haplic Xerosol[13] |
| Sand (%) | 48 | 79[13] |
| Silt (%) | 22 | 15[13] |
| Clay (%) | 30 | 6[13] |
| Soil texture | Sandy clay loam | Sandy stony[13] |
| pH of suspension in $H_2O$ (1 : 1) | 8.4 | 6.6[13] |
| Organic matter (%) | 0.60 | 0.50[13] |
| Total nitrogen (%) | 0.055 | 0.066[13] |
| C/N ratio | 10.9 | 7.6[13] |
| P-Olsen (mg $kg^{-1}$) | 23.5 | 20.5[34] |
| $CaCO_3$ (%) | 0.68 | 0.45[34] |
| ES (%) | 38.6 | Negligible[13b] |
| EC (dS $m^{-1}$) | 2.0 | 7.0[34] |
| *Exchangeable cations* | | |
| $K^+$ (mg $kg^{-1}$) | 390.2 | 424.4[34] |
| $Na^+$ (mg $kg^{-1}$) | 615.2 | – |
| $Mg^{2+}$ (mg $kg^{-1}$) | 342.7 | 279.2[34] |
| CEC (cmol $kg^{-1}$)[a] | 12.3 | 8.9[34] |

ES, exchangeable sodium; EC, electrical conductivity; CEC, cation exchange capacity.

[a] Centimoles of positive charge per kilogram of dry soil.

[b] Corresponds to exchangeable aluminium at pH 6.6.

| | Origin | Seed weight (1000 seeds) | Grain colour | Grain size (diameter ± SD) |
|---|---|---|---|---|
| Amilda | Bolivia (Patacamaya) | 2.96 | White | 2.0 (0.3) |
| Chucapaca | Bolivia (Patacamaya) | 2.55 | White | 2.0 (0.3) |
| CICA | Argentina (Salta) | 1.73 | Yellow | 2.0 (0.2) |
| Kamiri | Bolivia (Patacamaya) | 3.55 | White | 2.0 (0.4) |
| Kancolla | Bolivia (Patacamaya) | 1.70 | White | 1.7 (0.1) |
| Ratuqui | Bolivia (Patacamaya) | 3.16 | White | 2.0 (0.3) |
| Robura | Bolivia (Patacamaya) | 2.13 | White | 2.0 (0.1) |
| Sajama | Bolivia (Patacamaya) | 1.81 | White | 2.0 (0.2) |
| Samaranti | Bolivia (Patacamaya) | 1.61 | White | 1.9 (0.1) |
| Sayaña | Bolivia (Patacamaya) | 3.08 | Yellow cream | 1.8 (0.1) |

# Results

# Grain yield (2,000 m asl)

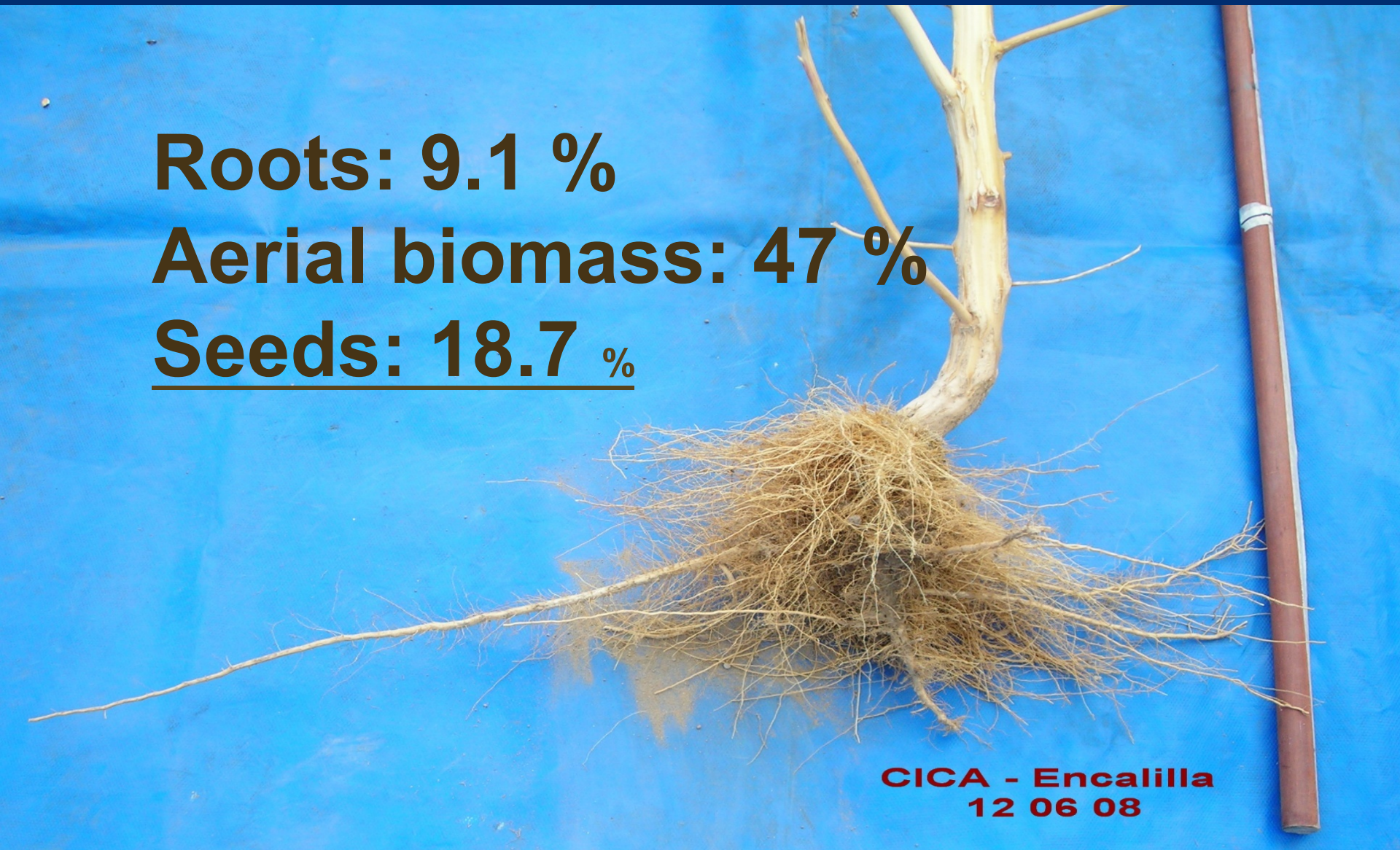
# Biomassa allocattion and yield

| | Roots (%) | Stem (%) | Seeds (%) | IF (%) | IS (%) | Yield (Kg/ha) |
|---|---|---|---|---|---|---|
| Amilda | 8.9 | 41.1 | 25.4 | 14.5 | 10.0 | 2109.8 |
| Chucapaca | 6.7 | 34.0 | 33.0 | 15.8 | 10.5 | 2754.9 |
| CICA | 9.1 | 46.9 | 18.7 | 17.2 | 8.1 | 2344.3 |
| Kamiri | 5.9 | 27.2 | 31.8 | 22.7 | 12.3 | 2191.7 |
| Kancolla | 4.8 | 41.3 | 24.5 | 20.6 | 8.7 | 2845.5 |
| Ratuqui | 7.0 | 29.4 | 35.1 | 22.5 | 6.0 | 2110.4 |
| Robura | 8.0 | 32.4 | 19.5 | 24.5 | 15.6 | 1326.1 |
| Sajama | 7.2 | 31.1 | 11.1 | 31.7 | 13.1 | 376.2 |
| Samaranti | 7.3 | 39.5 | 6.7 | 32.8 | 9.7 | 1069.3 |
| Sayaña | 8.0 | 33.2 | 34.1 | 18.0 | 6.7 | 3854.7 |

IF: Inflorescence bracts

IS: Inflorescence stems

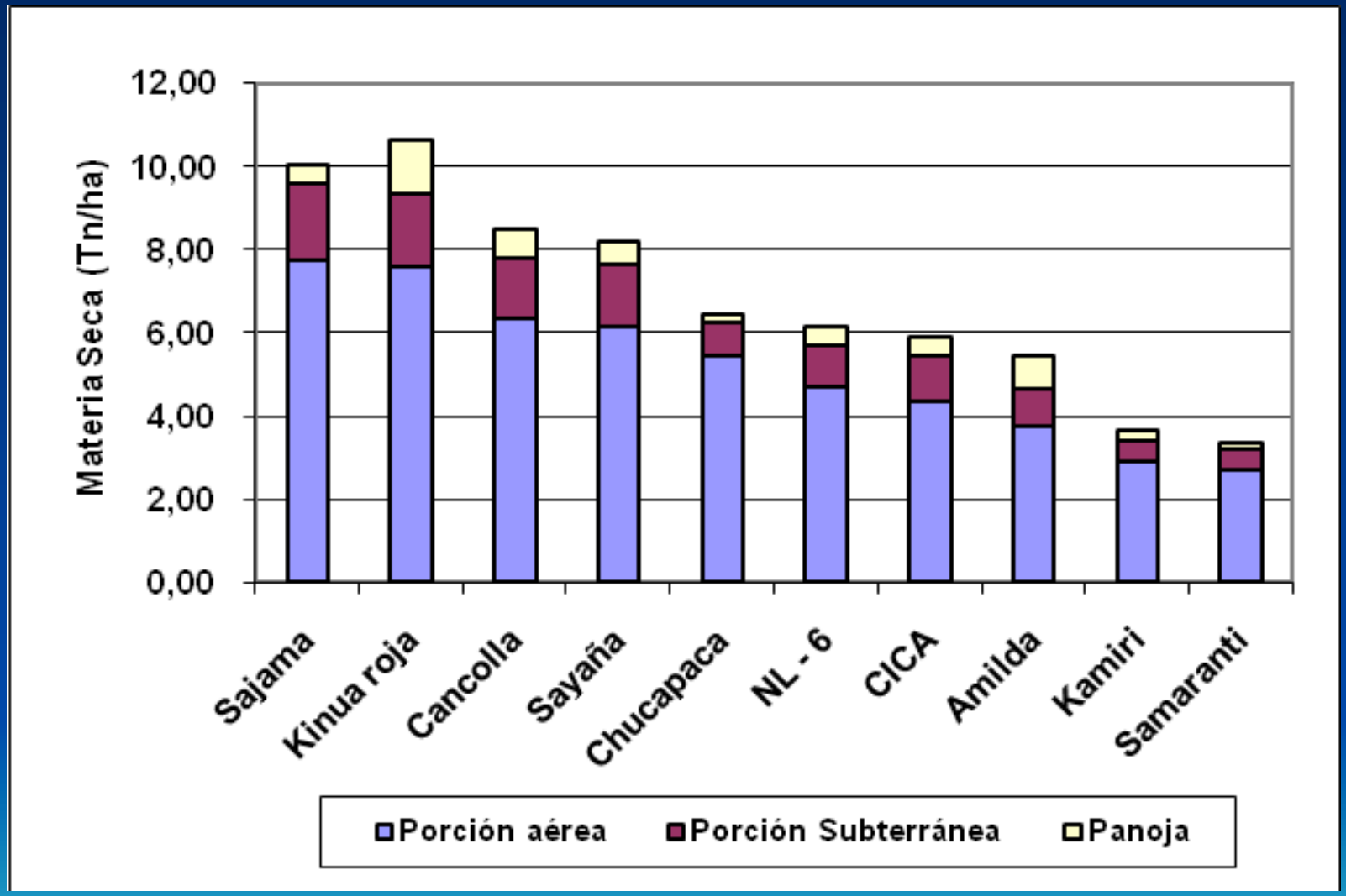
# CICA has a good aerial biomass (stem + leaves)



# Chucapaca and Sayaña have the better yield in grain in Encalilla

**Roots: 6.7 %**
**Aerial biomass: 34 %**
**Seeds: 33 %**

# Aerial dry weight (Tn/ha)




**Biomass production at 110 days . Potential fodder for cattle, camelids, goats and sheep, , etc.**

# Leaf protein, fibers and mineral content (at 110 days)

| Variedades | Proteínas (%) | | Fibras (%) | | | | Cenizas (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | FAD | FIDN | FAD | FIDN | | |
| | Hojas | Tallos | Hojas | Hojas | Tallos | Tallos | Hojas | Tallos |
| Amilda | 17,9 | 12,3 | 10,0 | 44,0 | 26,6 | 59,7 | 25,4 | sd |
| Chucapaca | 21,7 | 13,3 | 11,6 | 21,7 | 38,2 | 50,0 | 27,5 | 23,7 |
| CICA | 17,6 | 9,5 | 14,9 | 22,7 | 32,6 | 48,0 | sd | sd |
| Kamiri | 13,1 | 9,2 | 11,2 | 63,1 | 40,4 | 63,1 | 27,3 | 18,7 |
| Kancolla | 15,3 | 11,4 | 9,0 | 60,6 | 45,1 | 57,4 | sd | sd |
| Kinua Roja | 12,7 | 7,9 | 15,6 | 28,6 | 43,2 | 52,9 | sd | 16,8 |
| NL - 6 | 17,1 | 7,8 | 14,7 | 25,9 | 32,4 | 47,1 | 26,9 | 23,9 |
| Sajama | 13,0 | 9,6 | 21,0 | 40,3 | 28,6 | 60,0 | sd | sd |
| Samaranti | 14,9 | 10,2 | 13,0 | 37,7 | 40,4 | 68,3 | 33,6 | 21,9 |
| Sayaña | 13,7 | 7,4 | 21,2 | 41,4 | 39,6 | 71,4 | 29,5 | sd |
| **Promedio** | **15,7** | **9,9** | **14,2** | **38,6** | **36,7** | **57,2** | **28,4** | **21,0** |

FAD: Fibra Acido Detergente; FND: Fibra Insoluble en Detergente Neutro

Tabla 3: Análisis foliar de cenizas

| Variedades | Nitrógeno (%) | Fósforo (%) | K (%) | Ca (%) | Mg (%) | C (%) | C/N |
|---|---|---|---|---|---|---|---|
| Amilda | 4,2 | 0,2 | 9,47 | 2,5 | 1,1 | 38,7 | 9,3 |
| Ayara | 4,4 | 0,2 | 9,14 | 2,7 | 1,3 | 38,4 | 8,7 |
| Samaranti | 3,9 | 0,2 | 9,93 | 2,5 | 0,9 | 38,0 | 9,7 |
| Sajama | 3,9 | 0,2 | 9,86 | 2,6 | 1,4 | 37,7 | 9,8 |
| Robura | 4,1 | 0,3 | 9,40 | 2,8 | 1,0 | 38,4 | 9,4 |
| Sayaña | 3,9 | 0,2 | 9,20 | 2,7 | 1,6 | 39,5 | 10,1 |
| Ratuqui | 4,1 | 0,3 | 8,54 | 2,5 | 1,3 | 39,4 | 9,6 |
| Kamiri | 4,5 | 0,3 | 8,74 | 2,6 | 1,1 | 39,6 | 8,7 |
| Kancolla | 5,4 | 0,3 | 8,54 | 2,8 | 1,2 | 42,0 | 7,8 |
| Chucapaca | 4,6 | 0,2 | 8,98 | 3,0 | 0,9 | 40,7 | 8,9 |
| CICA | 4,6 | 0,3 | 9,07 | 2,5 | 0,9 | 40,1 | 8,7 |
| **Promedio** | **4,3** | **0,3** | **9,2** | **2,7** | **1,2** | **39,3** | **9,2** |

**The relationship biomass production, seed production is a very important aspect related to the use of quinoa (eg. seed production or fodder production)**

# In Calcahquí Valley there is a few green material for fodder



**So quinoa may be a good suplementary fodder for animals (goat, rabbit, cow and others)**

It is possible to designed a crop with different quinoa varieties

in order to get grain, fodder or vegetables

# Proteins

# Encalilla (2,000 m asl) (Tucuman – Argentina)

**The total protein content (average) in *Chenopodium quinoa* (12.7 %)**

**higher than wheat (10.7 %), maize (9.0 %) and barley's (1 1.9 %) (Janssen et al., 1979).**

**Soluble proteins content: 10.04%,**

**Table 4.** Two-year mean values of total protein content and protein quality index of quinoa seeds from both growing sites

| Cultivar | Total protein (g kg$^{-1}$ dry mass) | | Protein quality index (%) | |
|---|---|---|---|---|
| | Encalilla | Bolivia/ Argentina | Encalilla | Bolivia/ Argentina |
| Amilda | 125.0a | 114.1a | 5.20b | 6.57a |
| Chucapaca | 143.4a | 116.7b | 4.04b | 5.57a |
| CICA | 134.6b | 154.6a | 5.94b | 7.24a |
| Camiri | 131.2a | 139.8a | 5.64b | 7.44a |
| Kancolla | 151.7a | 144.4a | 4.28a | 4.78a |
| Ratuqui | 155.3a | 103.8b | 6.05a | 6.94a |
| Robura | 104.3a | 96.2a | 9.87a | 9.36a |
| Sajama | 91.5b | 120.0a | 6.78b | 8.75a |
| Samaranti | 93.4b | 122.6a | 8.78a | 7.50b |
| Sayaña | 138.5a | 113.6b | 4.26b | 10.12a |
| Mean | 126.9a | 122.6a | 6.08b | 7.43a |

Values followed by the same letter for each pair of data within a row are not significantly different at $P < 0.05$ ($n = 3$ per year).

# Amino acids

# Amino acids in Encalilla (2,000 m asl)

**Table 5.** Two-year mean values of amino acid (AA) composition of quinoa seeds from Encalilla and Bolivia/Argentina

| AA (g $kg^{-1}$ protein) | Amilda | Chucapaca | CICA | Kamiri | Kancolla | Ratuqui | Robura | Sajama | Samaranti | Sayaña |
|---|---|---|---|---|---|---|---|---|---|---|
| *Encalilla* | | | | | | | | | | |
| Aspartic acid | 78.3 | 67.4 | 71.4 | 79.9 | 72.8 | 93.6 | 102.8 | 51.5 | 61.0 | 69.1 |
| Threonine | 30.1 | 25.5 | 28.9 | 31.1 | 30.2 | 43.1 | 38.6 | 20.9 | 23.8 | 25.8 |
| Serine | 41.6 | 36.0 | 38.3 | 42.1 | 38.4 | 59.4 | 53.1 | 27.2 | 31.4 | 25.8 |
| Glutamic acid | 122.1 | 106.0 | 119.4 | 123.7 | 117.1 | 179.7 | 150.6 | 73.7 | 90.6 | 110.3 |
| Glycine | 50.8 | 43.1 | 44.7 | 49.9 | 47.7 | 71.0 | 64.3 | 33.6 | 40.4 | 41.7 |
| Alanine | 33.4 | 29.4 | 33.3 | 34.0 | 32.1 | 49.0 | 47.0 | 25.8 | 32.6 | 29.1 |
| Valine | 29.6 | 21.9 | 27.2 | 29.9 | 31.9 | 39.1 | 37.4 | 23.3 | 27.7 | 24.6 |
| Methionine | 13.1 | 11.0 | 11.6 | 12.4 | 11.8 | 17.9 | 15.7 | 7.3 | 9.1 | 10.8 |
| Isoleucine | 22.9 | 16.5 | 21.9 | 24.0 | 25.9 | 31.0 | 28.5 | 18.9 | 22.1 | 19.9 |
| Leucine | 52.3 | 43.6 | 49.3 | 54.7 | 52.1 | 74.6 | 67.1 | 37.5 | 43.0 | 44.7 |
| Tyrosine | 24.9 | 21.0 | 22.3 | 25.1 | 24.5 | 34.6 | 33.3 | 18.8 | 21.8 | 21.1 |
| Phenylalanine | 32.4 | 26.2 | 29.2 | 33.1 | 30.5 | 45.2 | 41.8 | 22.6 | 26.1 | 27.2 |
| Lysine | 43.0 | 36.2 | 39.4 | 43.3 | 44.4 | 62.3 | 52.2 | 24.4 | 29.8 | 37.3 |
| Histidine | 24.7 | 20.9 | 23.8 | 24.7 | 24.3 | 36.3 | 29.2 | 13.6 | 17.1 | 21.5 |
| Arginine | 78.2 | 66.4 | 68.5 | 75.4 | 70.1 | 98.4 | 84.2 | 36.8 | 45.9 | 66.5 |
| Proline | 31.2 | 26.0 | 29.0 | 35.7 | 31.4 | 43.5 | 40.8 | 22.1 | 25.7 | 26.1 |
| Tryptophan | 6.5 | 5.8 | 8.0 | 7.4 | 6.5 | 9.4 | 10.3 | 6.2 | 8.2 | 5.9 |
| Total | 715.1a | 602.9a | 666.2a | 726.4a | 691.7a | 988.1b | 896.9b | 464.2a | 556.3a | 616.9a |

# Essential amino acids in Encalilla (2,000 m asl)

**Table 6.** Two-year mean values of essential amino acid (EAA) composition of quinoa seeds from Encalilla and Bolivia/Argentina

| EAA (g $kg^{-1}$ protein) | Amilda | Chucapaca | CICA | Kamiri | Kancolla | Ratuqui | Robura | Sajama | Samaranti | Sayaña |
|---|---|---|---|---|---|---|---|---|---|---|
| *Encalilla* | | | | | | | | | | |
| Leucine | 52.3 | 43.6 | 49.3 | 54.7 | 52.1 | 74.6 | 67.1 | 37.5 | 43.0 | 44.7 |
| Lysine | 43.0 | 36.2 | 39.4 | 43.3 | 44.4 | 62.3 | 52.2 | 24.4 | 29.8 | 37.3 |
| Methionine | 13.1 | 11.0 | 11.6 | 12.4 | 11.8 | 17.9 | 15.7 | 7.3 | 9.1 | 10.8 |
| Phenylalanine | 32.4 | 26.2 | 29.2 | 33.1 | 30.5 | 45.2 | 41.8 | 22.6 | 26.1 | 27.2 |
| Threonine | 30.1 | 25.5 | 28.9 | 31.1 | 30.2 | 43.1 | 38.6 | 20.9 | 23.8 | 25.8 |
| Isoleucine | 22.9 | 16.6 | 21.9 | 24.0 | 25.9 | 31.0 | 28.5 | 18.9 | 22.1 | 19.9 |
| Tyrosine | 24.9 | 21.0 | 22.3 | 25.1 | 24.5 | 34.6 | 33.3 | 18.8 | 21.8 | 21.1 |
| Valine | 29.6 | 21.9 | 27.2 | 29.9 | 31.9 | 39.1 | 37.4 | 23.3 | 27.7 | 24.6 |
| Tryptophan | 6.5 | 5.8 | 8.0 | 7.4 | 6.5 | 9.4 | 10.3 | 6.2 | 8.2 | 5.9 |
| Cysteine | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Total | 254.8a | 207.8a | 237.8a | 261.0a | 257.8a | 357.2b | 324.9b | 179.9a | 211.6a | 217.3a |

- Lysine (6.6%) (high proportion)
- Methionine (2.4%) (scarce in most cereal proteins,
- 
- Tryptophan (1.1 %) is very close to that registered for other cereals (Risi and Galwey, 1984).

# Protein and  Amino acids

Protein content in quinoa is low in relation to eggs protein but

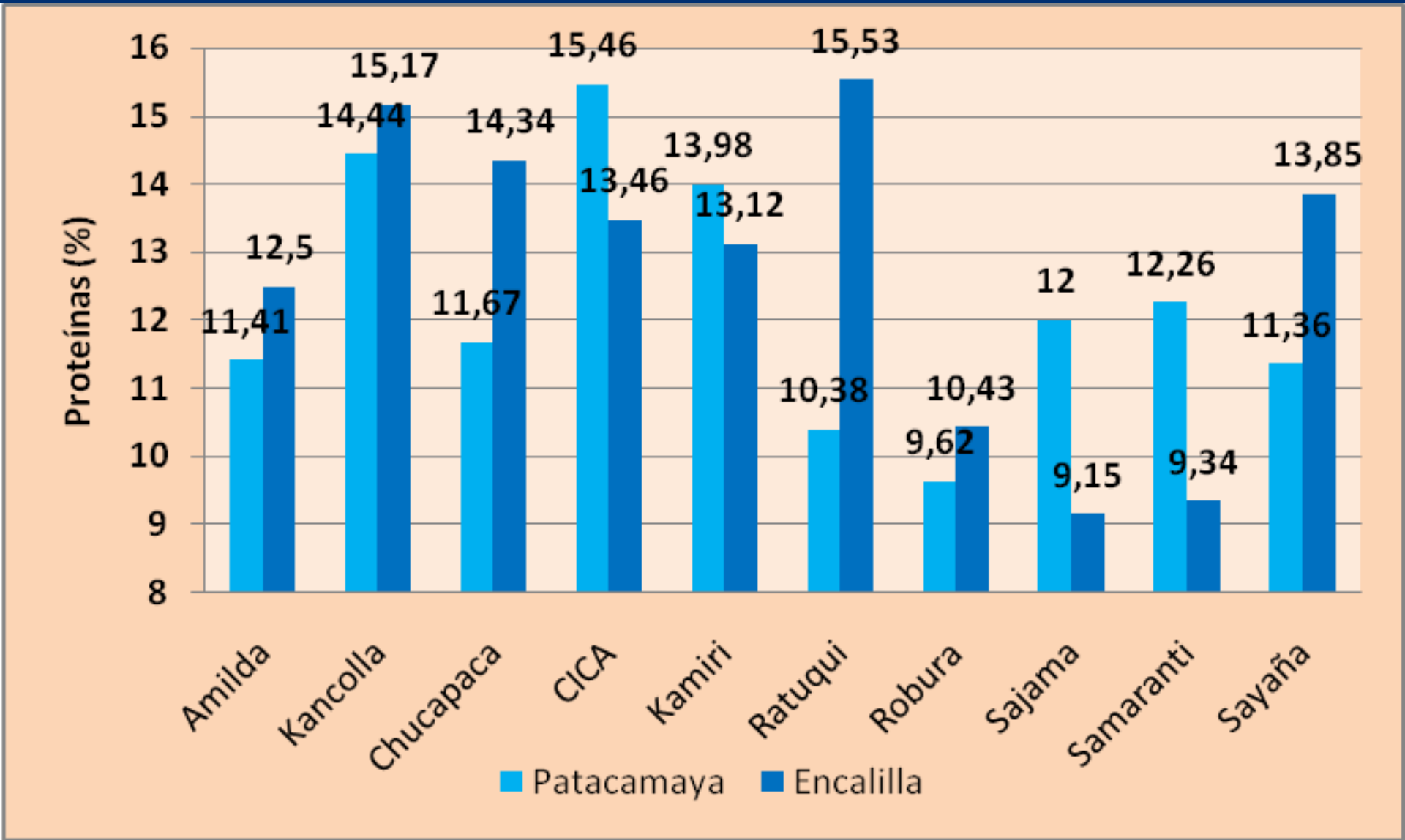
**have a very closed amino acid content than in chicken eggs**

- Quinoa have the neccesary content of isoleucine, leucine, phenilalanine, valine, histidin and threonin for school boys requeriments.

# Genotype x environment relationship

**In our experience with seeds from Bolivia (3,750 m asl) but cultivated in Tucumán (Argentina) at 2,000 m asl we detected a significative change in protein and amino acids content**

# Protein (%) at two sites (3,750 and 1,995 m asl)



In general,
In  low altittudes we get a better protein percentage

**In general, total amino acid contents are higher at 3,750 m asl in relation to those at 2,000 m asl (with exception of Ratuqui and Robura varieties)**

# Lisine and threonin amino acids

Presence of lisine and threonin are very important because they have a very low content in other grains (according to the standard of FAO)

# Quality Index of protein (QI)

## QI= Tryptophan/total protein

**QI Patacamaya: 4,74 to 10,12 %**

**QI Encalilla: 4,04 to 9,87 %**

***QI for quinoa seeds from the two sites (2,000 and 3,750 m asl) was significantlly higher than reported for common cereals***

# Mineral contents (seed)

# Mineral content

- We have an analysis of quinoa seeds (10 varieties) where 56 chemical elements were analyzed: among others the following: Al, Fe, Mg, Ca, Na, K, P, Li, Mn, Co, Ni, Cu, Zn,

- We found a good correlation between mineral and protein content

Tabla 1: Contenido de cenizas y minerales principales en 10 var. de quinoa cultivas en Encalilla (Tucumán)

| | Amilda | Chucapaca | CICA | Kancolla | Kamiri | Ratuqui | Sayaña | Robura | Sajama | Samaranti | promedio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cenizas (%) | 2,9 | 3,0 | 3,7 | 3,5 | 2,6 | 2,7 | 2,6 | 2,6 | 2,5 | 2,8 | 2,9 |
| Al (mg/kg PS) | 126,4 | 148,5 | 148,9 | 153,8 | 79,6 | 45,2 | 54,3 | 57,5 | 52,0 | 87,7 | 95,4 |
| Ca (mg/kg PS) | 570,2 | 500,0 | 907,5 | 733,9 | 623,2 | 526,7 | 531,9 | 696,4 | 823,3 | 1166,0 | 707,9 |
| Cu (mg/kg PS) | 11,2 | 10,2 | 9,4 | 11,2 | 7,9 | 7,9 | 7,6 | 6,3 | 4,8 | 6,1 | 8,3 |
| Fe (mg/kg PS) | 89,7 | 95,3 | 98,4 | 104,6 | 81,3 | 74,2 | 74,7 | 61,9 | 47,6 | 61,5 | 78,9 |
| K (mg/kg PS) | 9605,3 | 9952,3 | 12595,4 | 11525,8 | 8618,3 | 9321,5 | 8870,4 | 9523,1 | 8932,7 | 9021,3 | 9796,6 |
| Mg (mg/kg PS) | 1229,8 | 1461,3 | 1514,4 | 2459,6 | 1394,5 | 1549,2 | 1394,9 | 1018,8 | 855,0 | 968,4 | 1384,6 |
| Mn (mg/kg PS) | 16,9 | 24,2 | 38,5 | 42,2 | 18,5 | 20,1 | 20,5 | 19,9 | 24,6 | 31,3 | 25,7 |
| Na (mg/kg PS) | 37,8 | 35,4 | 73,3 | 77,7 | 21,6 | 18,8 | 20,5 | 20,5 | 19,1 | 26,5 | 35,1 |
| P (mg/kg PS) | 2623,2 | 3133,0 | 3309,5 | 4529,7 | 2725,8 | 3270,6 | 2772,6 | 1758,5 | 1237,2 | 1341,5 | 2670,2 |
| Zn (mg/kg PS) | 38,5 | 37,2 | 42,2 | 48,8 | 34,4 | 31,0 | 26,8 | 23,6 | 21,2 | 20,6 | 32,5 |

Seed

- Iron and calcium levels were higher than the reported values for maize and barley.
- The same occurred for the caloric value (435.5 Kca1/100g).

# Espatial distribution of minerals (X rays)

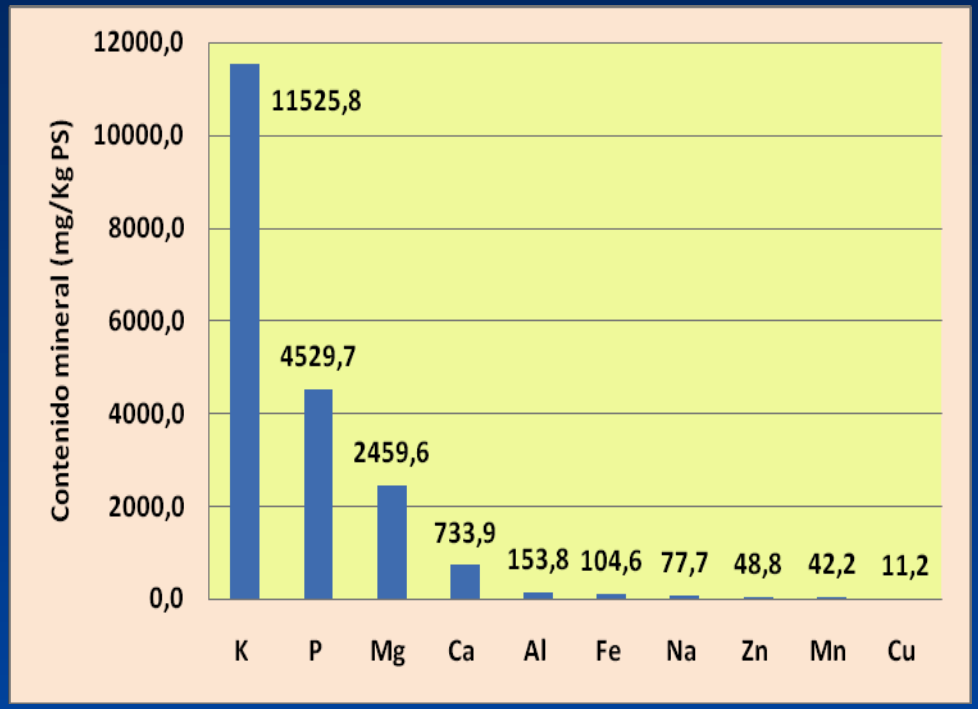
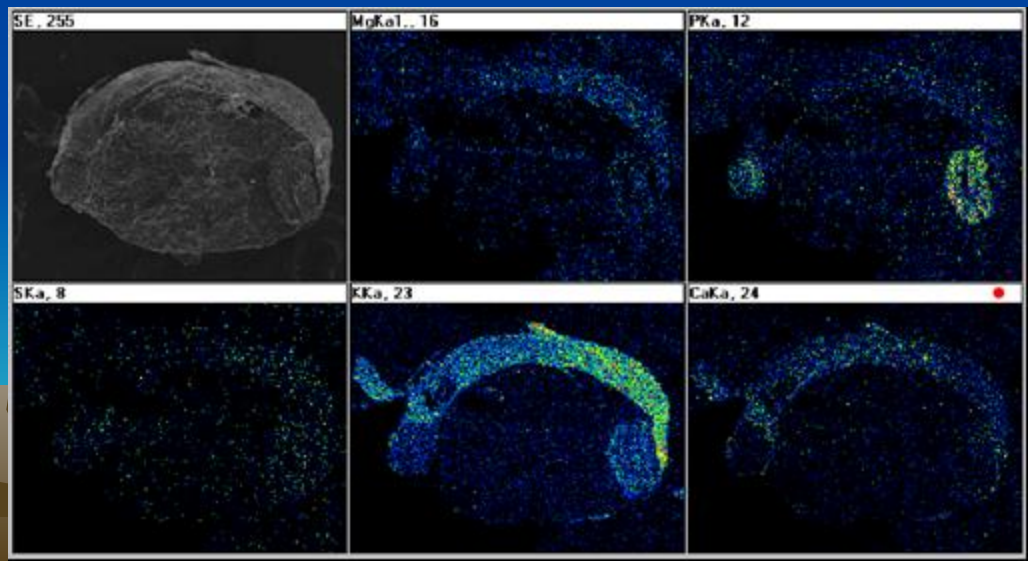
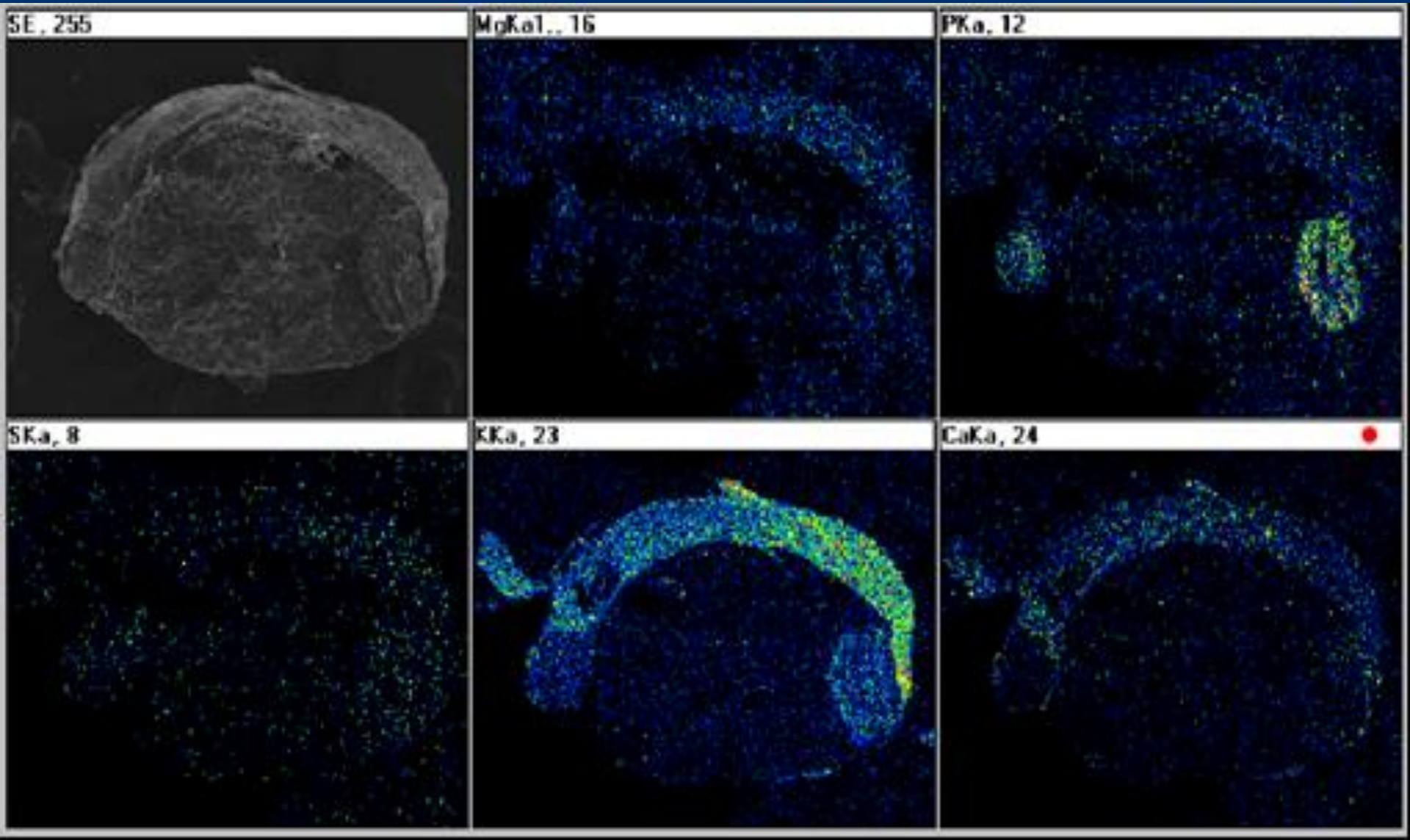



Fig. 2. Contenido mineral de “quinoa” Var. Kancolla.



# ¿Tissue culture of quinoa as an especial aliment ?



- In medium and high mountain near 20 % of the population is below the poverty line

**According to our results**

**protein, amino acids and mineral content**

**may be a good complementary food in Argentinean mountain area**

# Antinutritional compounds

## Saponins (0,21 %)

## Tannins (1,70 %)

First report in quinoa in 1989 by our group

- **Saponins**

- The content of saponins was 0.21 %.

- An important effect on disruption of the red blood cells caused by those glycosides was detected on groups **A** and 0.

- Tanins have been found in other species like sorghum (Price and Butler,1977), but this was the first report of tannins in grains of quinoa.

# “Saponin bodies”

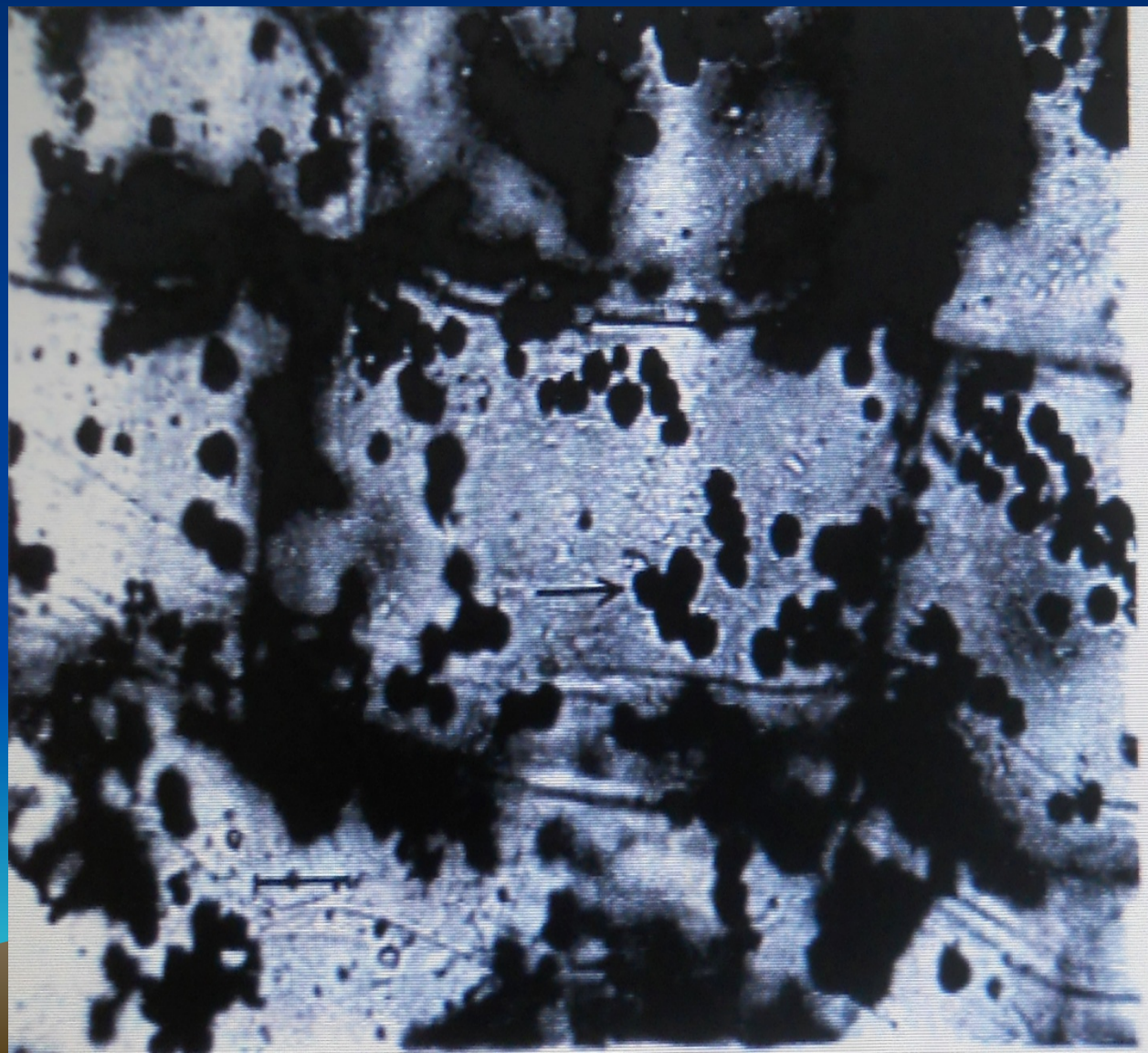


FIGURE 1. Light microscopy of quinoa pericarp cells. The arrow indicates the presence of saponins-bodies after Johansen's treatment (X 100). Scale bar = 19 μm.

# Dry method to remove saponin bodies from quinoa seed (Cochabamba - Bolivia)

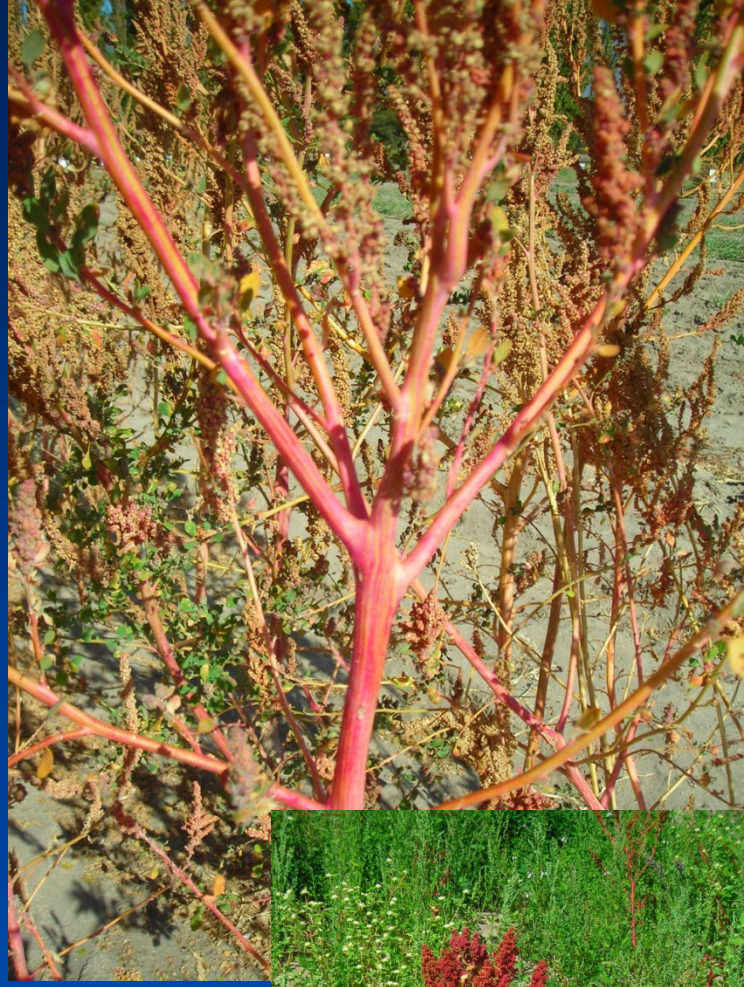
# Saponin and tanins may be an opportunity….

**The use of saponin and tannins may be a good industrial development with medical and pharmaceutical application….**

# Quinoa as a fountain of dye (colours)

- Chlorophyll
- Flavonoids (antioxidants)
- Red pigments (betalains)

Chucapaca
Red quinoa

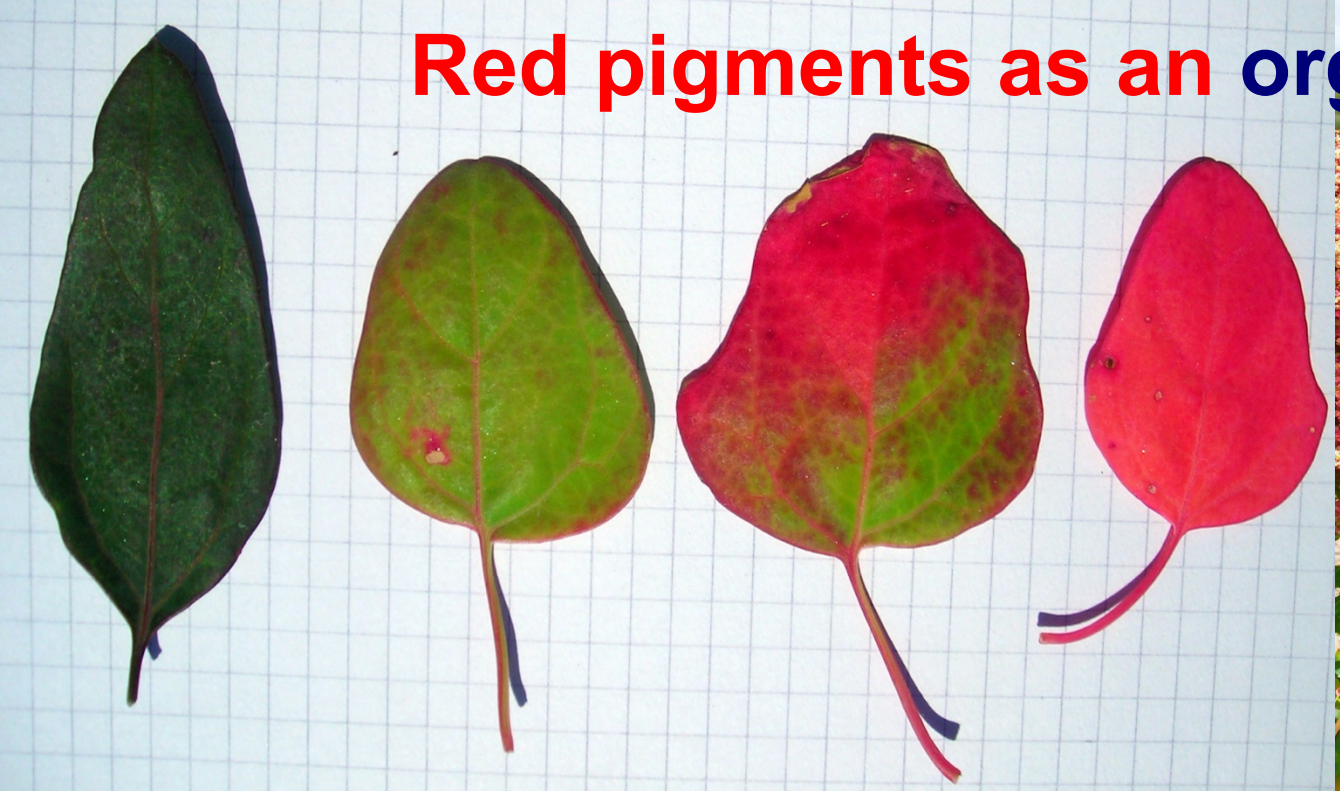


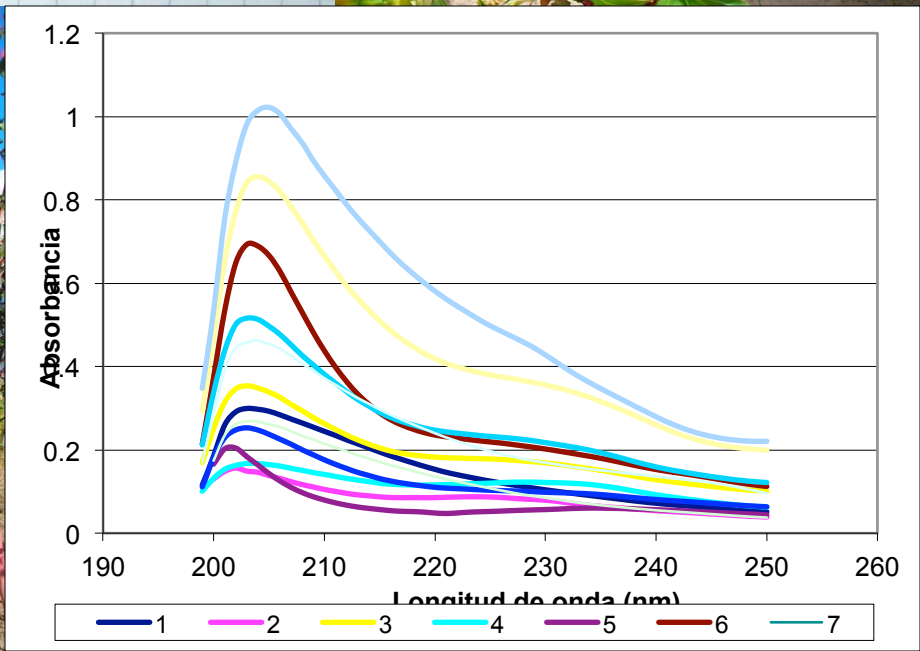
# NL – 6 varieties

There are another varities with different colours and pigments.

Pigments are important in medicine and pharmacia

# Red pigments as an organic dye





# Betalains

- **Red pigments may be used as an organic dye in yoghurt, cheese and in pharmaceutical industries.**

- **Our investigation found betalains in quinoa (first report) and the enzymes involved in their synthesis (this enzymes was known in fungi)**

Photochemistry and Photobiology, 2004, 79(2): 205–210

# Epidermal Lignin Deposition in Quinoa Cotyledons in Response to UV-B Radiation¶

**Mirna Hilal*[1], María Francisca Parrado[2], Mariana Rosa[1], Miriam Gallardo[2], Luis Orce[3], Eddy Marta Massa[4], Juan Antonio González[2] and Fernando Eduardo Prado[1]**

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[2]Fundación Miguel Lillo, Instituto de Ecología (Botánica), Tucumán, Argentina
[3]Instituto de Genética y Biología Molecular (INGEBI-CONICET), Buenos Aires, Argentina
[4]Crisóstomo Alvarez, Tucumán, Argentina

# Anatomical features and lignin deposition

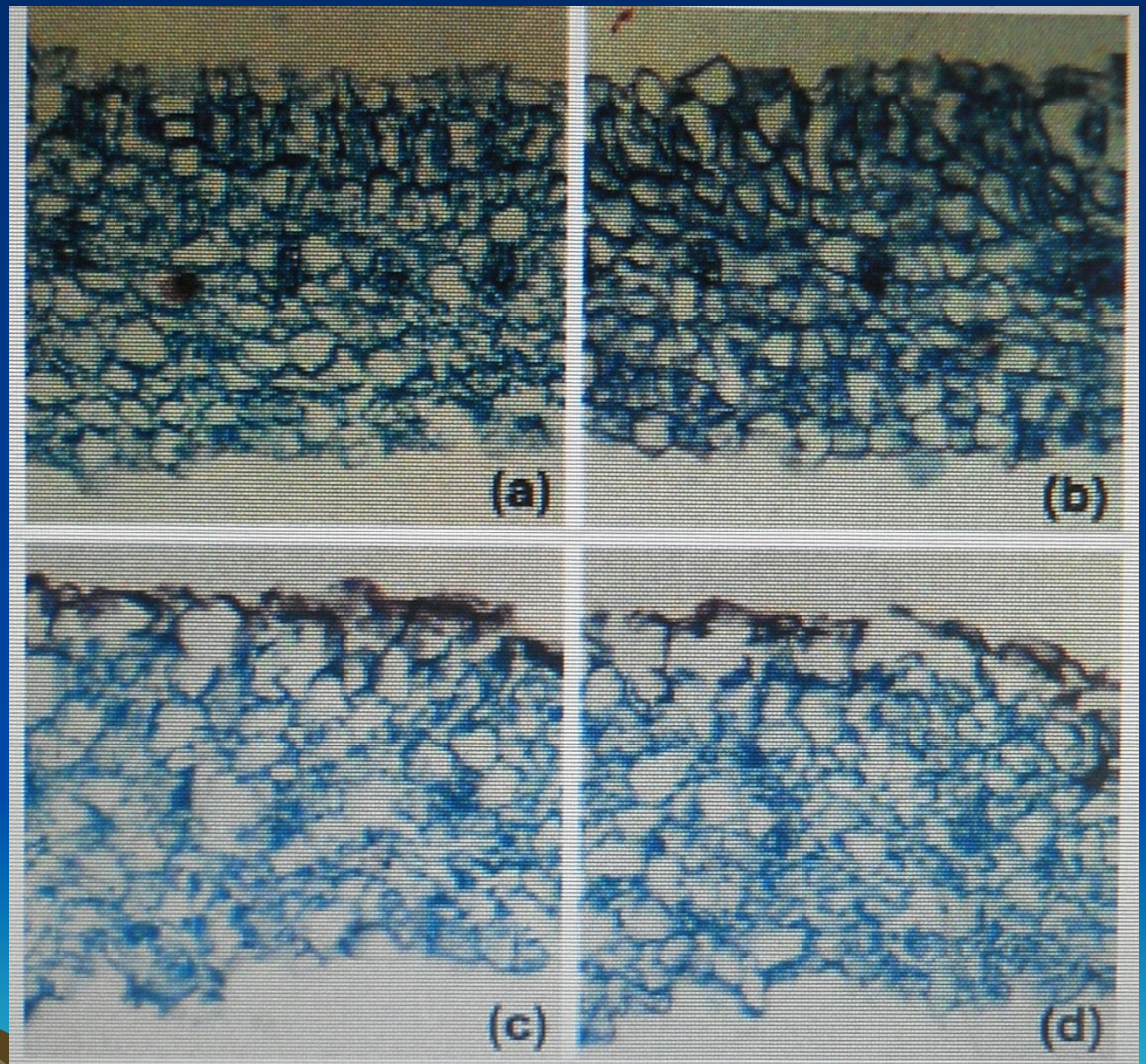
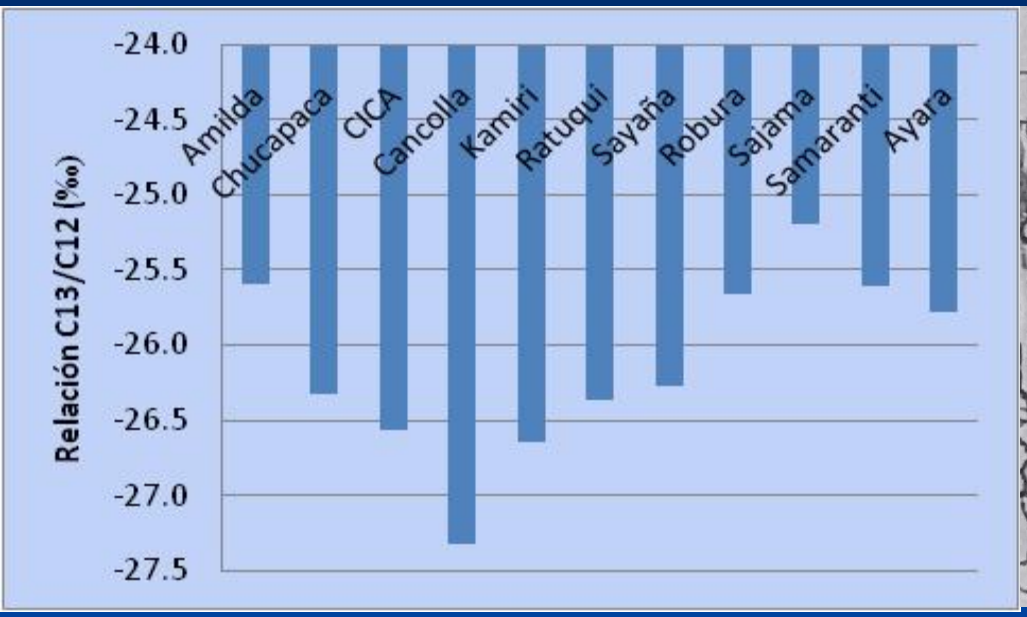
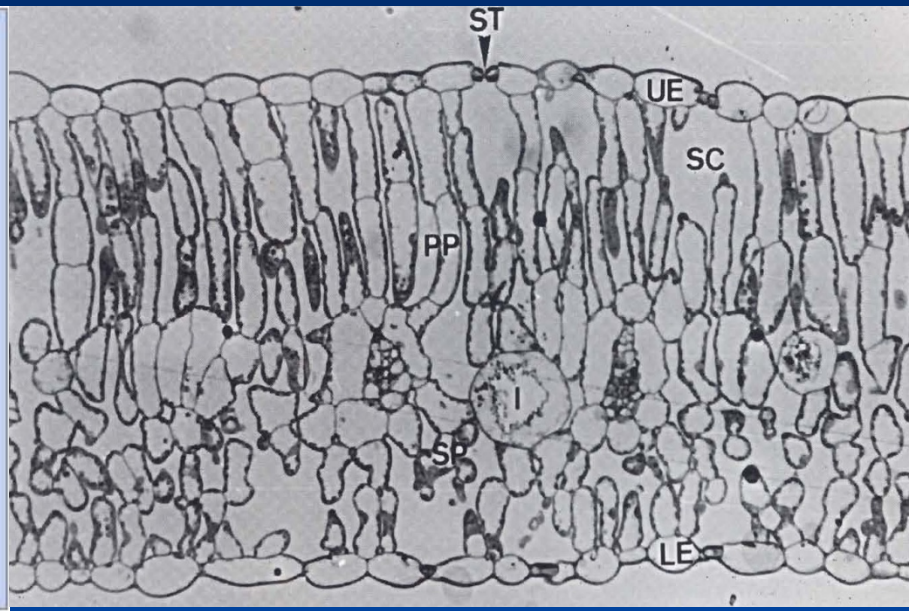



**Figure 1.** Light photomicrographs of cross sections from quinoa cotyledons with or without UV-B treatment. a: Zero dose (control). b: One dose. c: Two doses. d: Three doses. (200×).

# Biological results

# Photosynthetic pathway

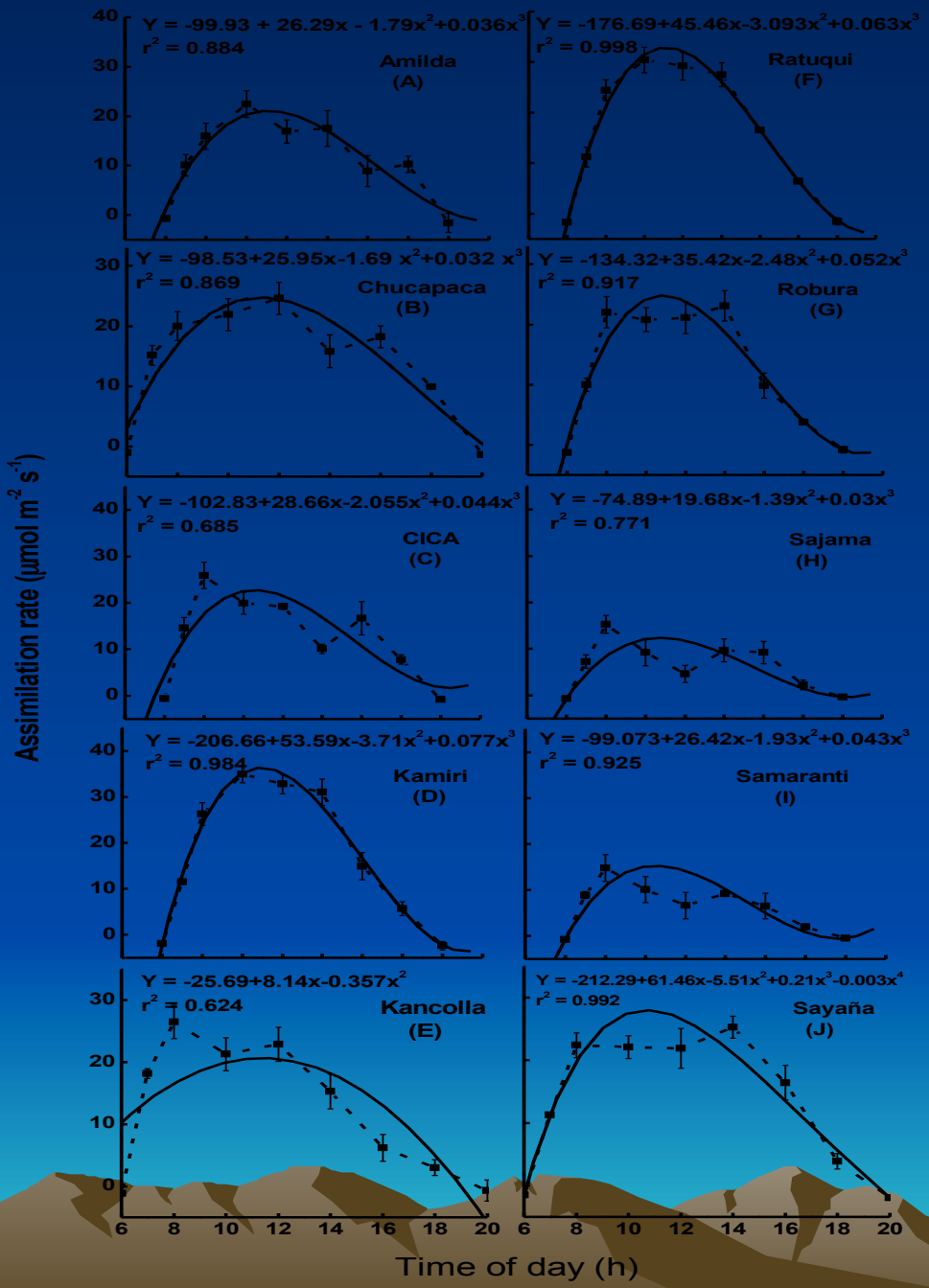


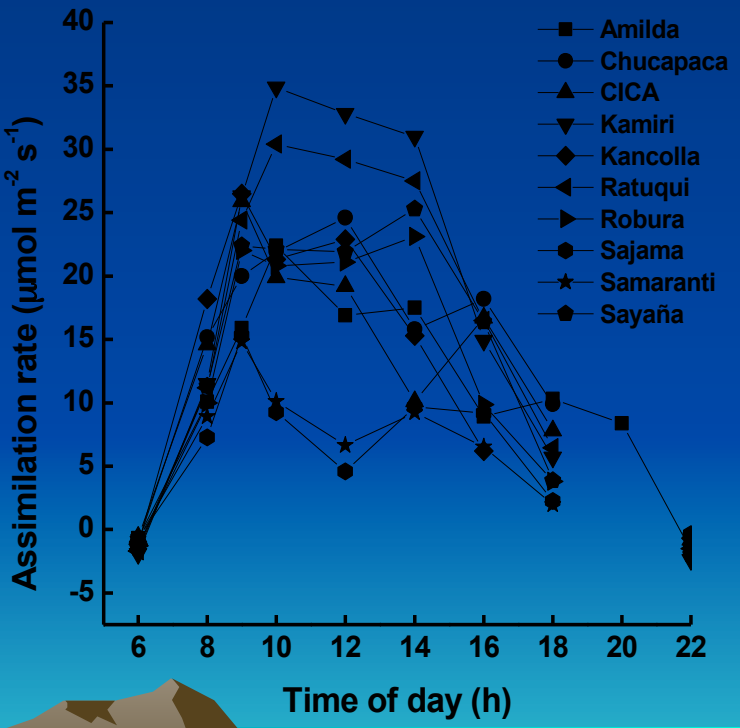




**According to C isotope discrimination and anatomical data quinoa is a C3 specie…**

**C13/C12 low (mean: -27 ‰ )**
**C13/C12 high (mean: -13 ‰. Between -9 -to -16 ‰)**

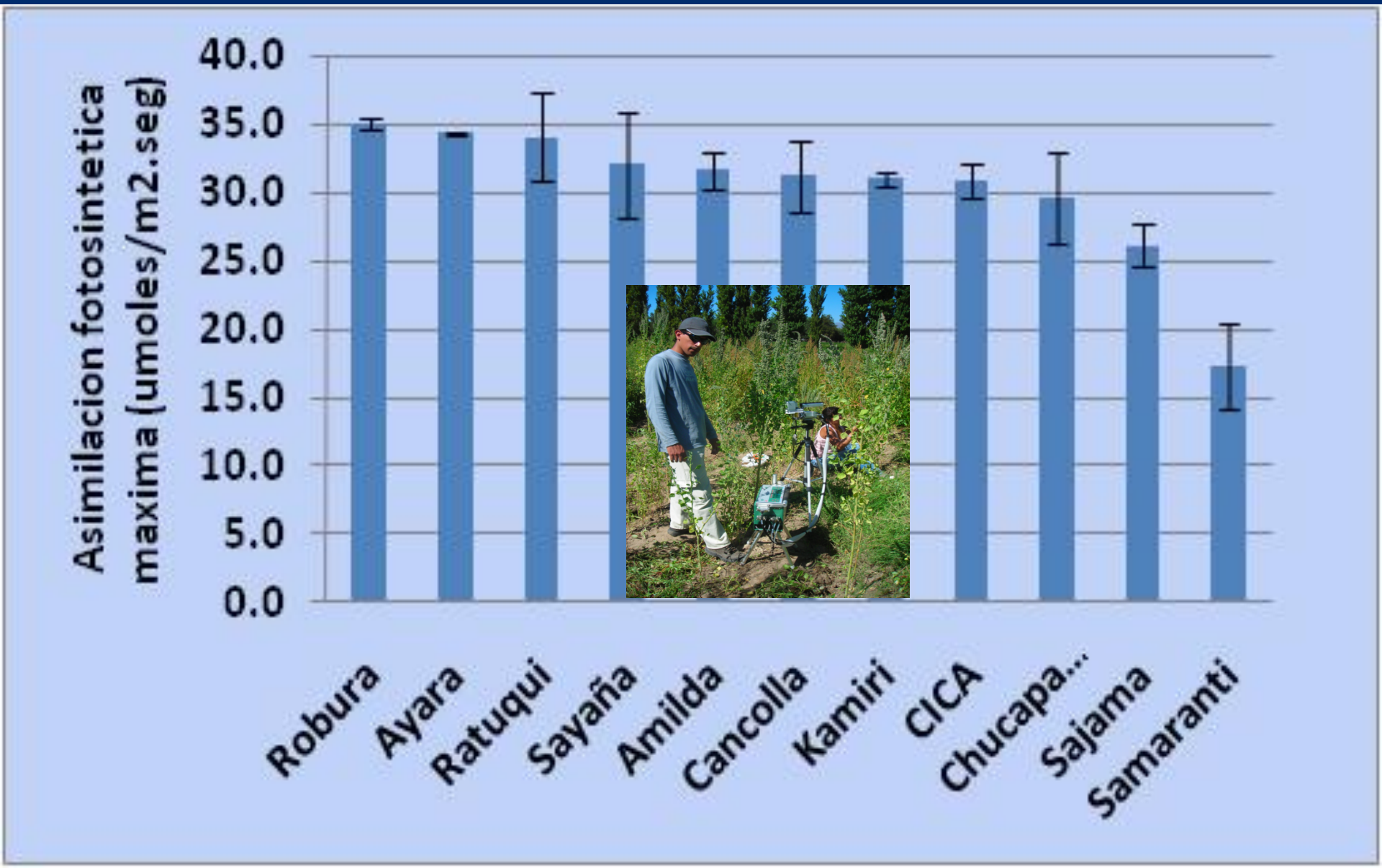
# Assimilation rate



- **Assimilation rate were different depending on the varities**

# Maximal assimilation



# Community participation

# High school pupils in sowing quinoa

**Very important aspect in the reintroduction of any ancient crops**

# Seed recolletion

- **Quinoa in the near future**

- We hope to understand the interaction between low germination in field in relation to environmental factors (reduction of seed numbers in sowing step)

- Biochemical studies in relation to red pigments.

- Achieve a  varieties with short life cycle (actually 150 – 160 days against 90 – 100 for an varieties from Holland).