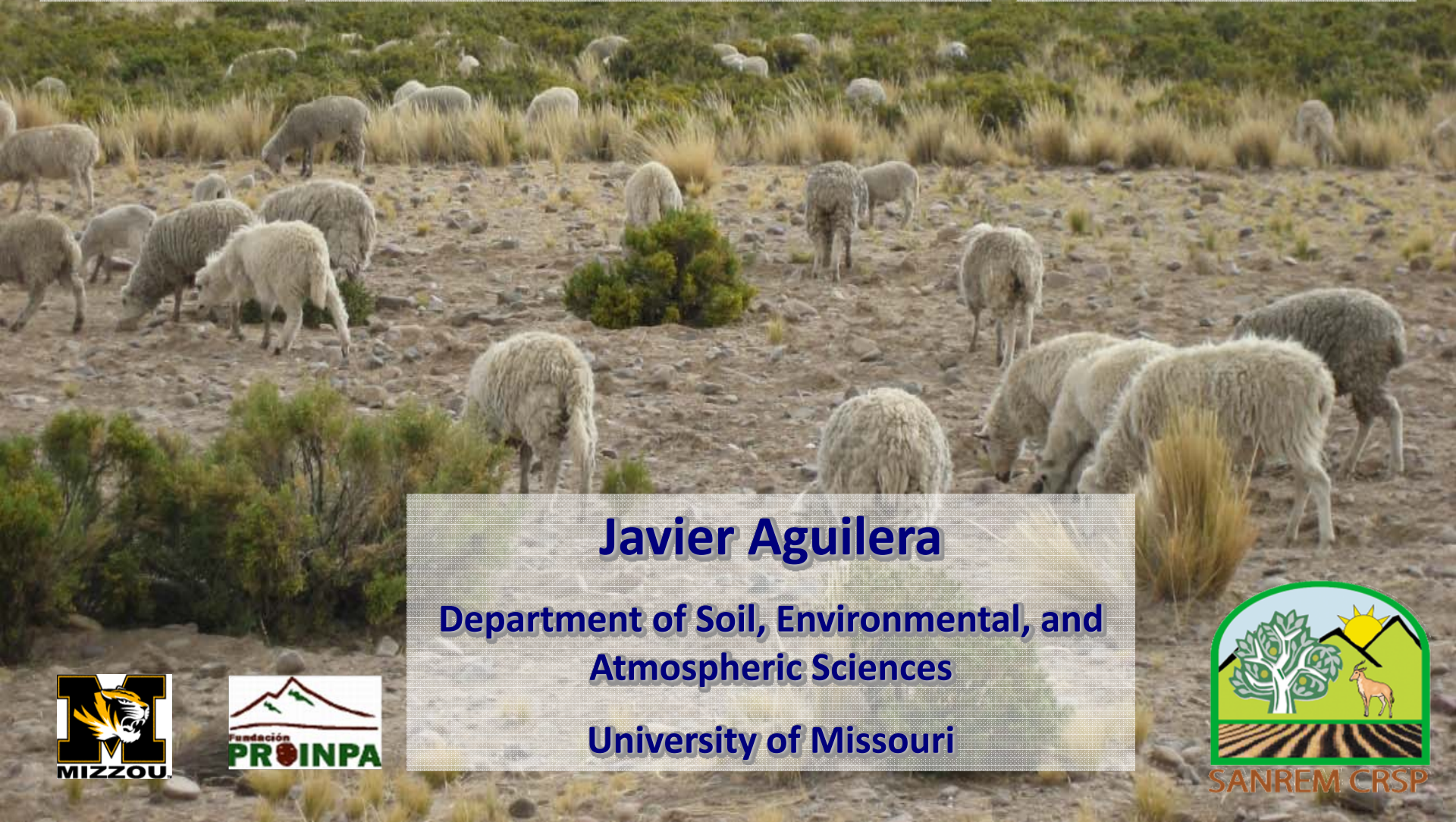


# The Impacts of Soil Management Practices on Nitrogen Availability in Potato-Based Cropping Systems in the Bolivian Highlands



**Javier Aguilera**

**Department of Soil, Environmental, and  
Atmospheric Sciences**

**University of Missouri**



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## **Committee Members:**

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  - **Dr. Robert Kremer**
  - **Dr. Jere Gilles**
  - **Dr. John Lory**
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  - **Farmers of the Bolivian Highlands Region**

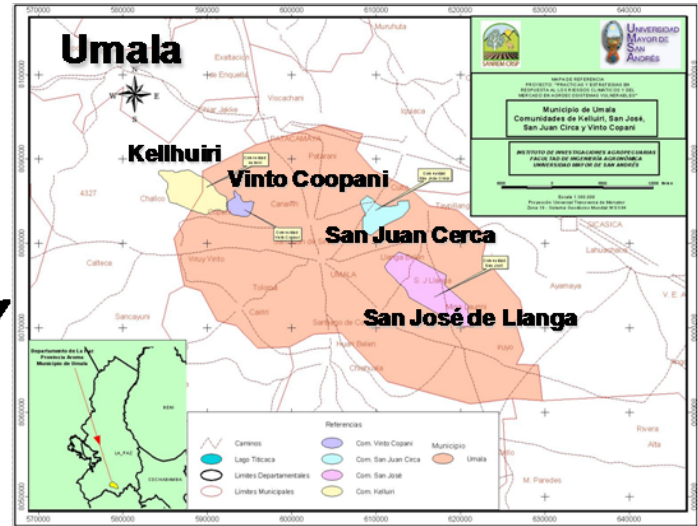


# OUTLINE

- **INTRODUCTION**
- **OBJECTIVES**
- **METHODOLOGY**
  - **Research Approach**
- **SELECTED RESULTS**
- **PRELIMINARY CONCLUSIONS**



# INTRODUCTION



# Nature of the Highlands

- High altitude (3,500 - 4,200 masl)
- Semi-arid climate ( $11^{\circ}$  C and 350 mm year<sup>-1</sup>)
- High risk of frost, hail, and drought and high rate of evapotranspiration.
- Native indigenous people with low incomes and limited access to market and technologies



- **Combine agriculture and livestock**
- **Production system:**
  - *Potato, quinoa, barley or oats*
  - *Fallow from 3 up to 20 years (only native vegetation)*
- **Livestock: Mainly beef and sheep**
- **Mostly utilize local technology**



# CHANGES IN SOIL AND CROP MANAGEMENT PRACTICES

- Increase in other income-generating activities
- Decrease in the length of the fallow
- Inadequate soil management practices (e.g. tractor use for tillage, overgrazing, etc.)
- Loss of native species (e.g., th'ola)



- **Suboptimal amount of inorganic and organic soil amendments (surveys)**
  - **Manure transportation and availability**
  - **Cost and availability of fertilizers**
  - **No soil testing labs nearby**
  - **Unclear soil fertility strategy**

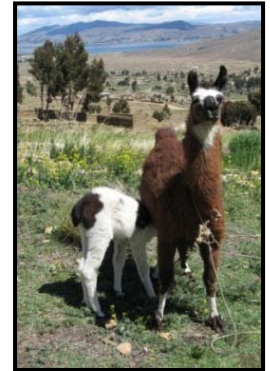


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# OBJECTIVES

- **To determine how current soil management practices have affected nitrogen (N) availability (i.e., effects of cropping and fallow length)**
- **To assess the effects of conventional and alternative inorganic and organic soil amendments on crop growth and plant N status**
- **To evaluate a rapid field test method for potato plant tissue that might help to improve N fertility management**



# MATERIALS AND METHODS

- **Area of study (Umala Municipality)**

- *4 representative communities:*

- *Kellhuiri*

- *Vinto Coopani*

- *San Juan Circa*

- *San Jose*



- **Sandy loam textural class with low native soil organic matter (0.2 – 1.5%).**

## ***Available N in Cropped and Fallow Fields***

- **Farm fields identified with different lengths of cropping and fallow in sandy loam soils**
  - *crop rotation (1,2,3 years of cropping)*
  - *fallow length (1, 10, 20, 30, 40 years)*
- **Soil sampling (20 cm depth)**
  - *Bulk density*
  - *Soil total inorganic N ( $\text{NH}_4^+\text{-N} + \text{NO}_3^-\text{-N}$ )*
  - *Soil total organic C and total N*



## ***Aerobic Leaching Incubations***

- **To determine potential soil N mineralization**
- **Incubation at room temperature (25° C)**
- **Incubation time: 1, 3, 7, 14, 21, 28, 42, 56, 70, 84 days**



## ***Field Trials (Inorg & Organic Soil Amendments)***

- **To assess local conventional and alternative inorganic and organic soil amendments**
- **Potato in 2006-07 and 2007-08 and subsequent crop (quinoa) in 2007-08 and 2008-2009**
- **Experimental design: RCB with four replications**



## ***Treatments (Applied to Potato Crop):***

- T1. Blank**
- T2. DAP + Urea (120 N- 80 P- 00 K)**
- T3. Cow manure (CM) (10 MT ha<sup>-1</sup>)**
- T4. Sheep manure (SM) (10 MT ha<sup>-1</sup>)**
- T5. CM (5 MT ha<sup>-1</sup>) + SM (5 MT ha<sup>-1</sup>)**
- T6. Compost (5 MT ha<sup>-1</sup>)**
- T7. CM + DAP + Urea**
- T8. SM + DAP + Urea**
- T9. CM + SM + DAP + Urea**
- T10. CM + Biofert (200 kg ha<sup>-1</sup>)**
- T11. SM + Biofert**
- T12. CM + SM + Biofert**



- **Soil samples collected before planting, at blooming, and at harvesting time.**
- **Manure, compost and biofert samples**
- **Agronomic evaluations**
- **Total tuber yield (potato) and grain yield (quinoa)**
- **Participatory evaluations**



## ***Aerobic Leaching Incubations***

- **To determine potential soil N mineralization (1, 3, 7, 14, 21, 28, 42, 56, 70, 84 days) with application of organic amendments**

### **Treatments:**

- **Blank**
- **7.5, 15, and 30 MT Cow manure (CM)**
- **7.5, 15, and 30 MT Sheep manure (SM)**
- **7.5, 15, and 30 MT CM+Biofert**
- **7.5, 15, and 30 MT SM+Biofert**
- **7.5, 15, and 30 MT Compost**



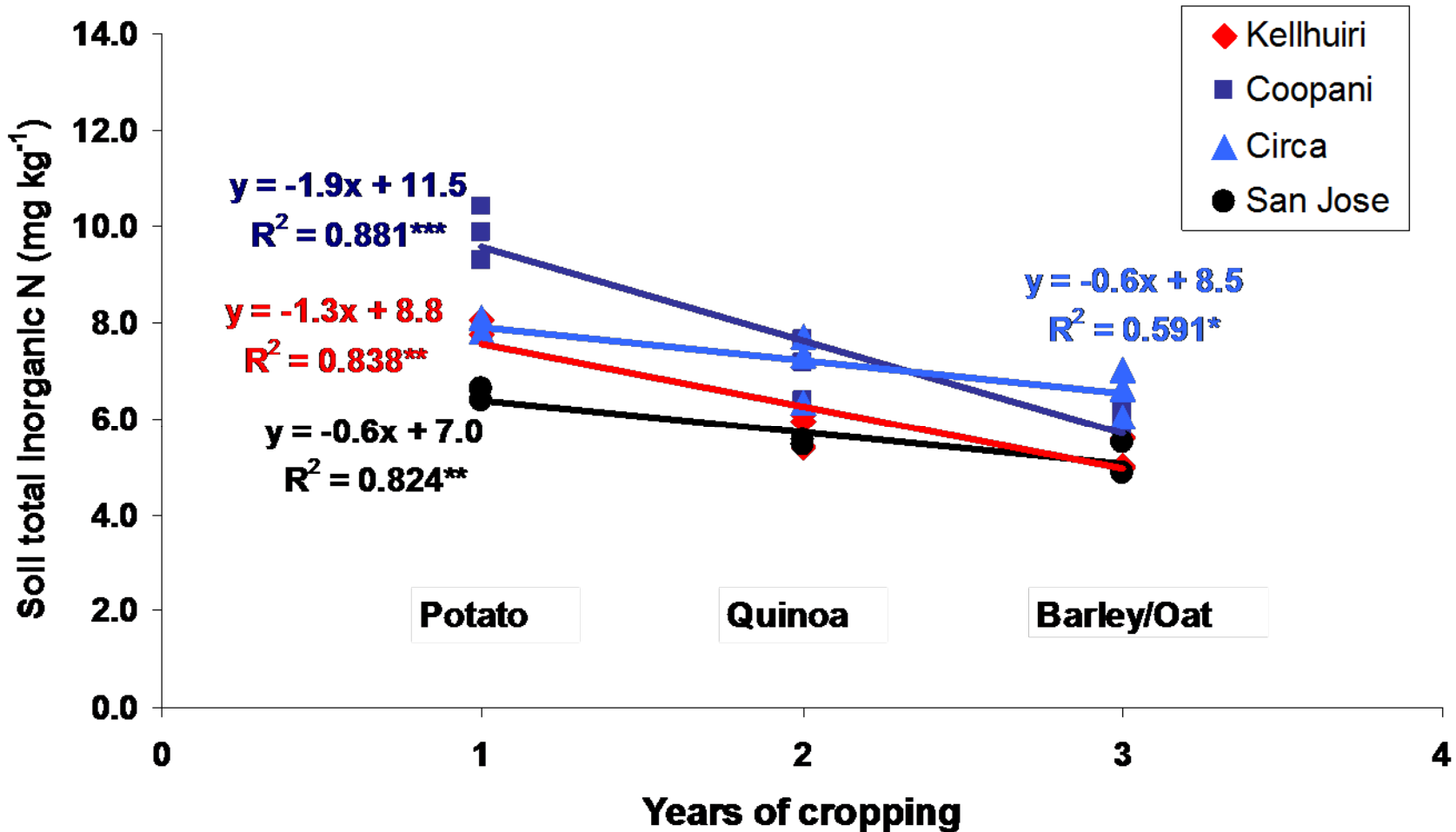
## *Cardy Meter Nitrate-N*

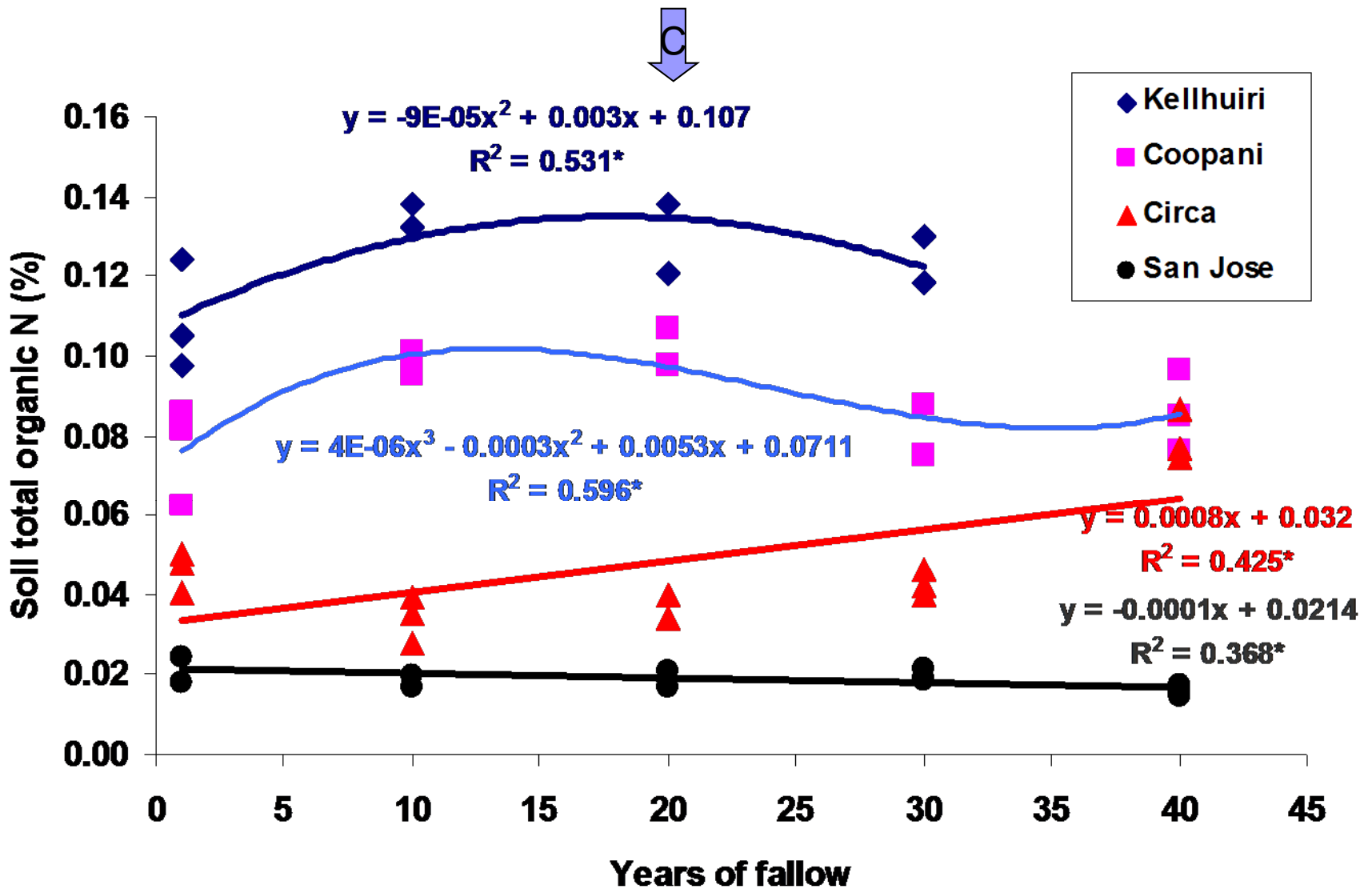
- Measured using potato petiole at potato blooming (both growing seasons)
- Sampling of petiole plant for total N analysis



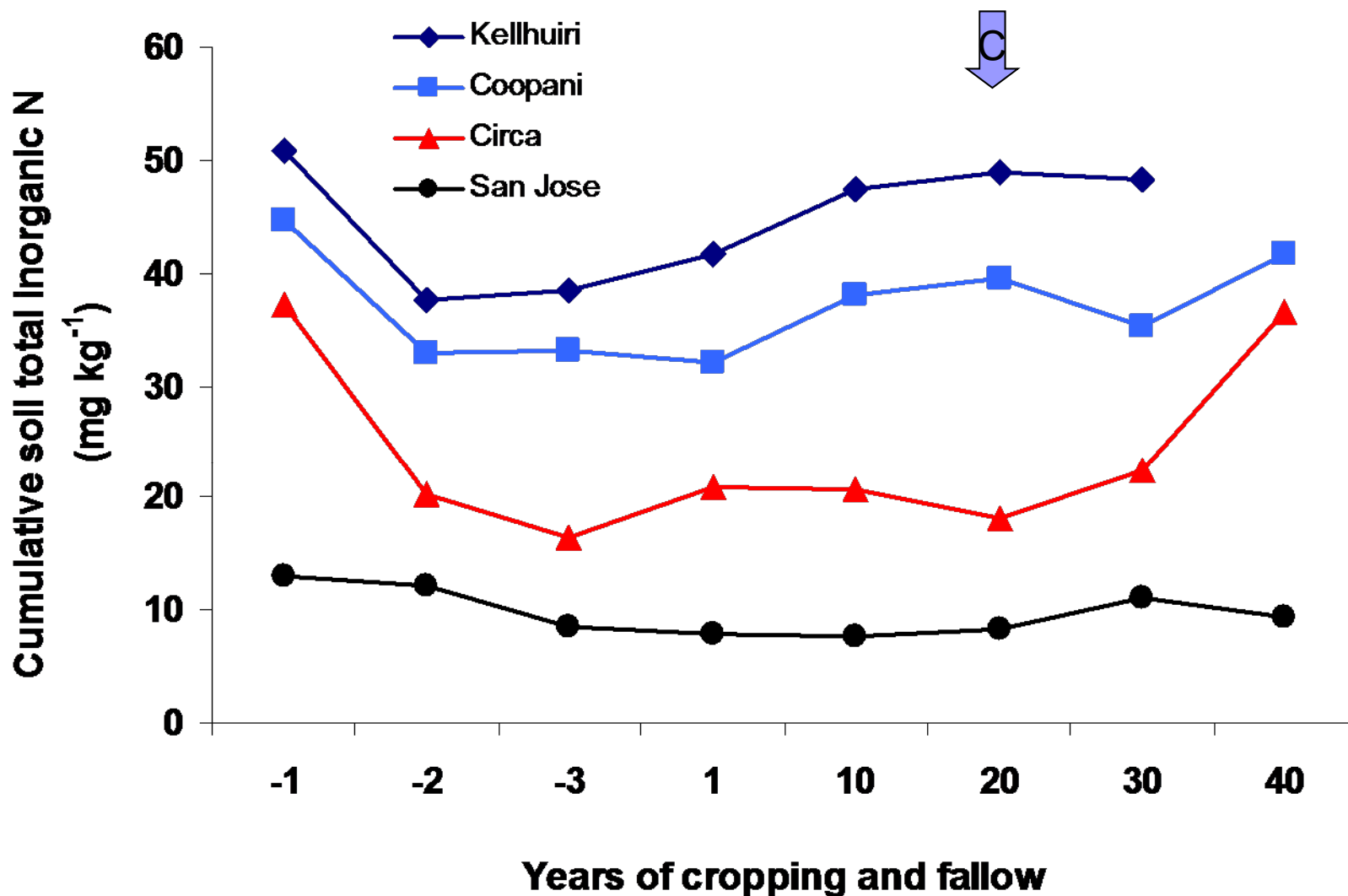
# RESULTS

## *N in Cropped and Fallow Fields*





# Aerobic Leaching Incubations

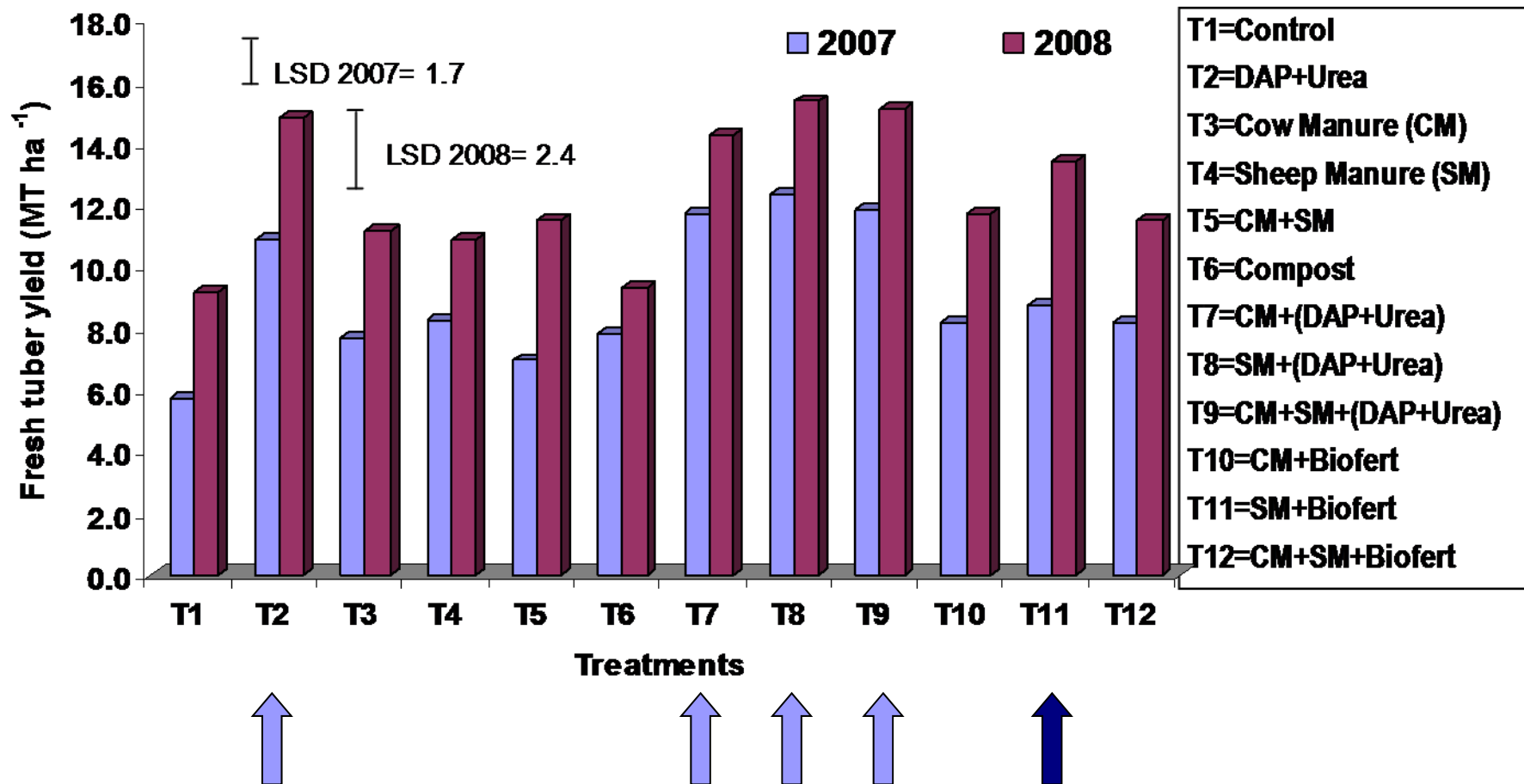


## Field trials (Inorganic & Organic Soil Amendments)

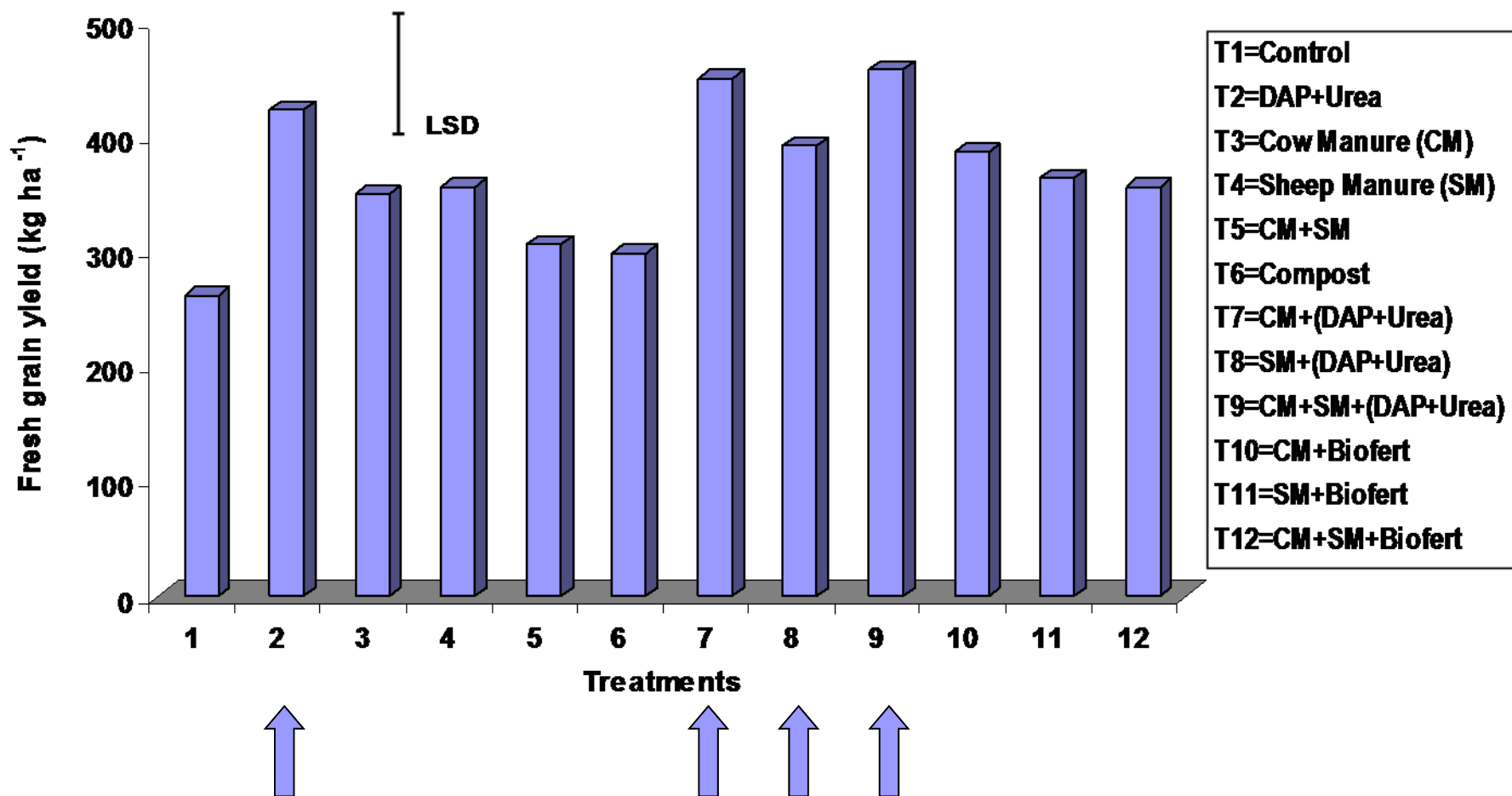
Organic amendments	C:N ratio	Total organic C	Total N	Total P	Total K
Sheep manure	18	29.4	1.7	0.34	2.2
Cow manure	18	26.6	1.4	0.31	2.1
Compost	11	13.0	1.2	0.34	0.7
Biofert	4	37.6	10.1	0.22	0.4

Community	pH <sub>s</sub>	Organic matter	Total N	Soil test Bray1 P	Soil test K	CEC	EC
		----- % -----		----- mg kg <sup>-1</sup> -----		----- cmol <sub>c</sub> kg <sup>-1</sup> -----	
Kellhuiri	5.5	1.6	0.08	51.0	243.0	8.3	0.2
Vinto Coopani	5.7	1.3	0.07	46.8	271.0	8.9	0.3
San Juan Circa	6.0	0.9	0.05	22.8	172.0	9.1	0.1
San José	5.5	0.3	0.04	35.0	166.0	3.1	0.1

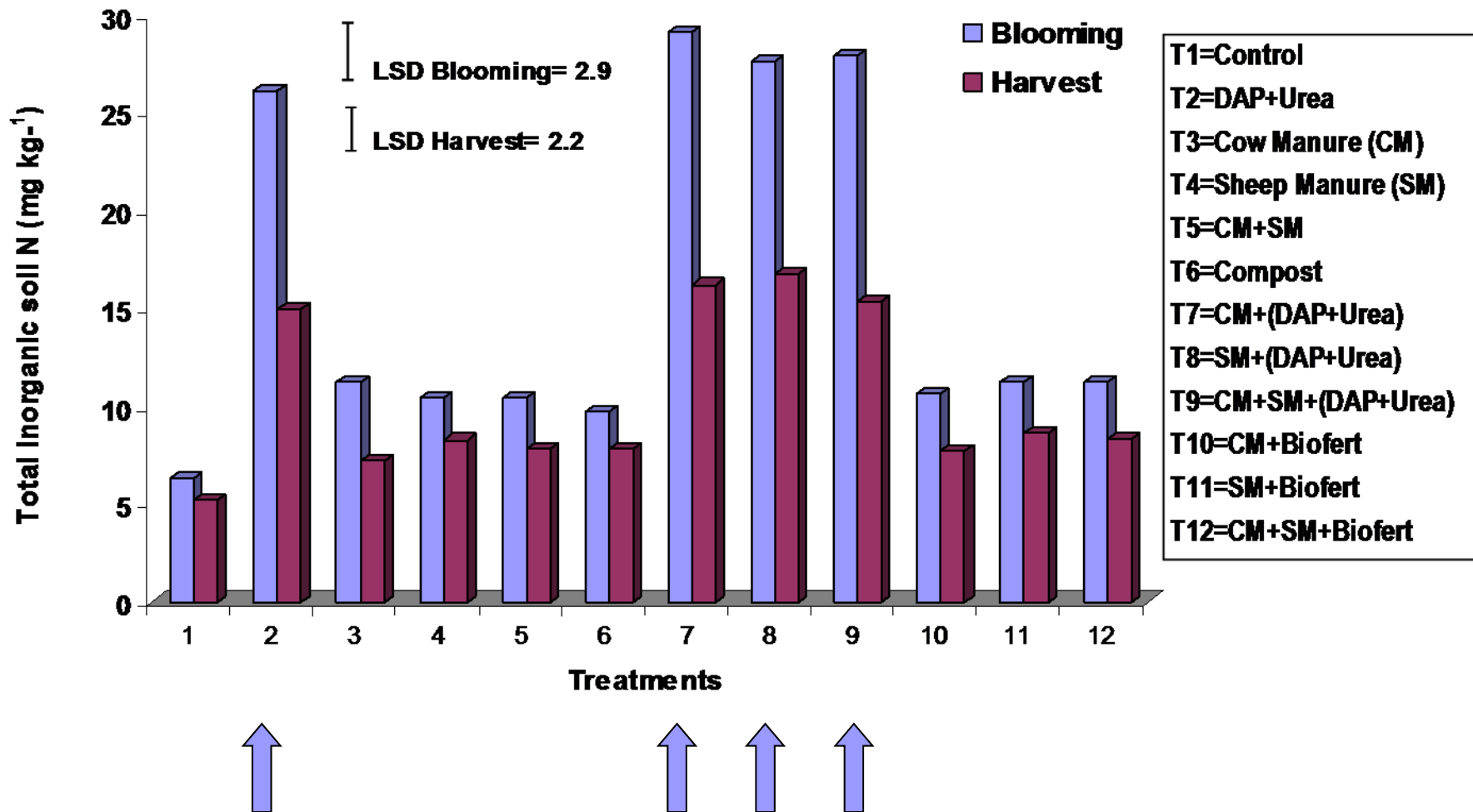
# Potato tuber yield



## Quinoa grain yield (residual effects of fertilization)

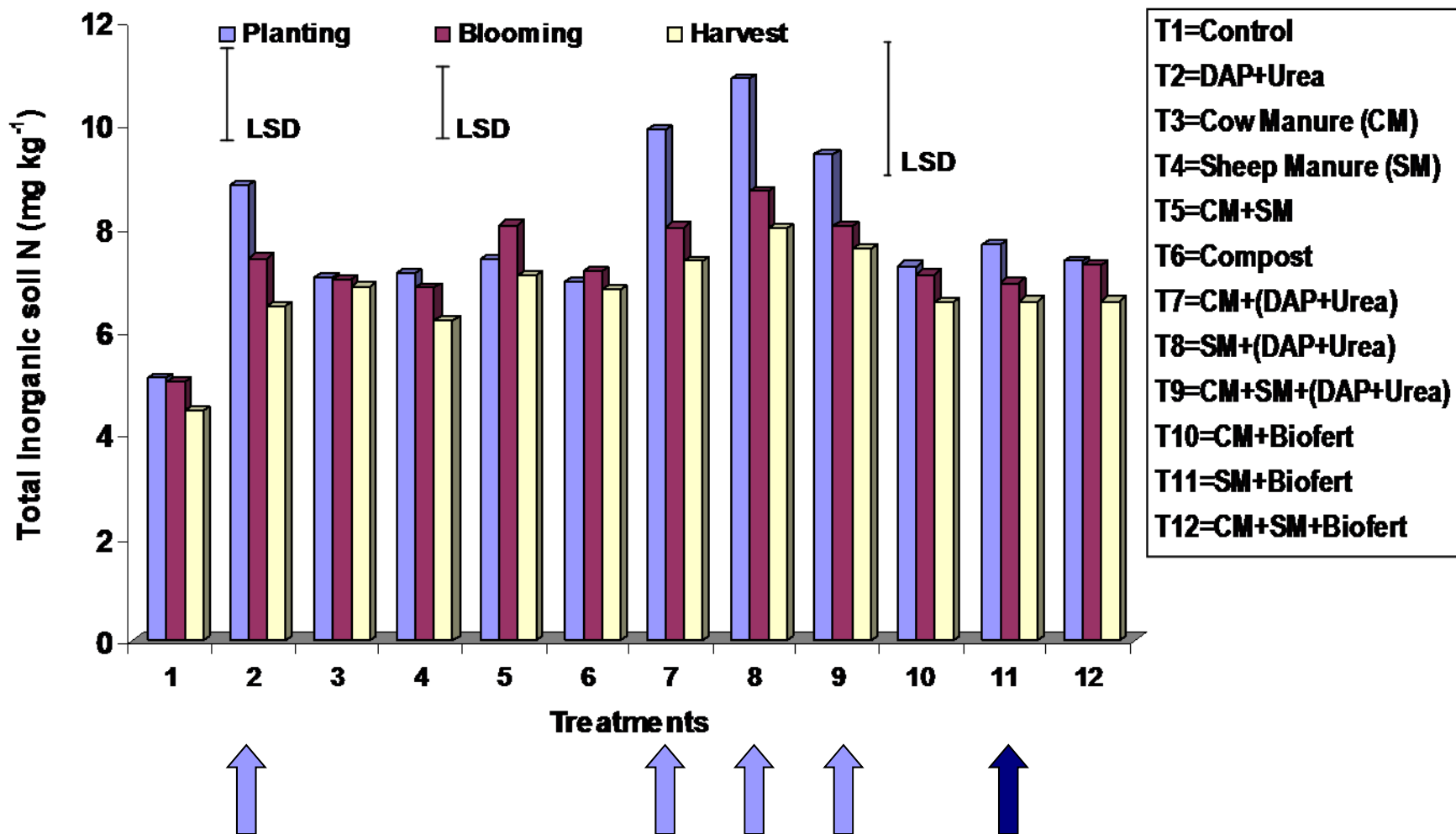


## Total Inorganic Soil N (Potato)

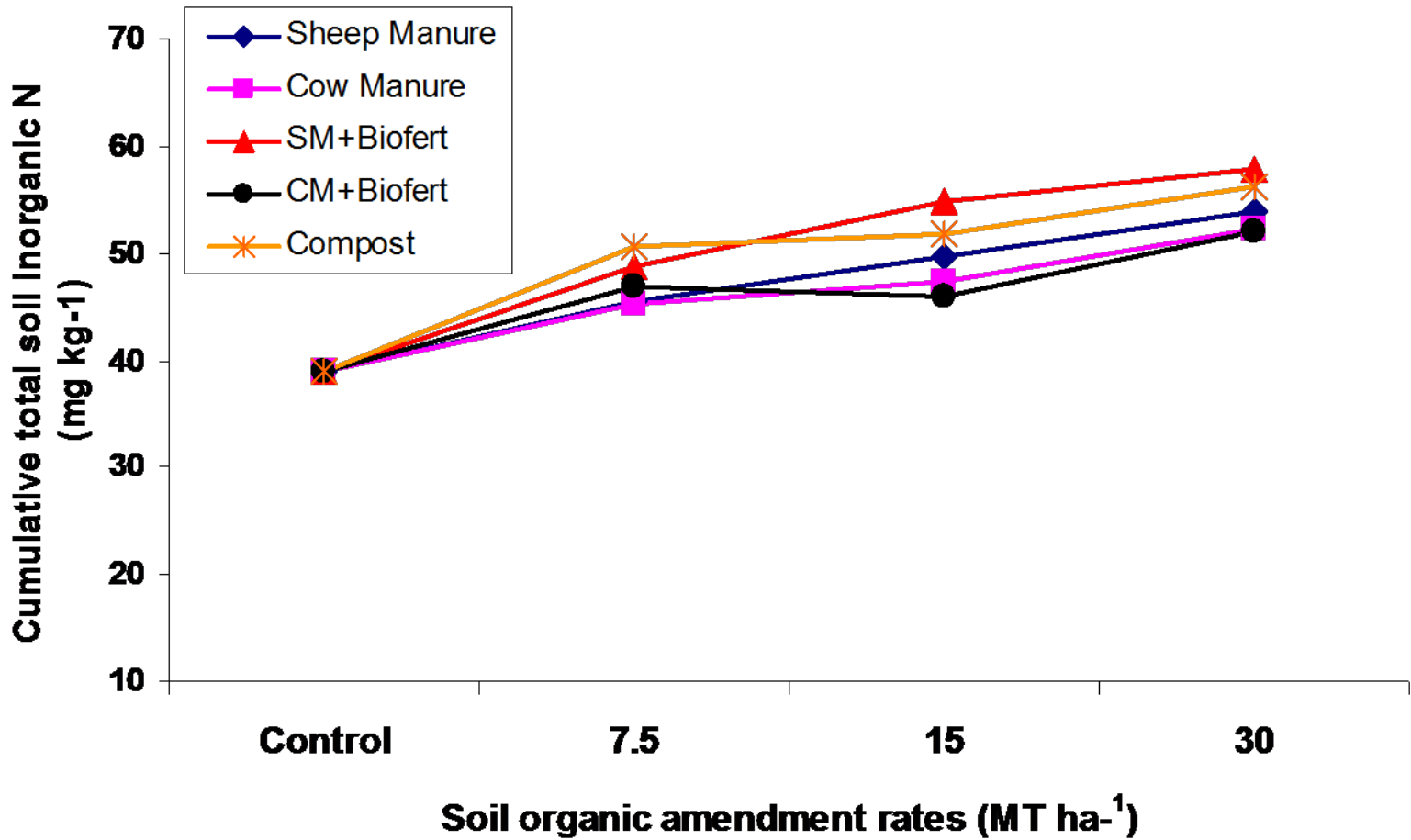




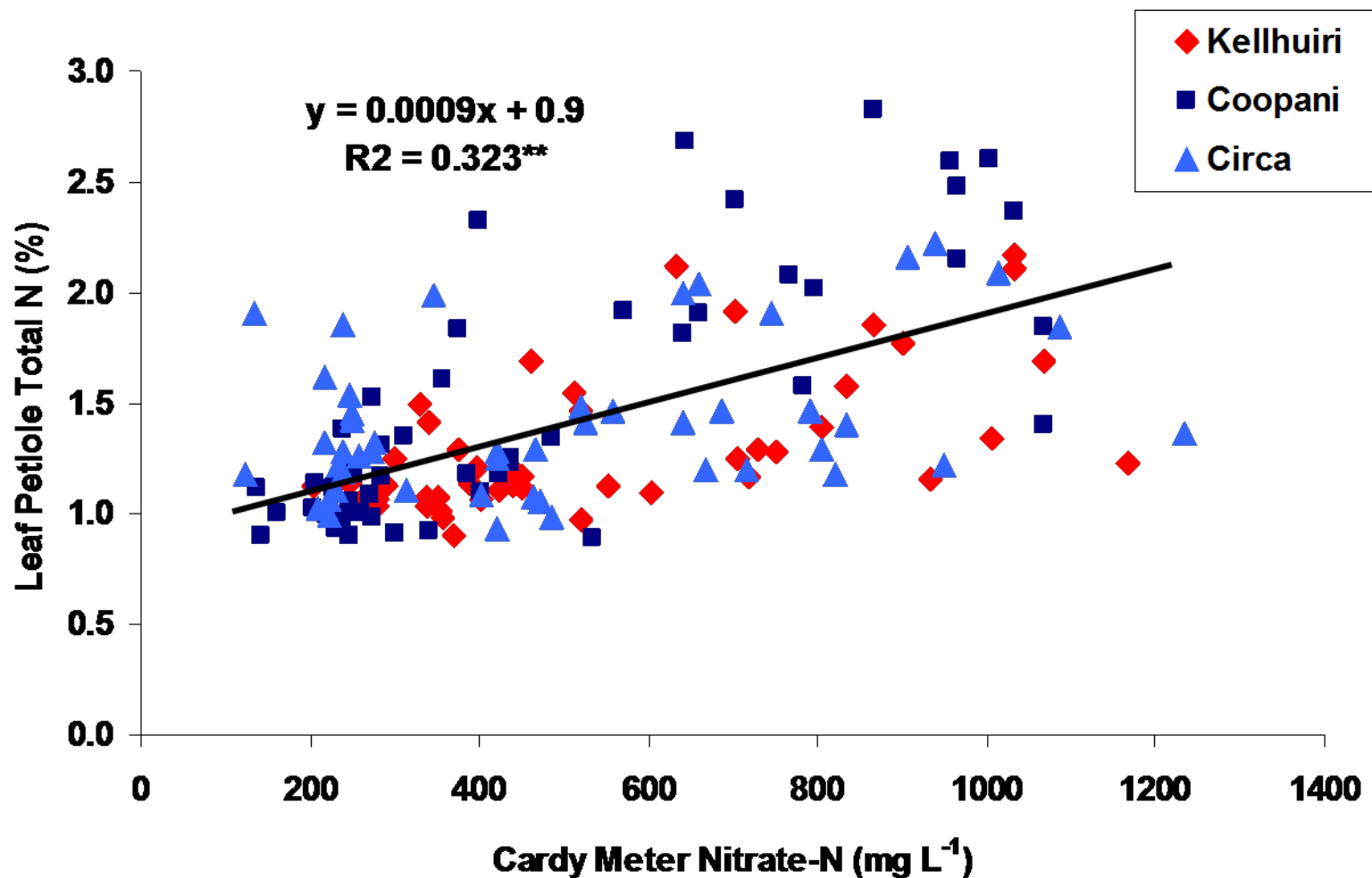
## Residual Inorganic soil N (Quinoa)

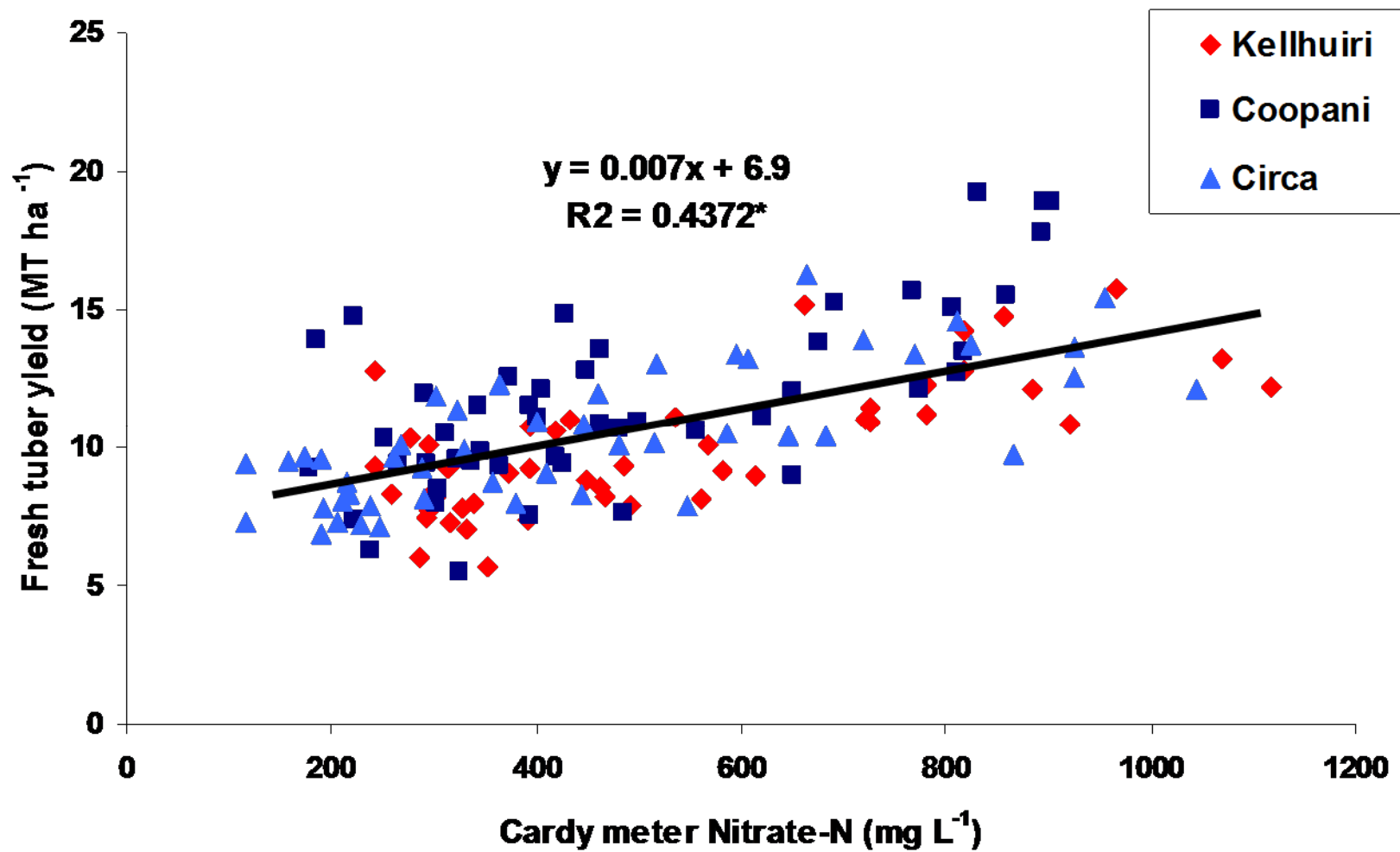


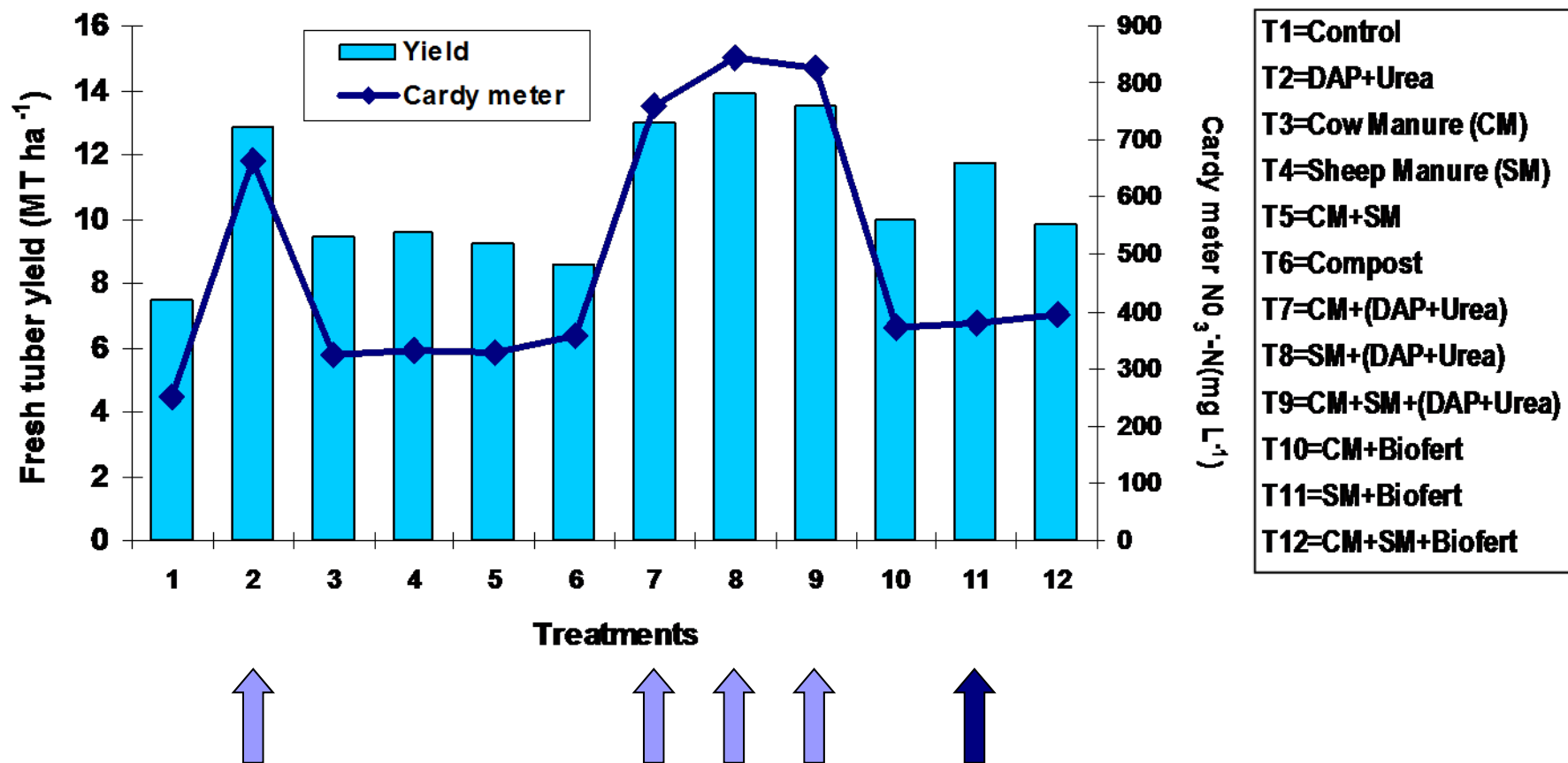
# Aerobic Leaching Incubations



# Cardy Meter Nitrate-N







# PRELIMINARY CONCLUSIONS

- **The longer the fallow the more total inorganic N accumulation**
- **More N accumulation in the relatively higher elevation land areas (animal-based tillage) than in the relatively low elevation land areas (tractor-based tillage)**
- **Residual inorganic N from both inorganic and organic amendments applied to the potato crop improved subsequent crop yield (quinoa)**

# PRELIMINARY CONCLUSIONS

- **Results for compost and Biofert as alternative soil amendments were not consistent. Biofert added to sheep manure may improve initial and residual crop yields.**
- **Cardy meter Nitrate-N may be an important tool to improve N fertility management**



**QUESTIONS?**

