IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

*IPNI Webinar Series*
*26 April 2017*

# Exploring nutrient deficiencies in the eastern plains of Bolivia


**Fernando O. García**

***International Plant Nutrition Institute***

IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

**fgarcia@ipni.net**
**http://lacs.ipni.net/**
**@IPNIcs**

# Outline

- ✓ Bolivia and its agriculture
- ✓ The eastern plains, characteristics
- ✓ Nutrient use and balance
- ✓ The Exploratory Trial Network of Fundacruz
- ✓ The Network of Nutrition Trials of CREA Eastern Santa Cruz
- ✓ Some conclusions

# Bolivia

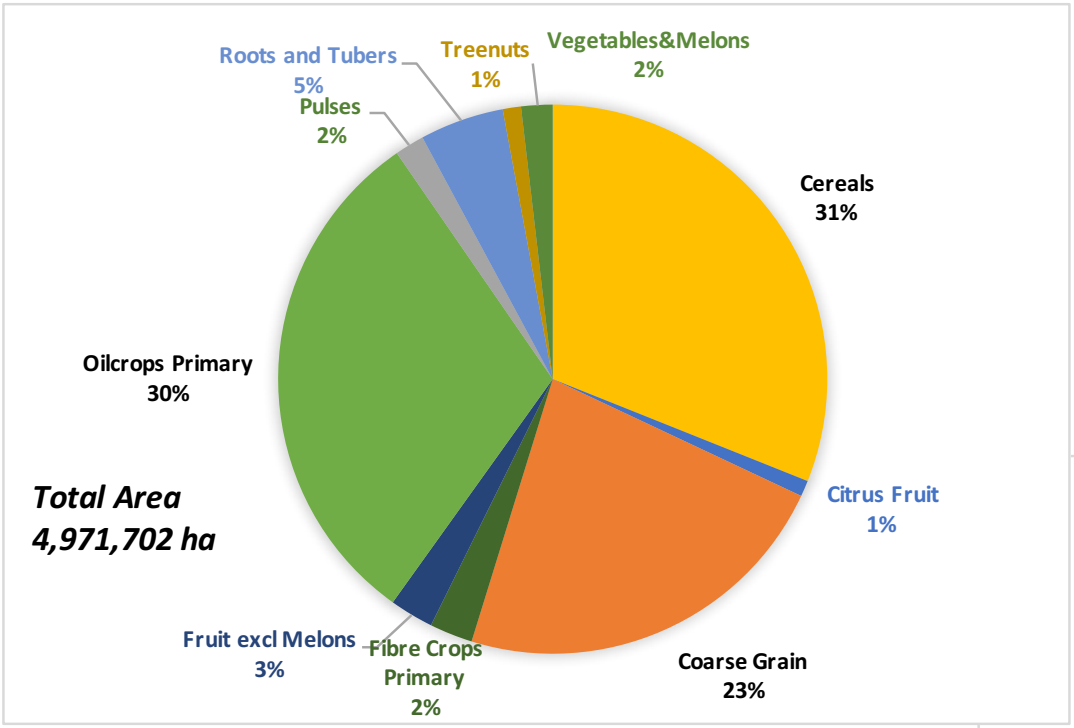
***10.7 million inhabitants***
***GDP 3276 USD/capita***

| | |
|---|---|
| **Total area** | **109.9 M ha** |
| **Agricultural area** | **37.7 M ha** |
| **Arable land** | **4.5 M ha** |
| **Permanent meadows and pastures** | **33.0 M ha** |
| **Forest** | **55.1 M ha** |

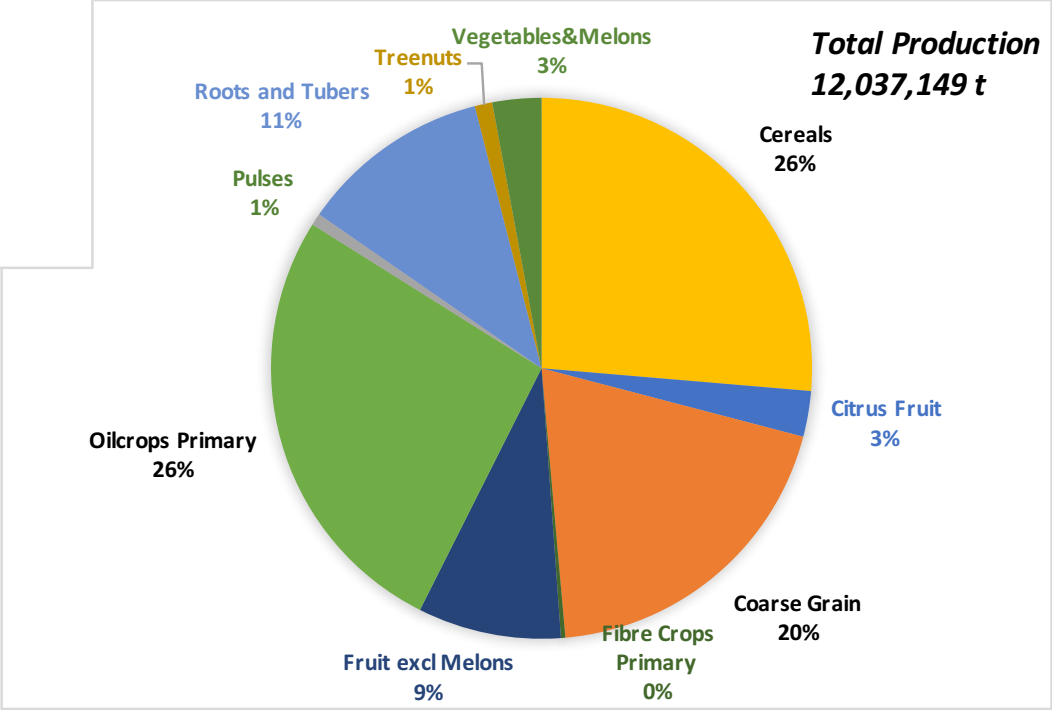
*Source : FAOSTAT, Google Earth*

IPNI

# Bolivia
# Area and Production of the Main Crop Groups




- *Total arable land represents approximately 4% of the land area and 12% of the agricultural area*
- *Total area is 3rd in the Southern Cone, after Argentina and Paraguay and before Uruguay and Chile*




- *Agriculture represents 13.2% of the GDP (World Bank)*

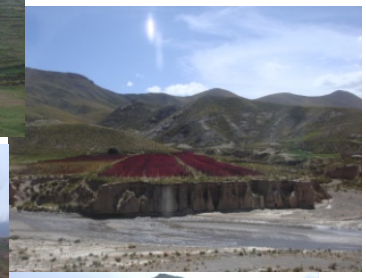
*Source : FAOSTAT*

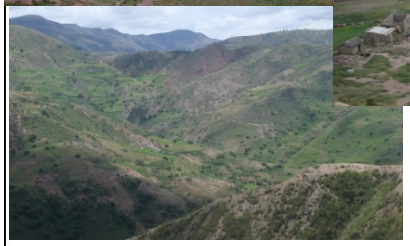
# Bolivia

**Tropical Area**: Banana, palm, and others

**Pastures and grasslands**: Beef

**Eastern Plains**: Soybean, sugarcane, field crops



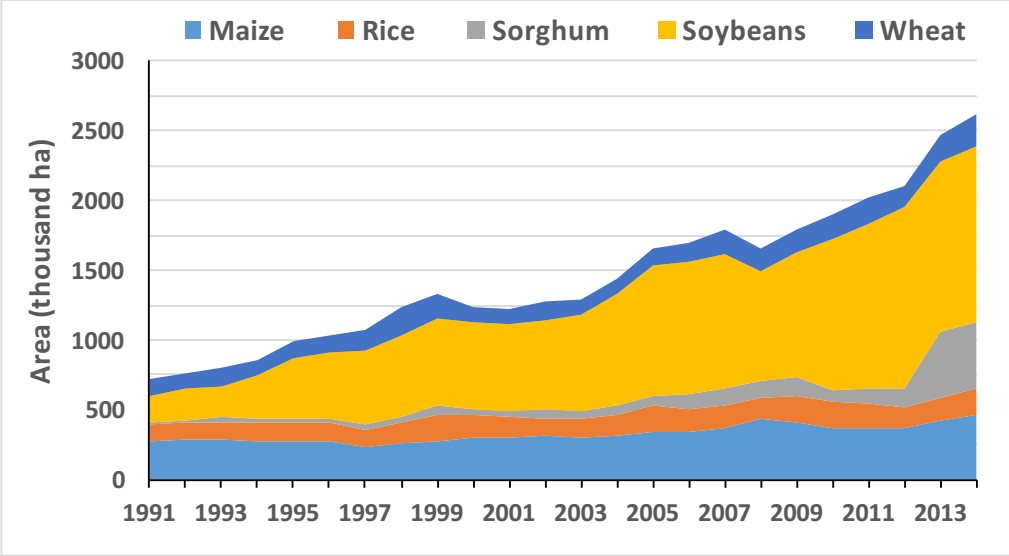


**Highlands (Altiplano)**: Small holders, Quinoa and cereals

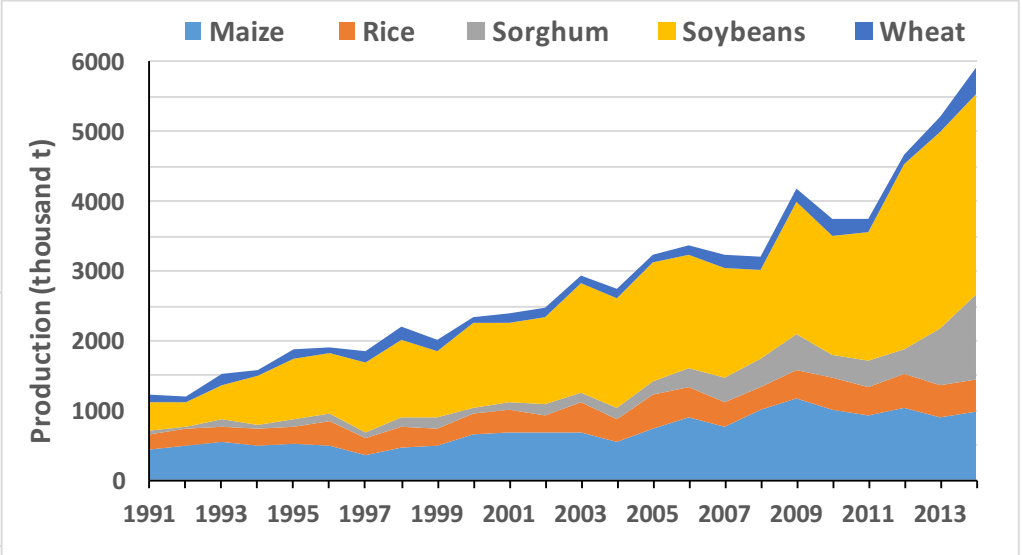
**Valleys**: Horticulture, Potato, and Fruits

# Bolivia – Field Crops Stats (1991-2014)

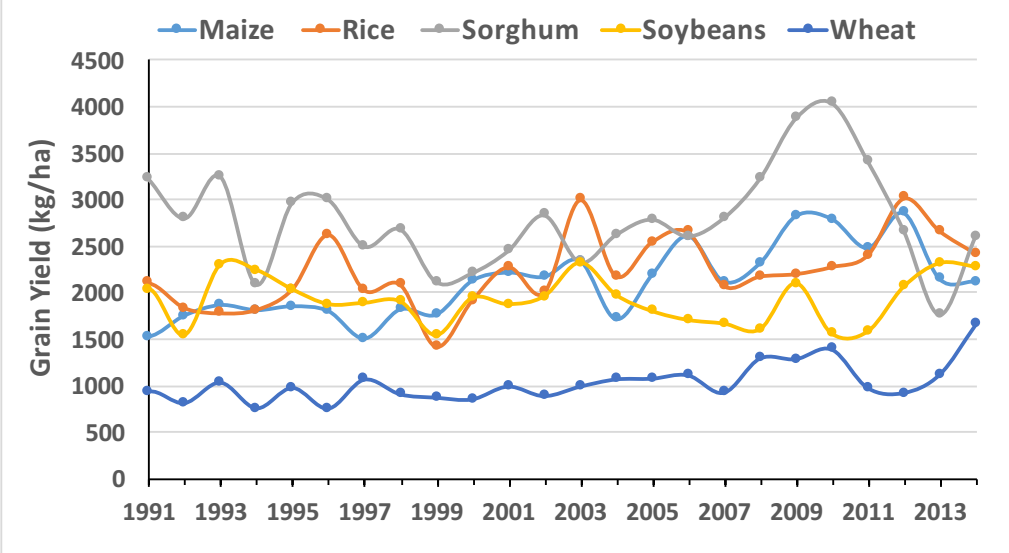
***Source : FAOSTAT***




- ***Area** under field crops expanded by **263%** from 1991 to 2014*




- ***Production** of field crops expanded by **386%** from 1991 to 2014*

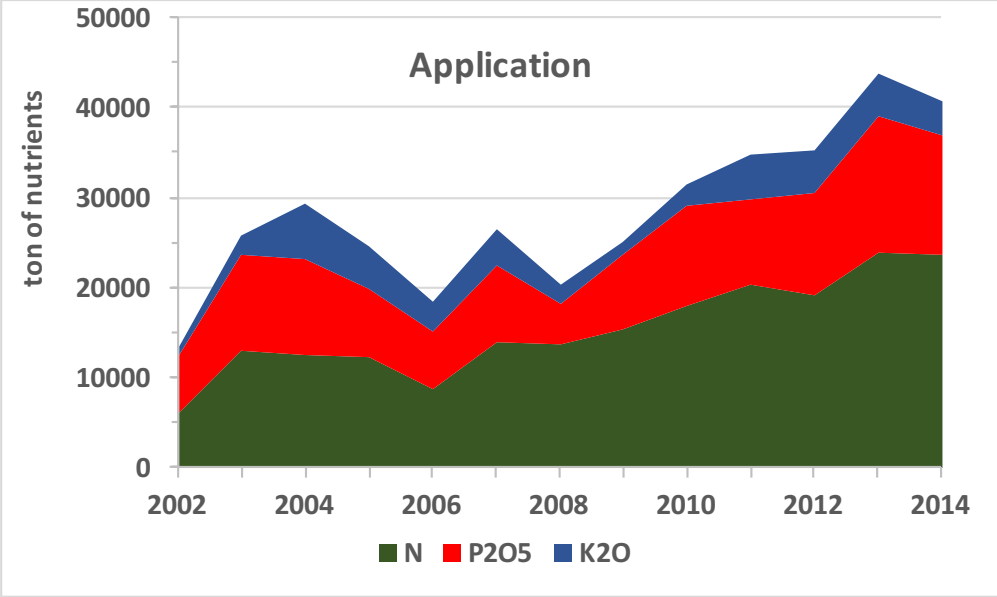


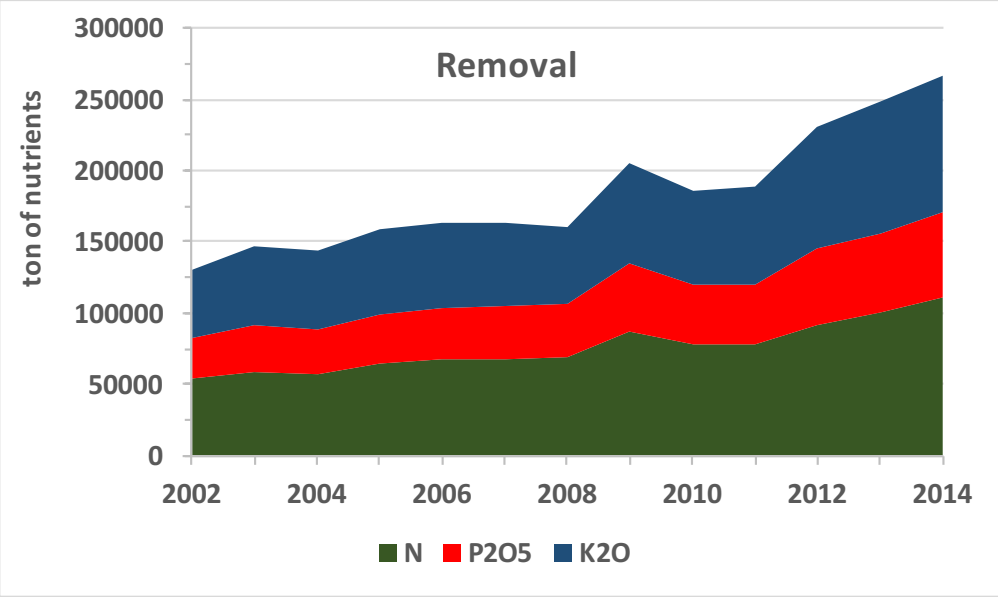

- ***Yields** increased at rates of:*

| | |
|---|---|
| ***Sorghum*** | ***58 kg/ha/year*** |
| ***Maize*** | ***26 kg/ha/year*** |
| ***Rice*** | ***21 kg/ha/year*** |
| ***Soybean*** | ***30 kg/ha/year*** |
| ***Wheat*** | ***12 kg/ha/year*** |

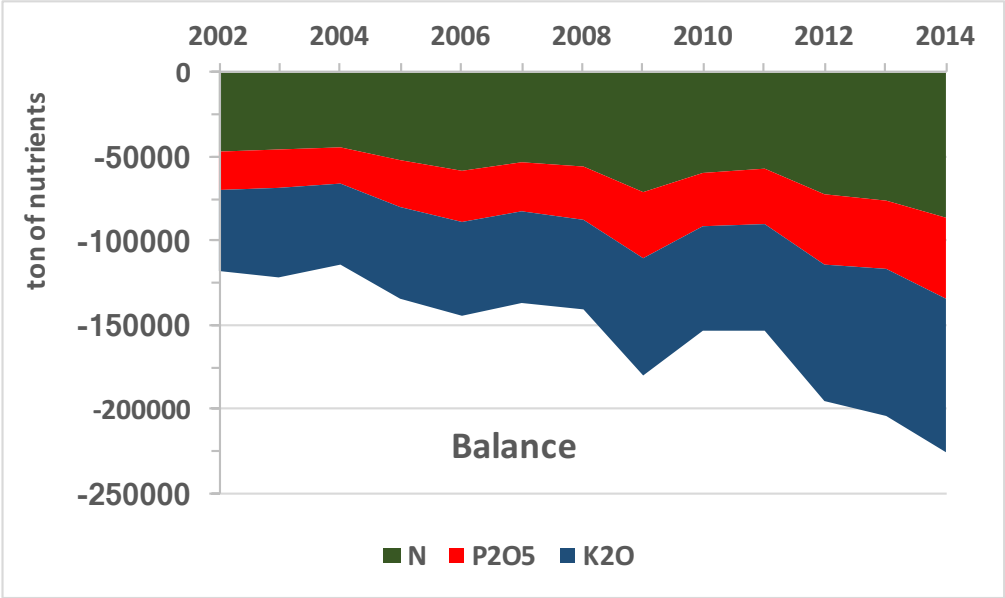
IPNI

# Bolivia: Nutrient Application, Removal, and Balance (2002-14)



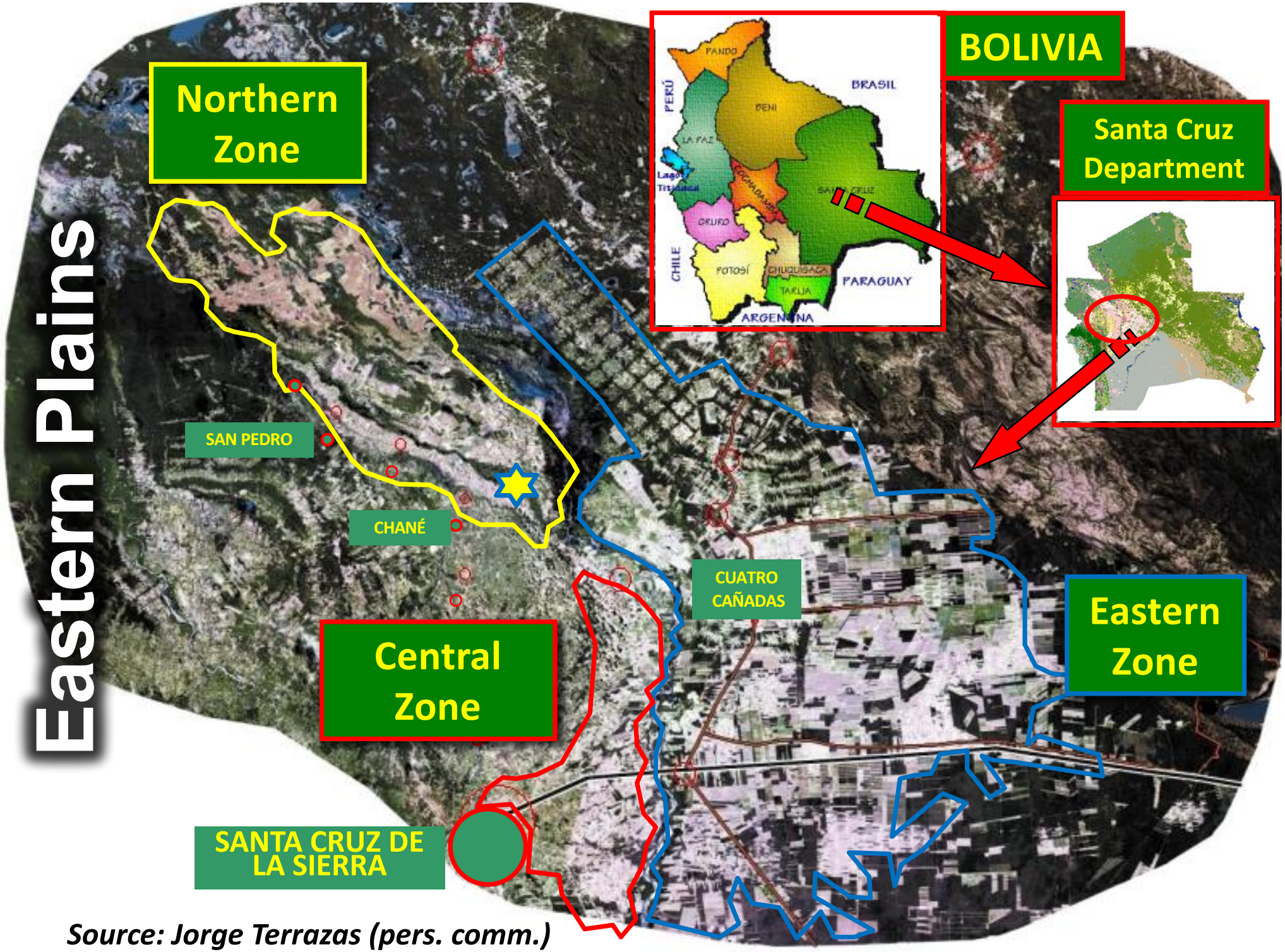




- ✓ *Nutrient application replenishes 22% of N, 23% of $P_2O_5$ and 5% of $K_2O$, removed by harvest*
- ✓ *Deficit equivalent to 171 thousand t of urea, 95 thousand t of DAP, and 144 thousand t of potash per year*



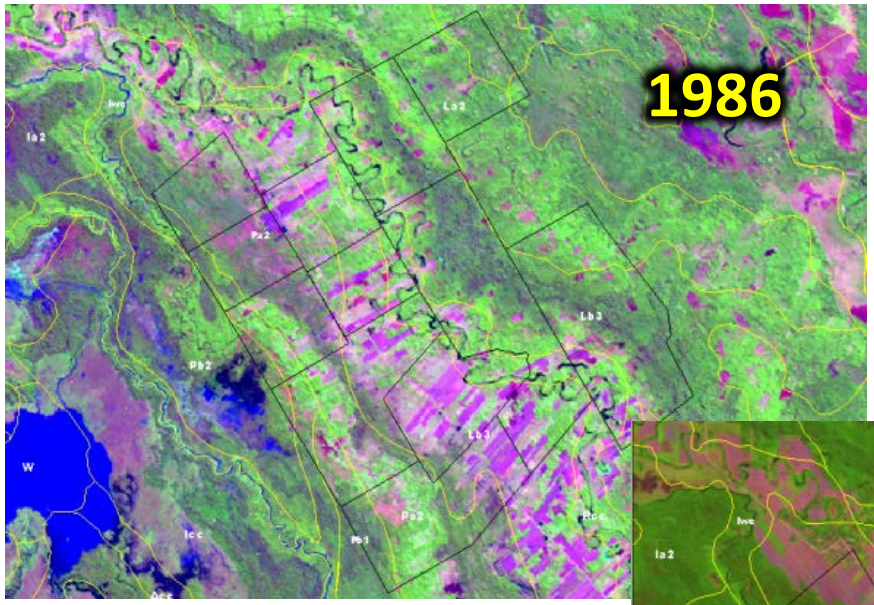

***Elaborated from FAOSTAT***

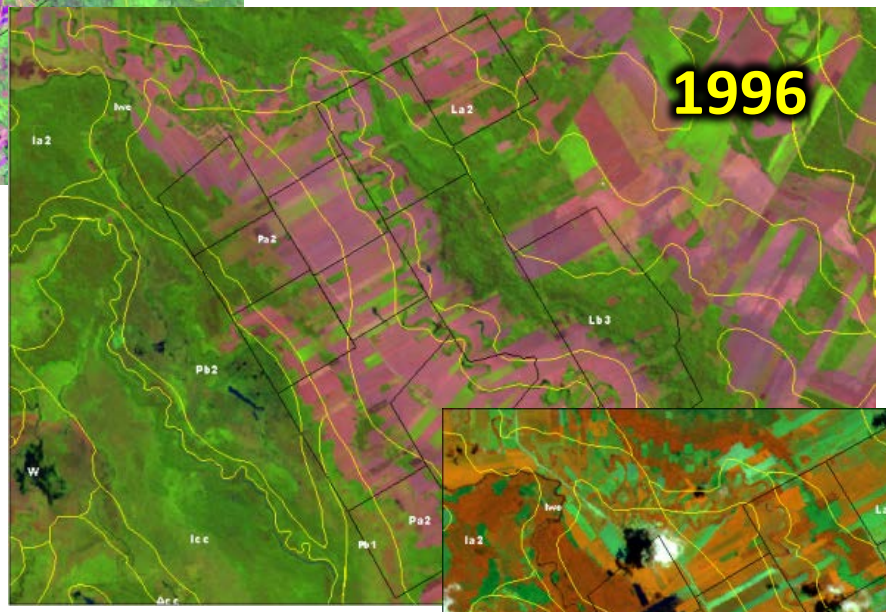
IPNI

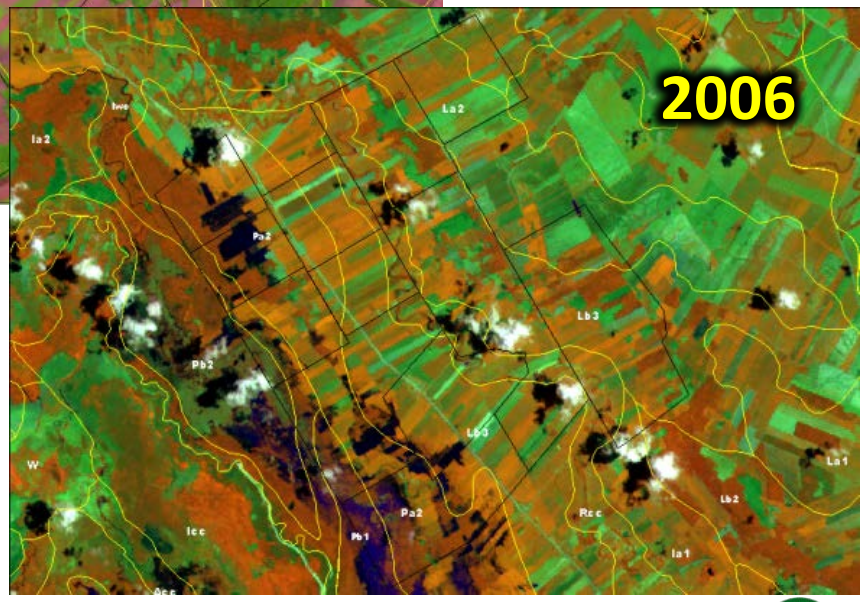



*Source: Jorge Terrazas (pers. comm.)*

# Cropped area evolution in the Eastern Zone



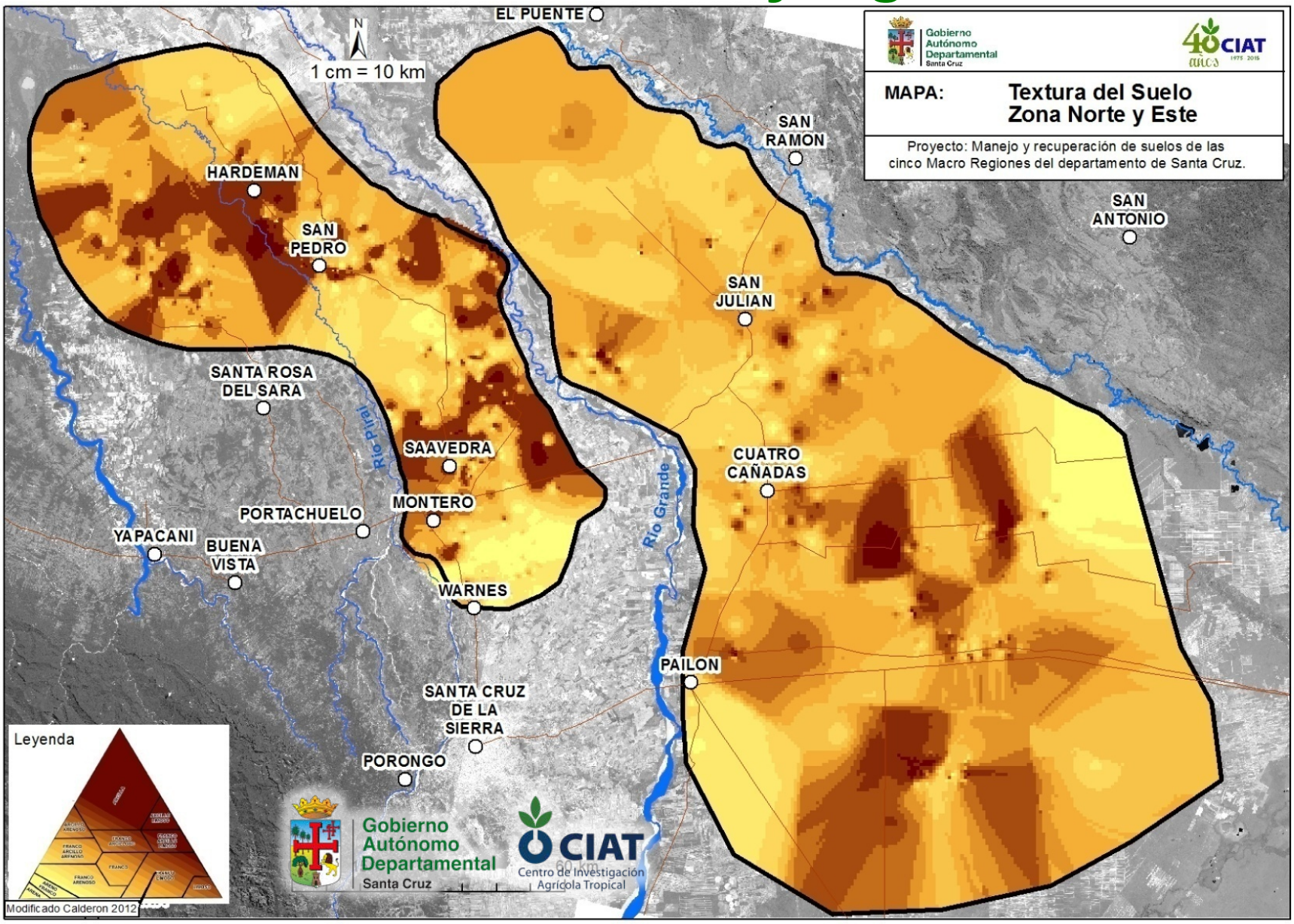

Gobierno Autónomo Departamental Santa Cruz

CIAT Centro de Investigación Agrícola Tropical

*Source: Mary Selva Viera (CIAT)*

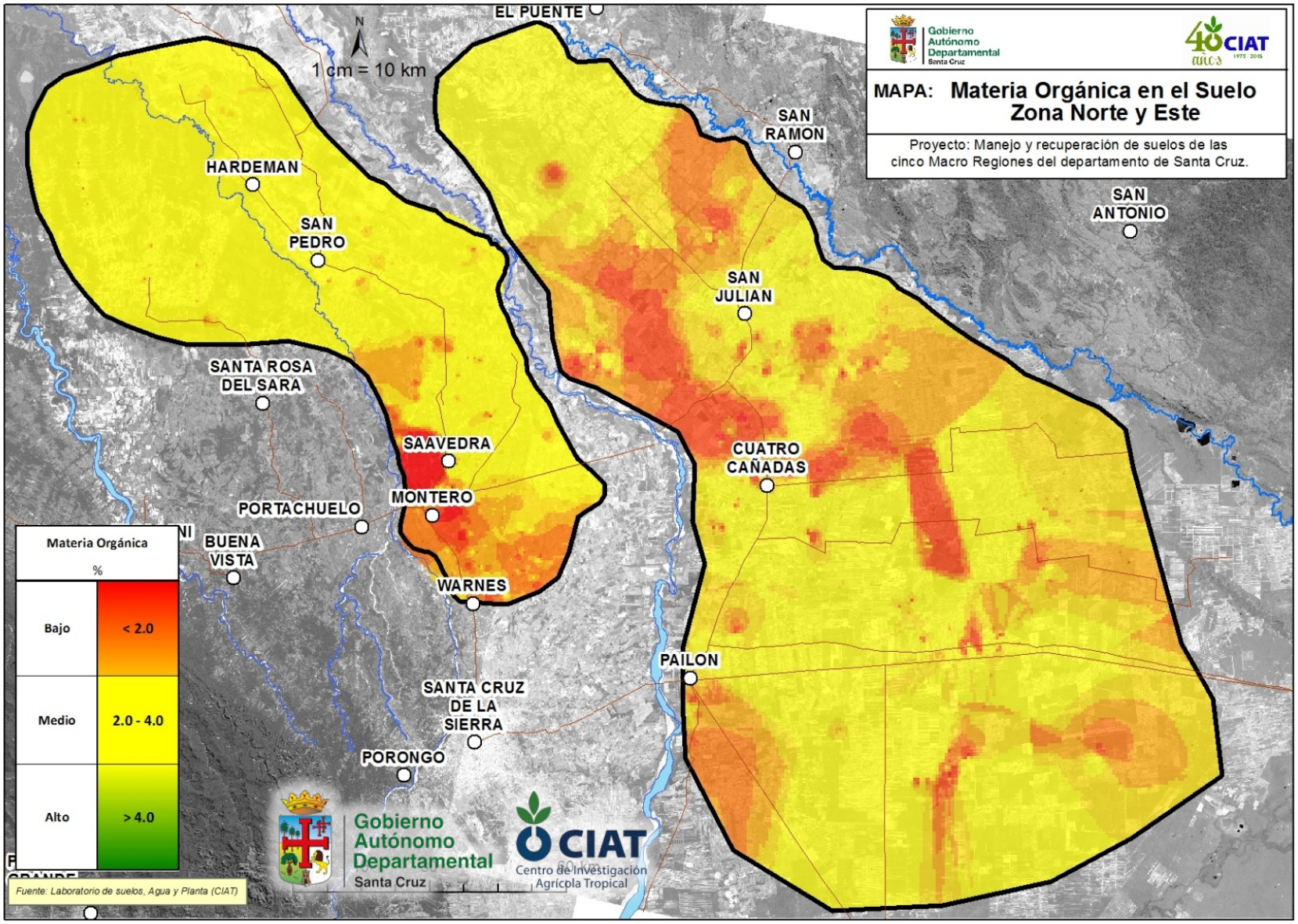
IPNI

# Soil texture: Mostly silt loam and silty clay loam, silt concentrations usually higher than 60%




*Source: Mary Selva Viera (CIAT)*

# Soil organic matter: Mostly between 2% and 4%, but many fields with less then 2%




***Source: Mary Selva Viera (CIAT)***

# Other soil properties: pH neutral to alkaline, low Olsen P at the Northern Zone, high base contents

| Parameter | Northern Zone | Eastern Zone |
|---|---|---|
| **pH** | 49% at 6.0-7.5 | 59% at 6.6-7.5 |
| **Olsen P** | 34% below 6 ppm<br>40% at 6-15 ppm | 1% below 6 ppm<br>4% at 6-15 ppm |
| **Exchangeable Ca** | 83% above 2.5 cmol/kg | 97% above 2.5 cmol/kg |
| **Exchangeable Mg** | 86% above 1.0 cmol/kg | 99% above 1.0 cmol/kg |
| **Exchangeable K** | 87% above 0.2 cmol/kg | 92% above 0.2 cmol/kg |

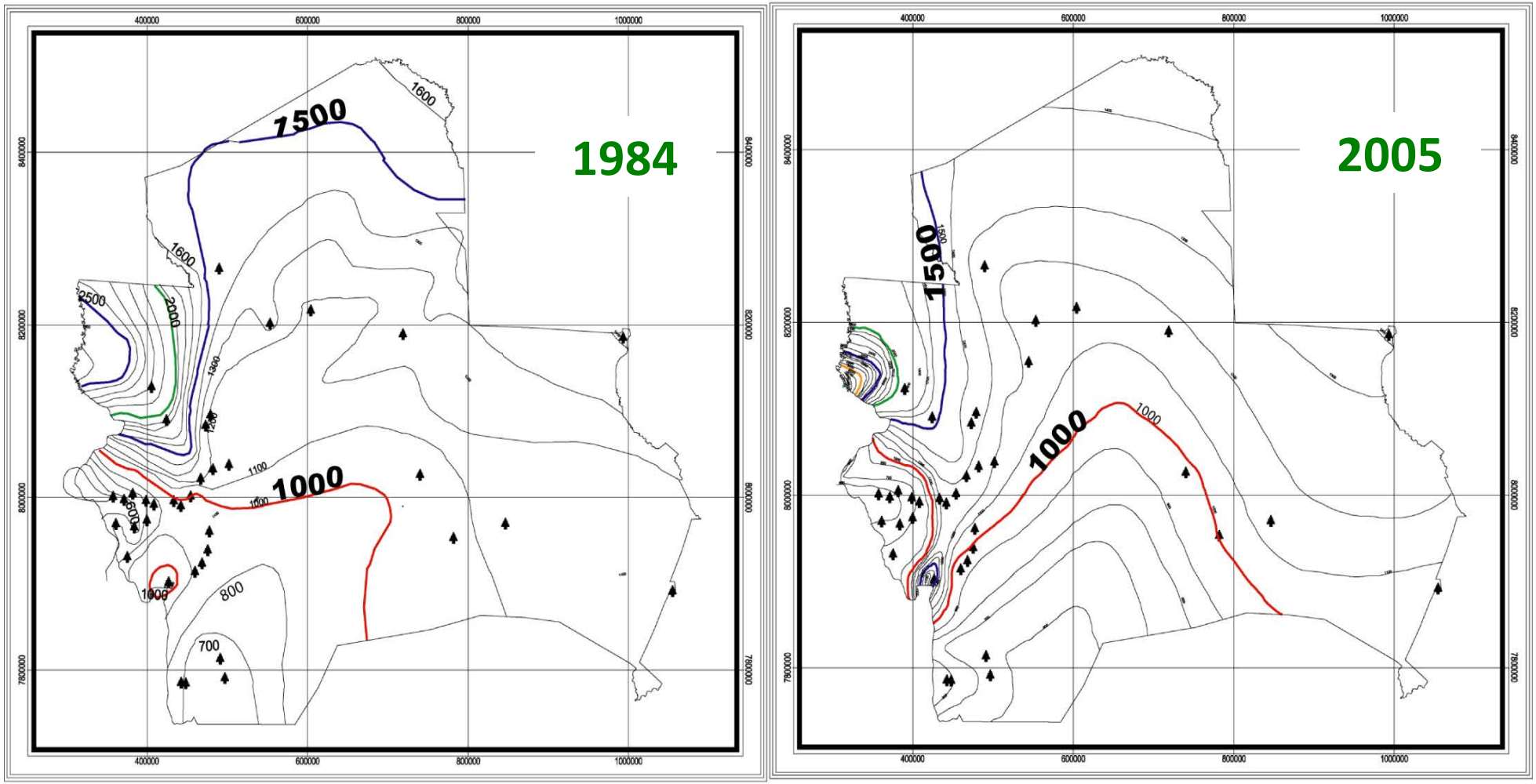
Gobierno Autónomo Departamental Santa Cruz

CIAT Centro de Investigación Agrícola Tropical

***Source: Mary Selva Viera (CIAT)***

IPNI

# Change of annual precipitations at Santa Cruz Department



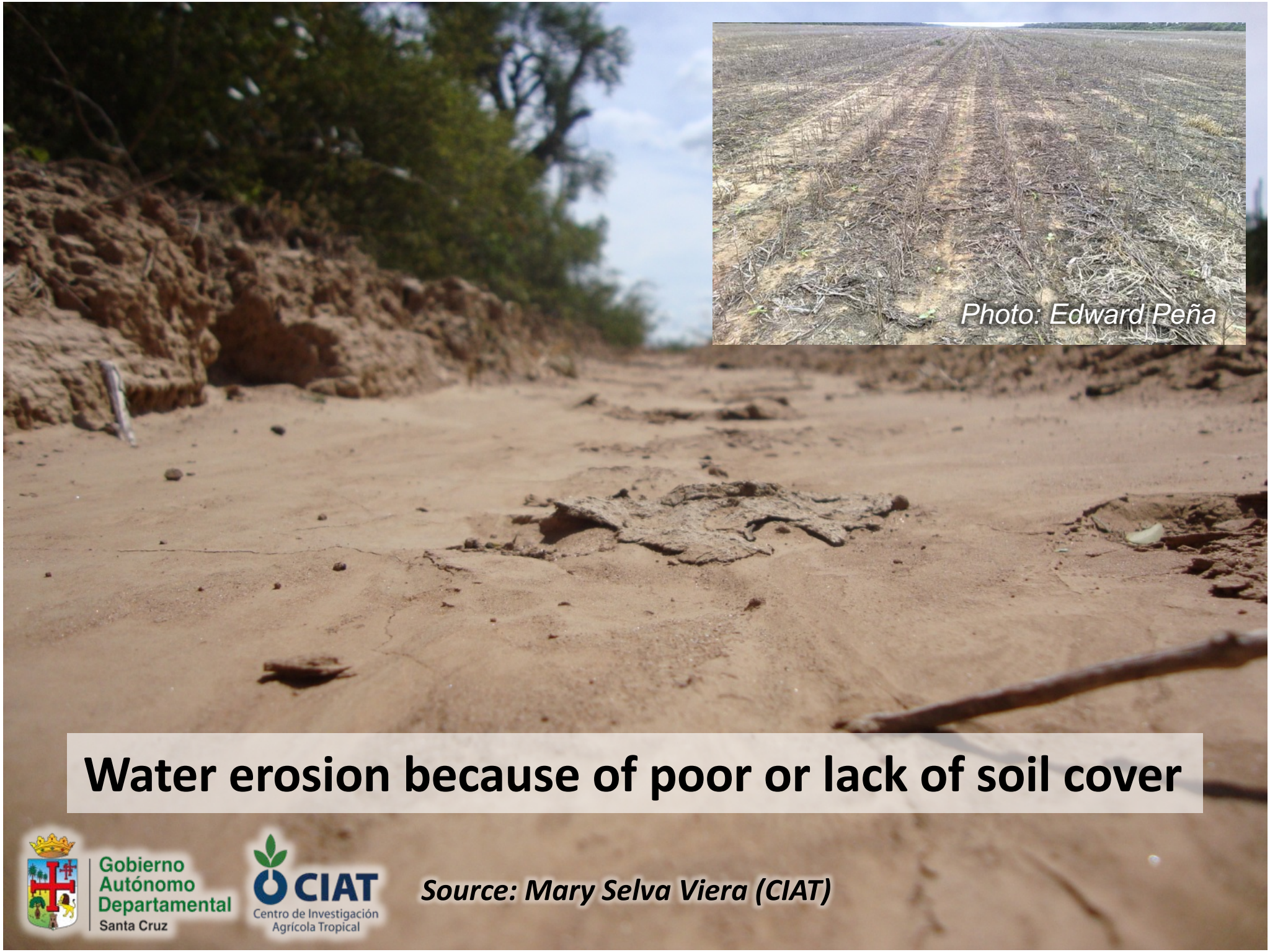

Iso-lines every 100 mm

Gobierno Autónomo Departamental Santa Cruz

CIAT Centro de Investigación Agrícola Tropical

*Source: Mary Selva Viera (CIAT)*

IPNI




# Water erosion because of poor or lack of soil cover

Gobierno Autónomo Departamental Santa Cruz

CIAT Centro de Investigación Agrícola Tropical

*Source: Mary Selva Viera (CIAT)*

*Deterioration of root systems as result of compaction problems*

# Crusting of silty soils

Gobierno Autónomo Departamental Santa Cruz

CIAT Centro de Investigación Agrícola Tropical

***Source: Mary Selva Viera (CIAT)***

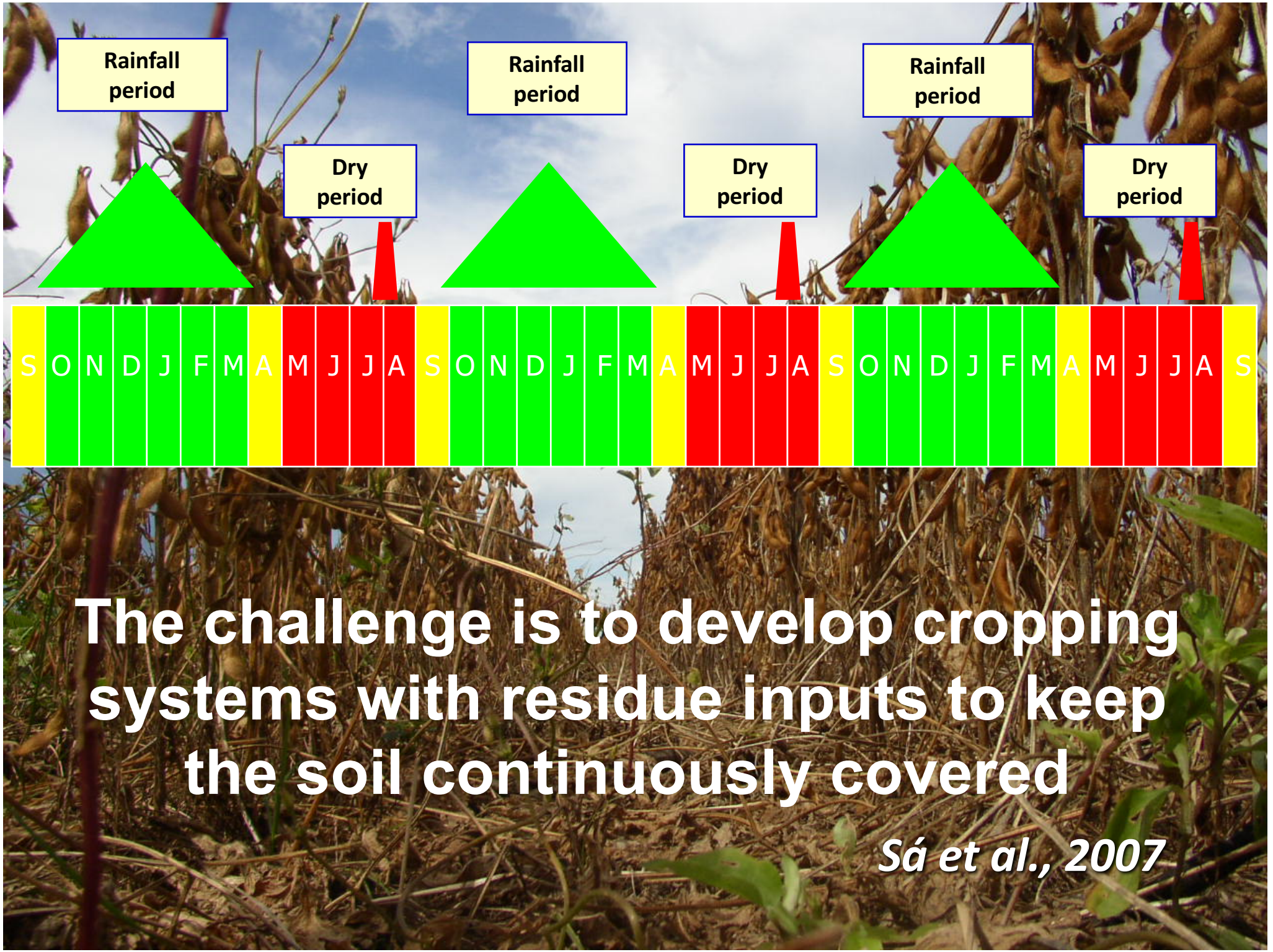
*Flooding from rivers and water courses coming from the Andes, drainage problems*

# Saline soils

Gobierno Autónomo Departamental Santa Cruz

CIAT Centro de Investigación Agrícola Tropical

*Source: Mary Selva Viera (CIAT)*


Rainfall period
Rainfall period
Rainfall period
Dry period
Dry period
Dry period
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
The challenge is to develop cropping systems with residue inputs to keep the soil continuously covered
Sá et al., 2007

# Cover Crops

*Photos: J. Terrazas, E. Peña and F. García*

IPNI

# Brachiaria and millet as cover crops in the Northern Zone of Santa Cruz

*Brachiaria in maize*
*Nuevo Horizonte Farm*
*March 2009*

*Millet and brachiaria in soybean*
*Cinco Estrellas and del Señor Farms*
*August 2010*

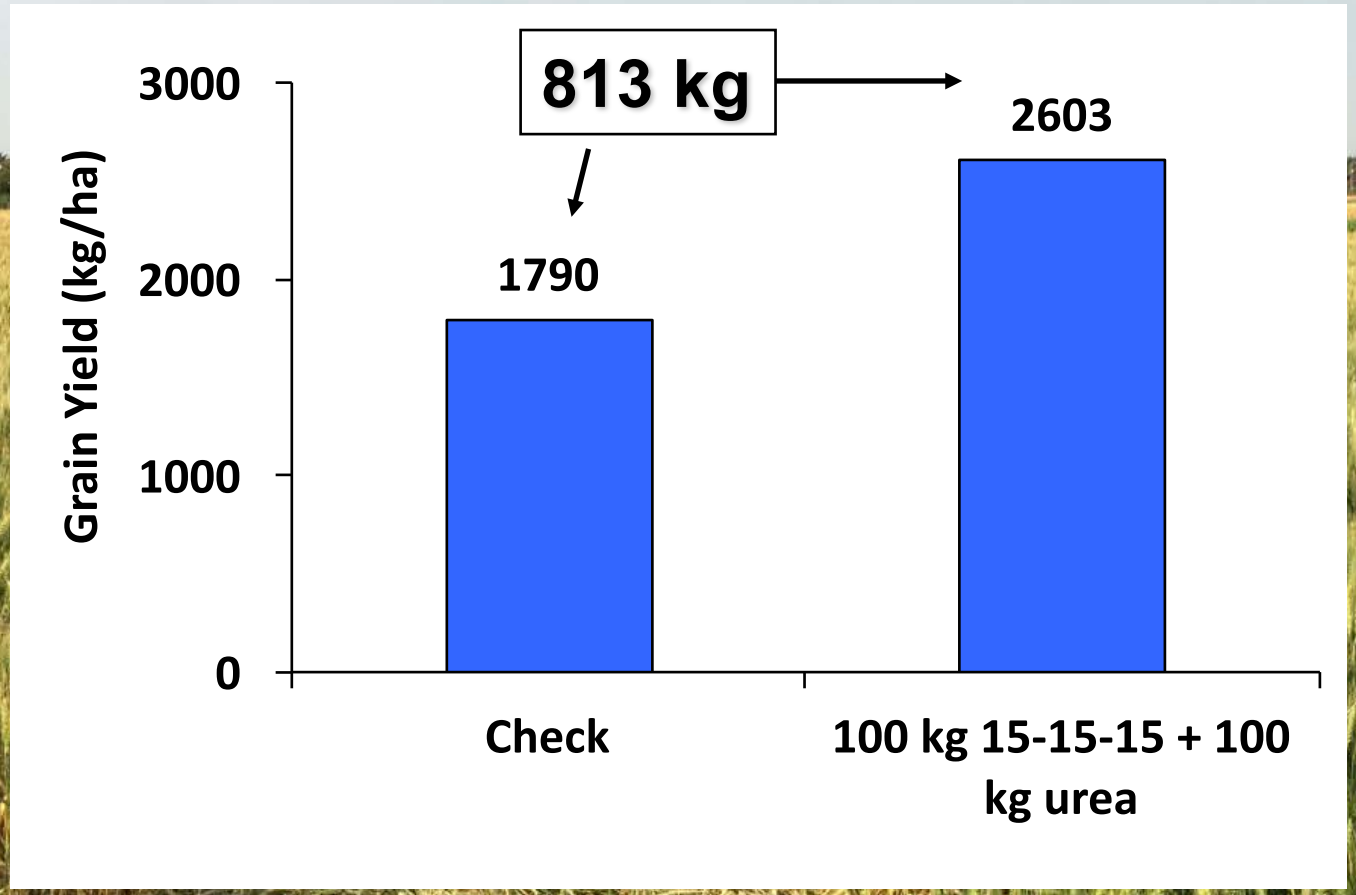
IPNI

# Need to know the soils !!!

Measuring infiltration

# Fertilization in Wheat

## CAICO-ANAPO - Corp. Misti (Okinawa 1, Santa Cruz, Bolivia)

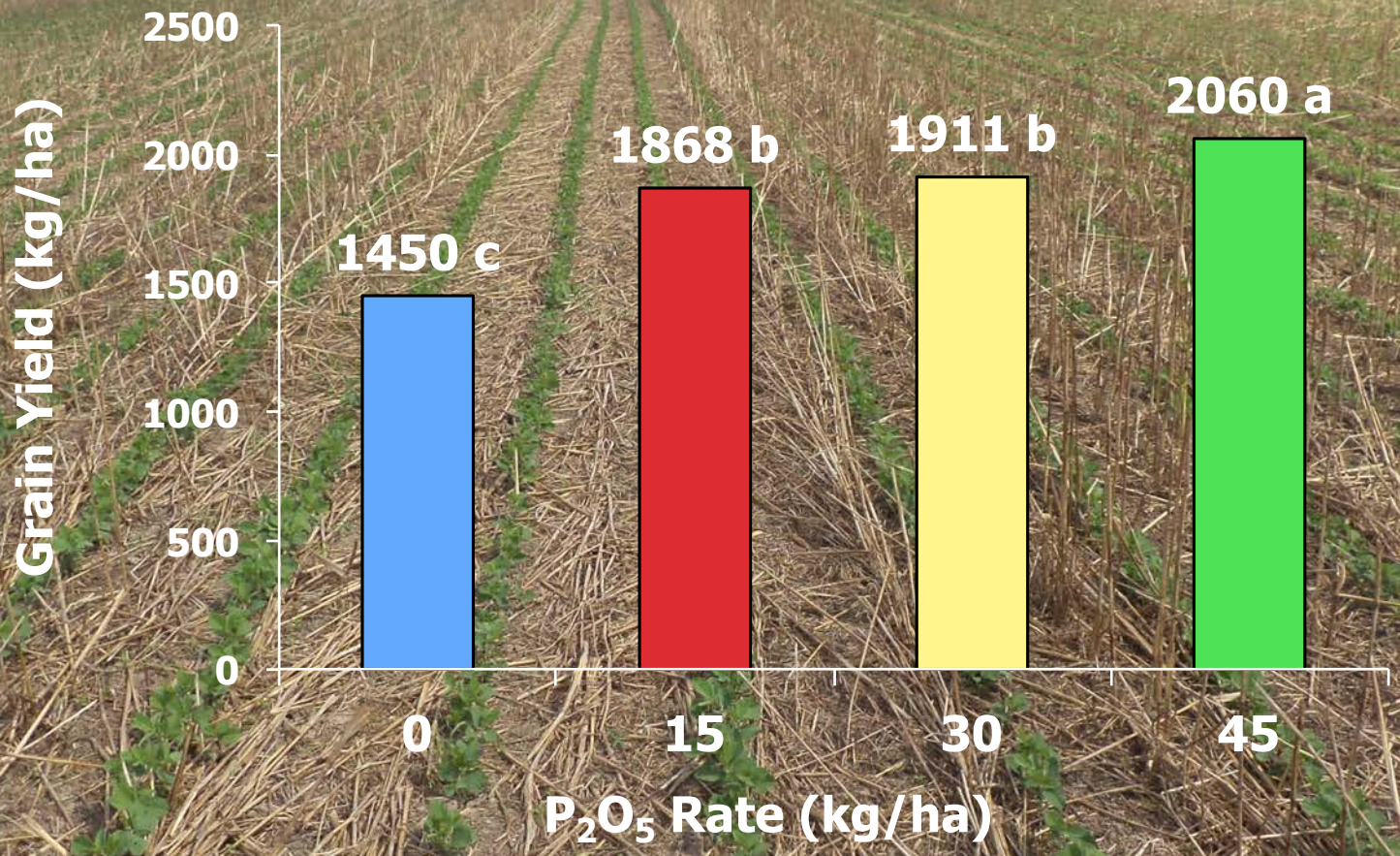



*Cost of fertilization equivalent to 495 kg wheat*
*Net benefit of 318 kg wheat*

# Soybean : Response to P fertilization

*Cinco Estrellas – Aguais - Santa Cruz de la Sierra – Winter 2004*

*Source: Juan Carlos Quevedo Camacho (2005)*




*Field open on 1995, cropped to winter and summer soybean in the last 8 years*

*Previous crop: Soybean – Planting 12/7/04 – Variety Tucunaré*

*Soil test: pH 6 –Olsen P 3.5 mg/kg – OM 1.5% - Silty loam soil*

FUNDACRUZ
IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE
Exploratory Trial Network Fundacruz
Winter 2005-Summer 2008
7 seasons

FUNDACRUZ

IPNI International Plant Nutrition Institute

# Exploratory Trial Network Fundacruz

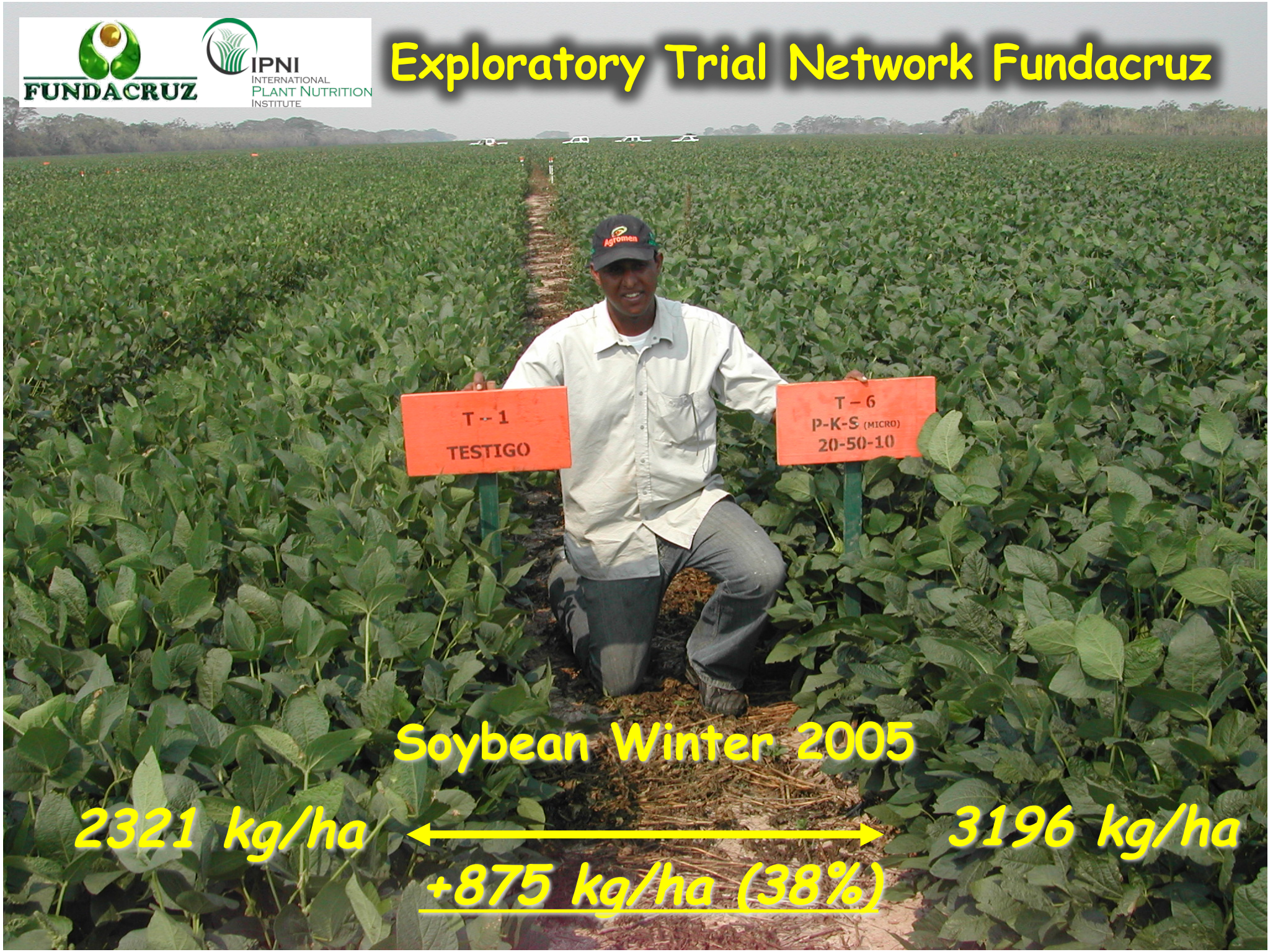
## Treatments

| Treatment | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | Check | PK | PS | KS | PKS | PKS Micros |
| | | | Nutrients (kg/ha) | | | |
| P | | 20 | 20 | | 20 | 20 |
| K | | 50 | | 50 | 50 | 50 |
| S | | | 10 | 10 | 10 | 10 |
| B | | | | | | 0.215 |
| Cu | | | | | | 0.005 |
| Zn | | | | | | 0.030 |

FUNDACRUZ

IPNI International Plant Nutrition Institute

# Exploratory Trial Network Fundacruz




## Soybean Winter 2005

2321 kg/ha ⟷ 3196 kg/ha

+875 kg/ha (38%)

FUNDACRUZ

IPNI International Plant Nutrition Institute

# Exploratory Trial Network Fundacruz

T-1 (Check)

T-2 (PK)

T-3 (PS)

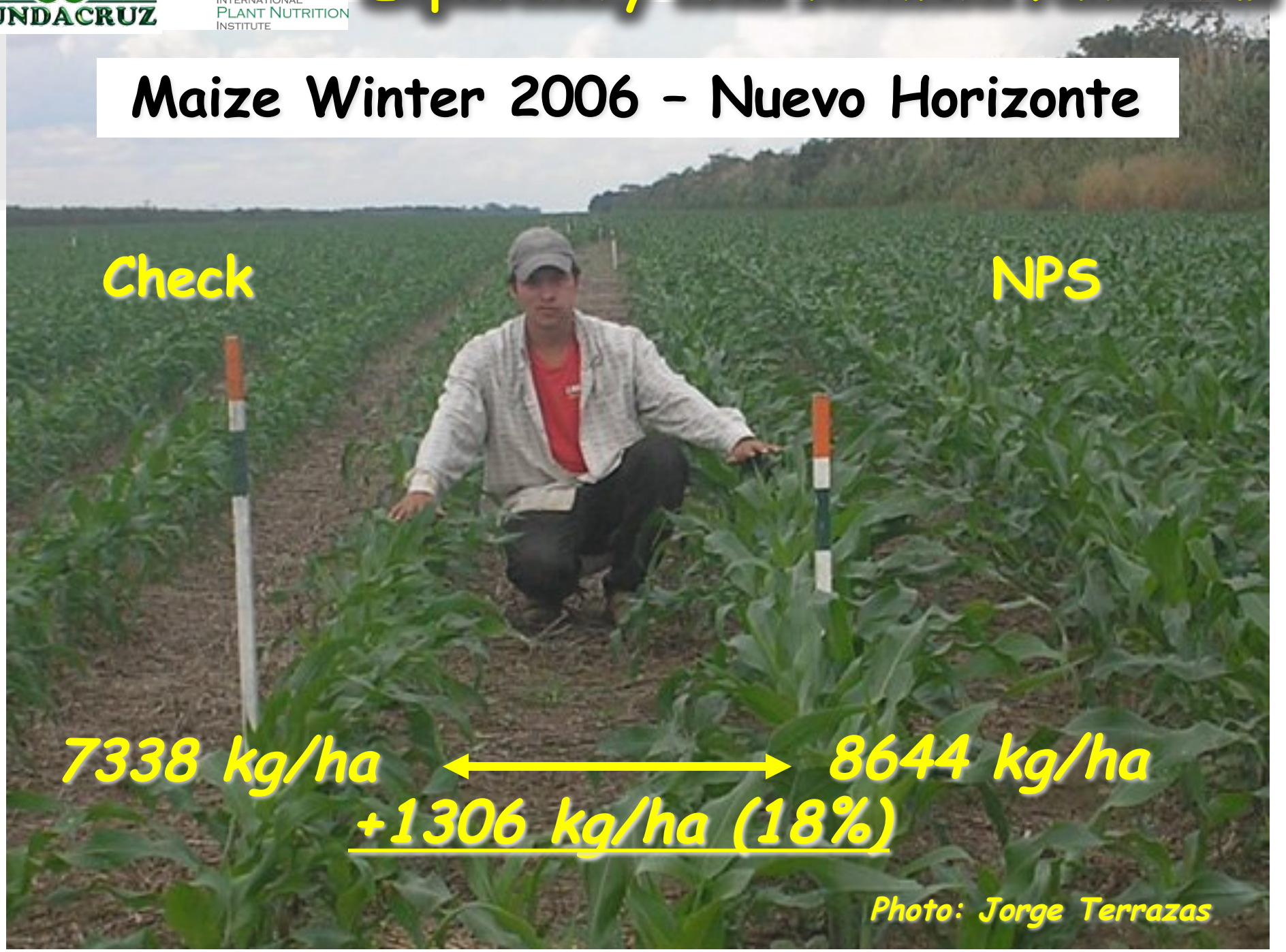
T-4 (KS)

T-5 (PKS)

T-6 (PKS MICRO)

# Exploratory Trial Network Fundacruz

## Maize Winter 2006 – Nuevo Horizonte



FUNDACRUZ

IPNI International Plant Nutrition Institute

# Exploratory Trial Network Fundacruz

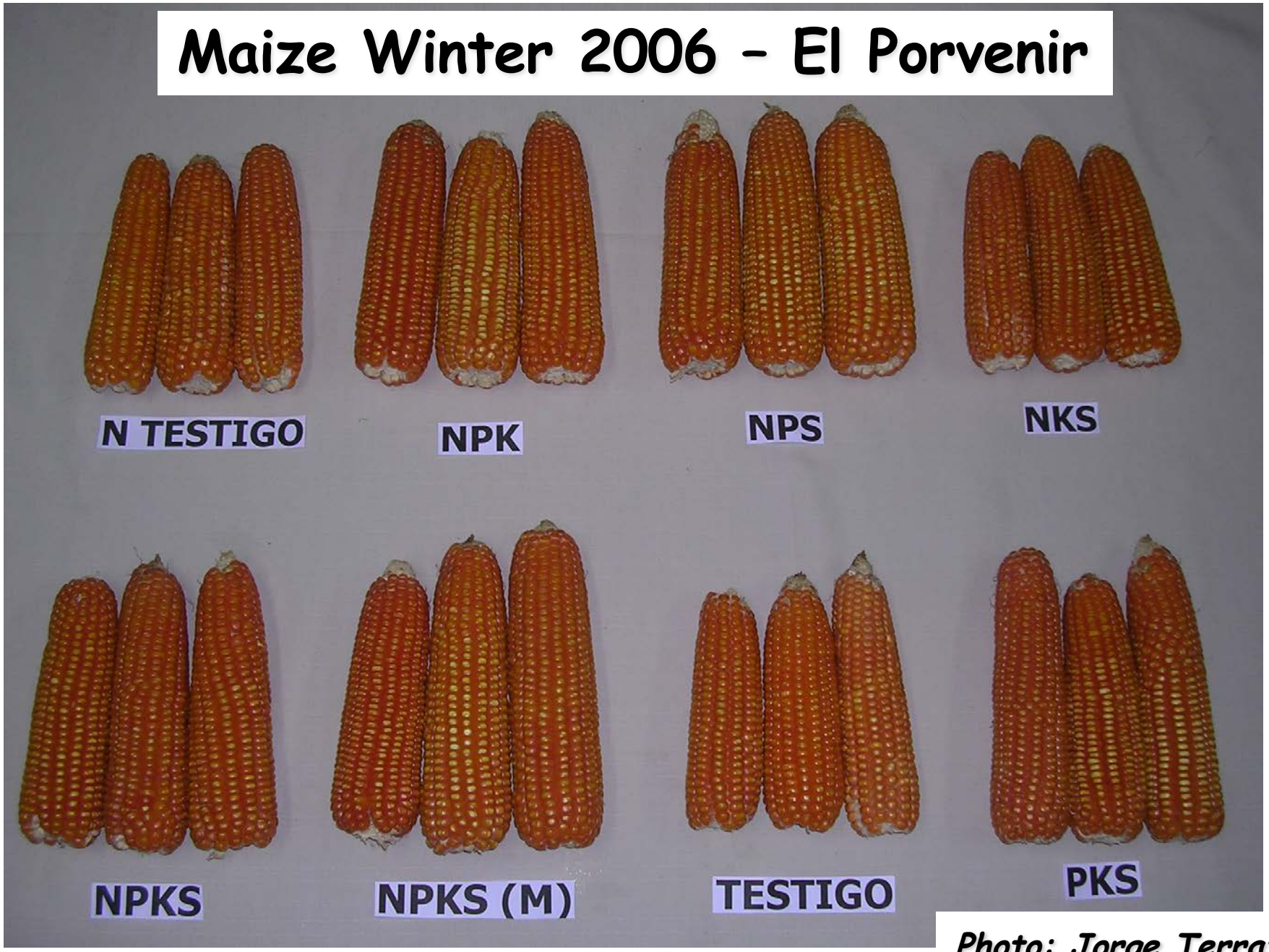



*Photo: Jorge Terrazas*

FUNDACRUZ

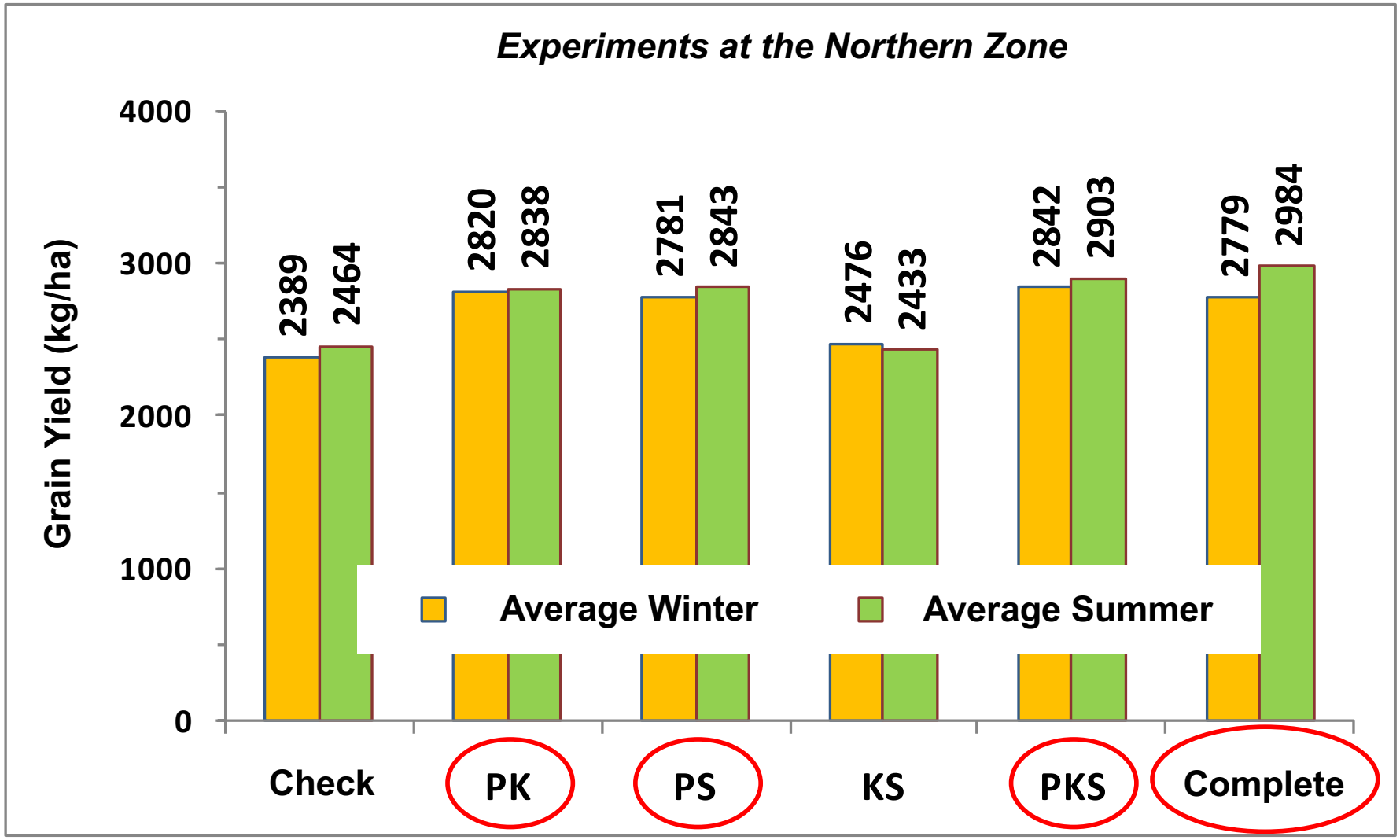
IPNI International Plant Nutrition Institute

# Exploratory Trial Network Fundacruz

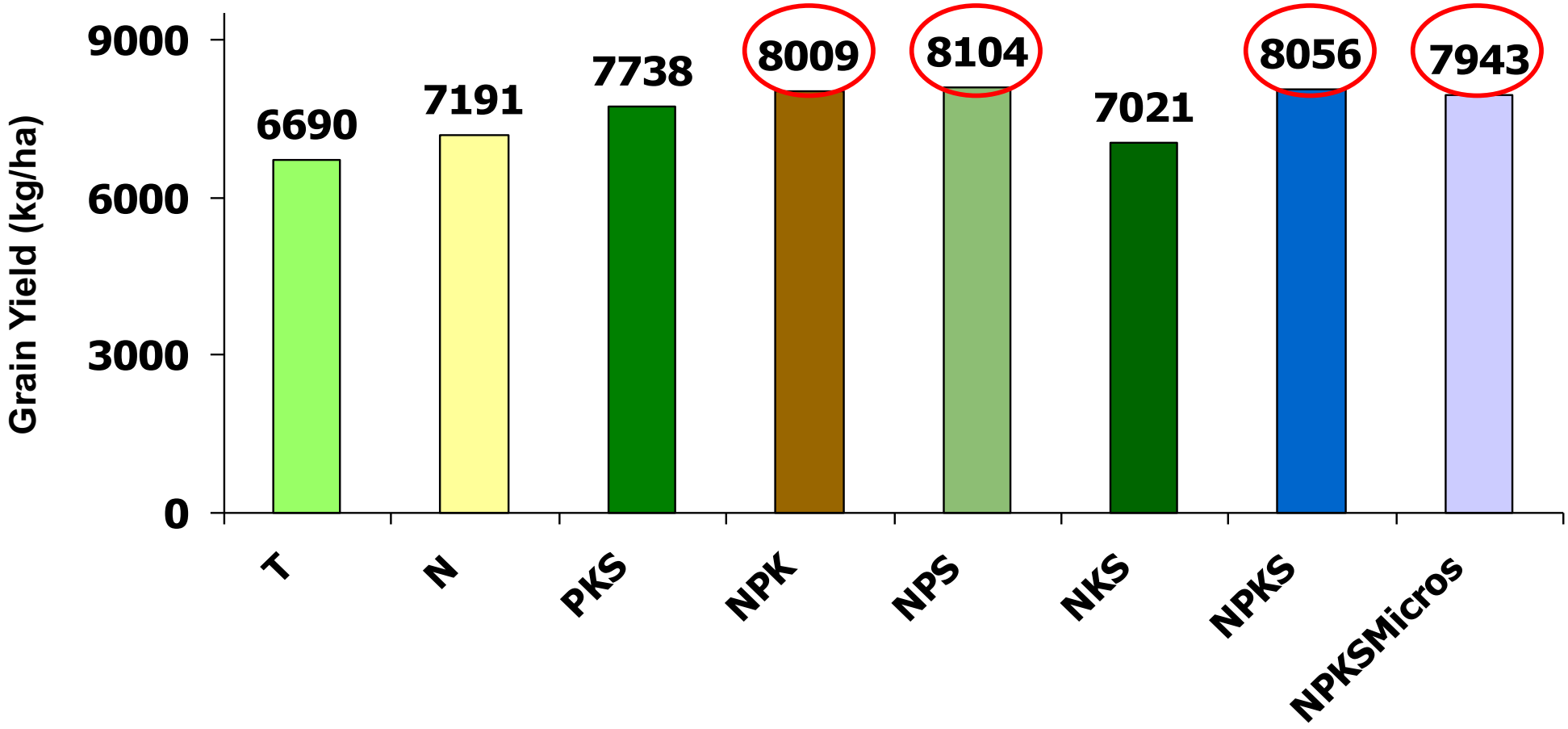
## Maize Winter 2006
## P deficiencies at Monica Norte

*Photo: Jorge Terrazas*

# Soybean: Average Grain Yields for the Winter and Summer Seasons



# Maize Winter 2006
# Averages of 4 trials in the Northern Zone

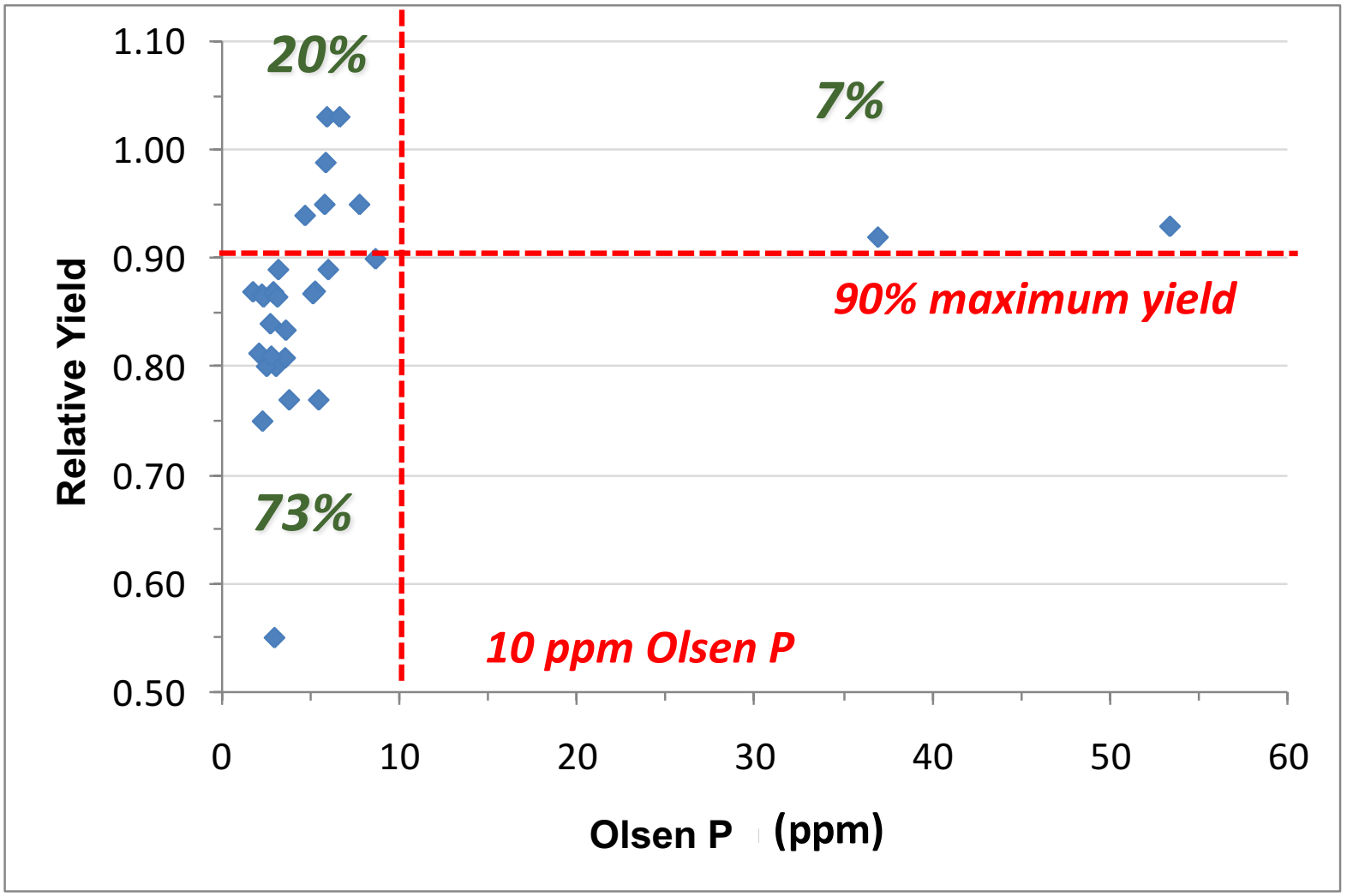



*Siginificant N effects at 3 sites and P effects at the 4 sites*

*Soil tests*

*pH 6.5-8.0 –Olsen P 1.8-7.8 mg/kg – OM 1.4-2.0% - K 0.15-0.36 cmol/kg*

# Soybean, Maize and Wheat Relative Yields as a function of Olsen test P




*Responses at 80% of sites with Olsen P < 10 ppm*

Network Fundacruz-IPNI

# Economic analysis of P fertilization

| Crop | Response | Cost P | Income | Net margin |
|---|---|---|---|---|
| | kg/ha | U$/ha | U$/ha | U$/ha |
| Winter Soy (8 trials) | 366 | 80 | 115 | 35 |
| Summer Soy (11 trials) | 470 | 80 | 148 | 68 |
| Winter Maize (4 trials) | 1035 | 80 | 176 | 96 |

*Prices: 315 U$/t soy; 170 U$/t maize*
*4048 U$/t P (920 U$/t DAP)*

## Network Fundacruz-IPNI

# P Fertilization Efficiency

- Winter Soy → 18 kg soy per kg P
  *(4.1 kg soy per kg DAP)*
- Summer Soy → 23 soy per kg P
  *(5.2 kg soy per kg DAP)*
- Winter Maize → 50 kg de maize per kg P
  *(11.4 kg maize per kg DAP)*

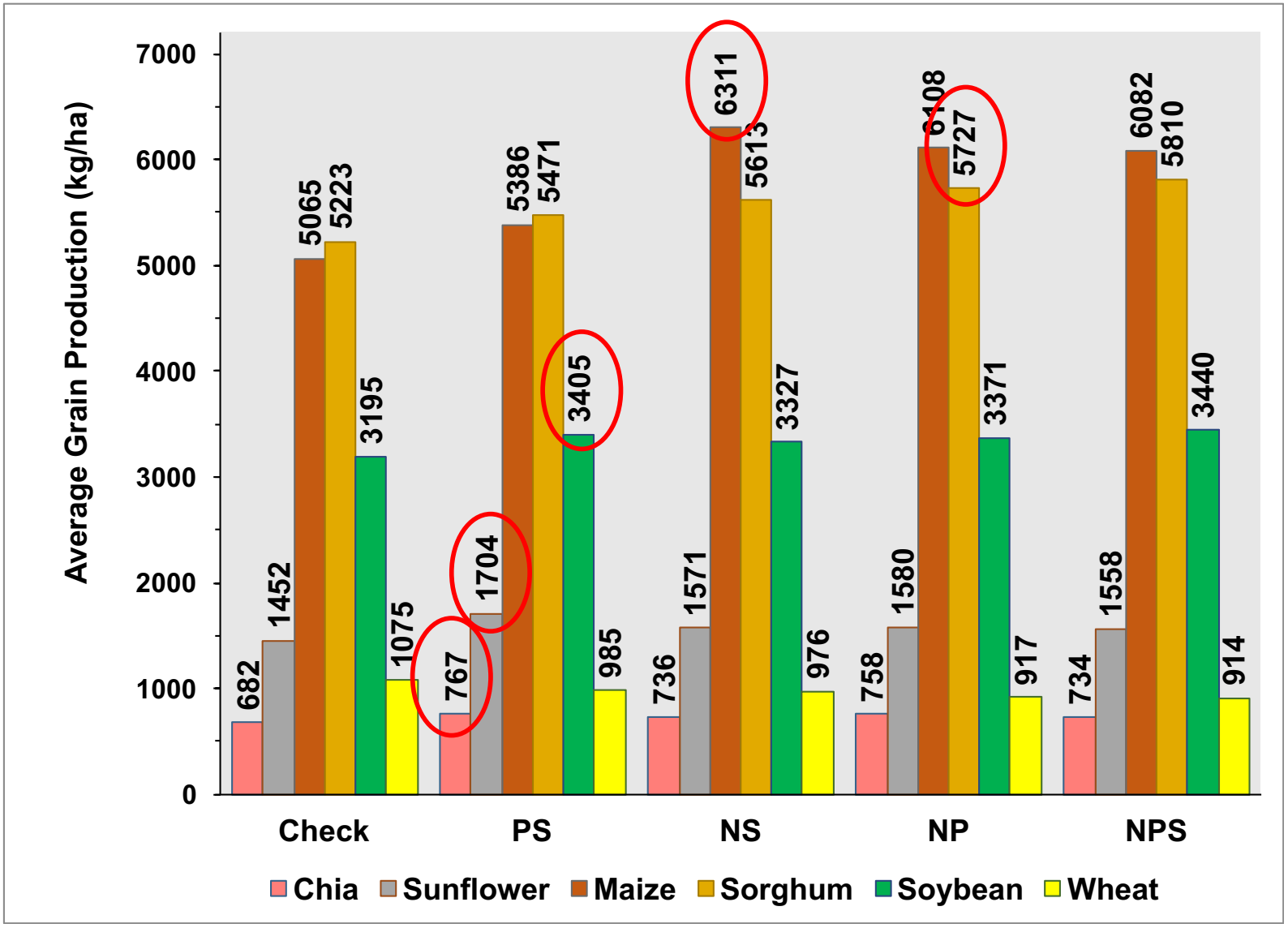
# Potential impact of P fertilization in the Northern Zone of Santa Cruz

- Considering 60% of the 600 thousand ha planted at the Northern Zone, with Olsen P levels below 10 ppm → **360.000 ha**
- At rates of 80 kg/ha DAP → 28.800 ton DAP, **cost of 26.5 million U$**
- Considering averages responses of 300 kg/ha → 108.000 t soybean, **income of 34.0 million U$**
- **Net profit → 8 million U$, return investment of 1.28**

AB-CREA
IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE
CREA Eastern Santa Cruz
Network of Nutrition Trials
Summer 2012/13- …….
9 seasons

# CREA Eastern Santa Cruz Network of Nutrition Trials

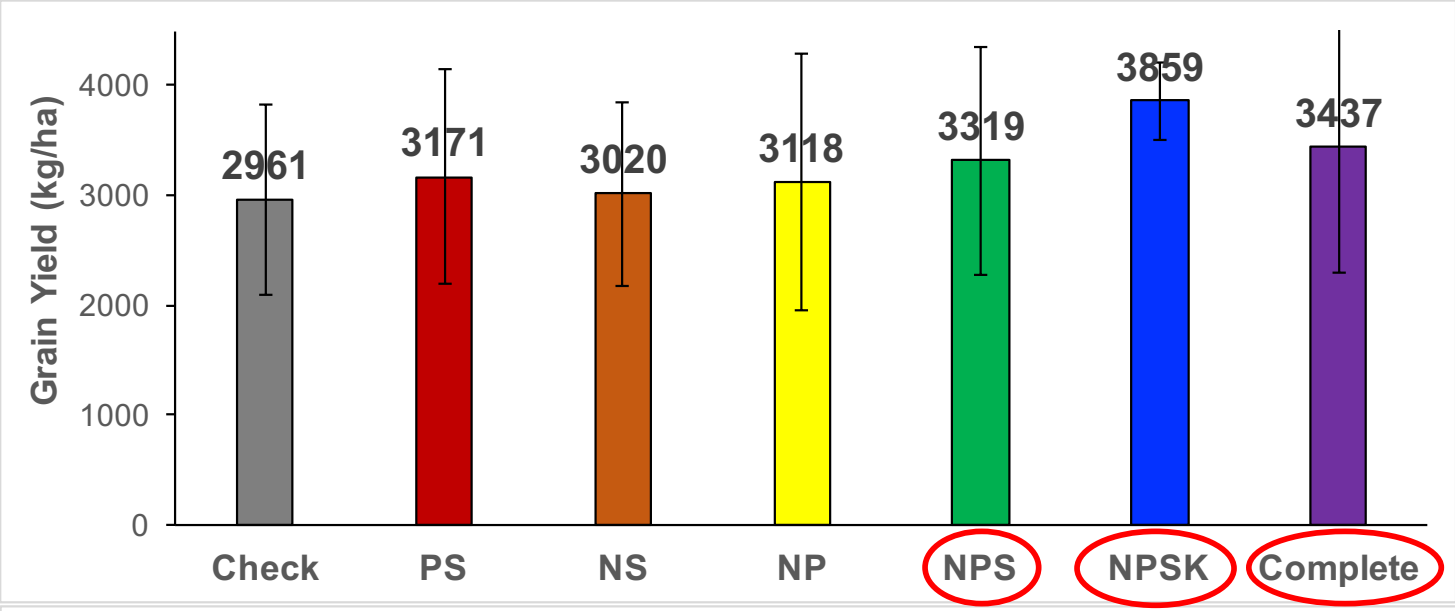
7 seasons (Winter 12/13 – Summer 15/16)



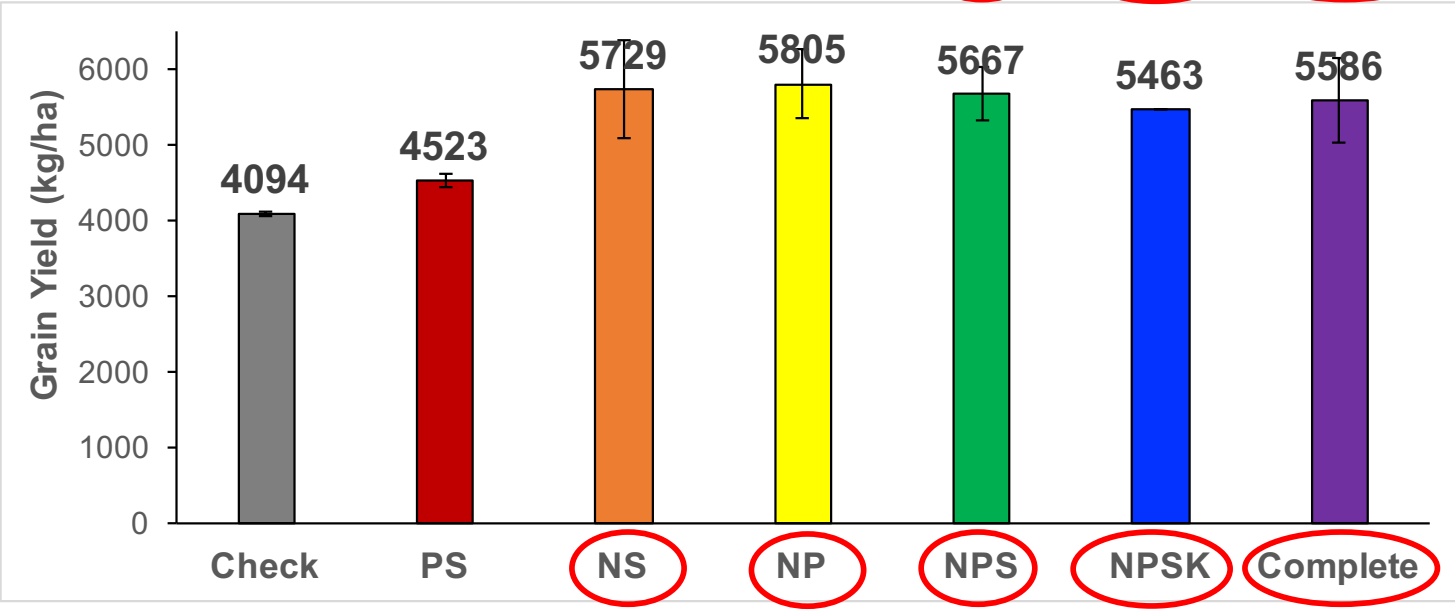

*Largest responses with PS for chía (+12%), sunflower (+17%) and soybean (+7%), under NS in maize (+25%) and under NP in sorghum (+10%)*

# Grain yield averages 2015/16 Summer Season

## Soybean (4 trials)




## Maize (2 trials)



# Conclusions

- Field crop area and production have rapidly expanded in the last 20 years in the eastern plains of Bolivia
- Soils of region are affected by erosion, crusting, compaction, salinity, and periodical flooding.
- Most of the soils of the Northern and Eastern Zones test low to medium for organic matter, but are usually well provided with K and other nutrients
- Soil Olsen P is high at the Eastern Zone, but medium to low in the Northern Zone
- Negative nutrient balances have resulted in loss of soil fertility in both zones
- Field research indicates deficiencies and profitable responses:
  - ***Northern Zone: to N and P, and to a lesser extent to S***
  - ***Eastern Zone: to N and S, and to a lesser extent to P***
- Future research should address further exploration of responses and deficiencies in recently open areas, calibration of soil test, and site-specific nutrient management alternatives, among others

IPNI

# Acknowledgements

Our work at the eastern plains of Bolivia has been possible through the help and support of many fertilizer and ag companies and of partner institutions:

AB-CREA, ANAPO, CAICO, CETABOL,
CIAT, FUNDACRUZ, MRDyT, and others

and to their staff:

Roxana Barba, Nelson Ojeda, Carlos Paz, Ronald Paz,
Edward Peña, Mario Porcel, Juan C. Quevedo,
Limbert Rivera, David Ruiz, Roxana Sandoval,
Jorge Terrazas, Richard Trujillo, Mary Selva Viera,
and many others

and

all the farmers involved in the trials and the many discussions

*We are thankful to all our friends!!!*

IPNI

# Thank you!!

For more information please visit
http://research.ipni.net/project/IPNI-2003-BOL-1

IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

http://lacs.ipni.net/
fgarcia@ipni.net