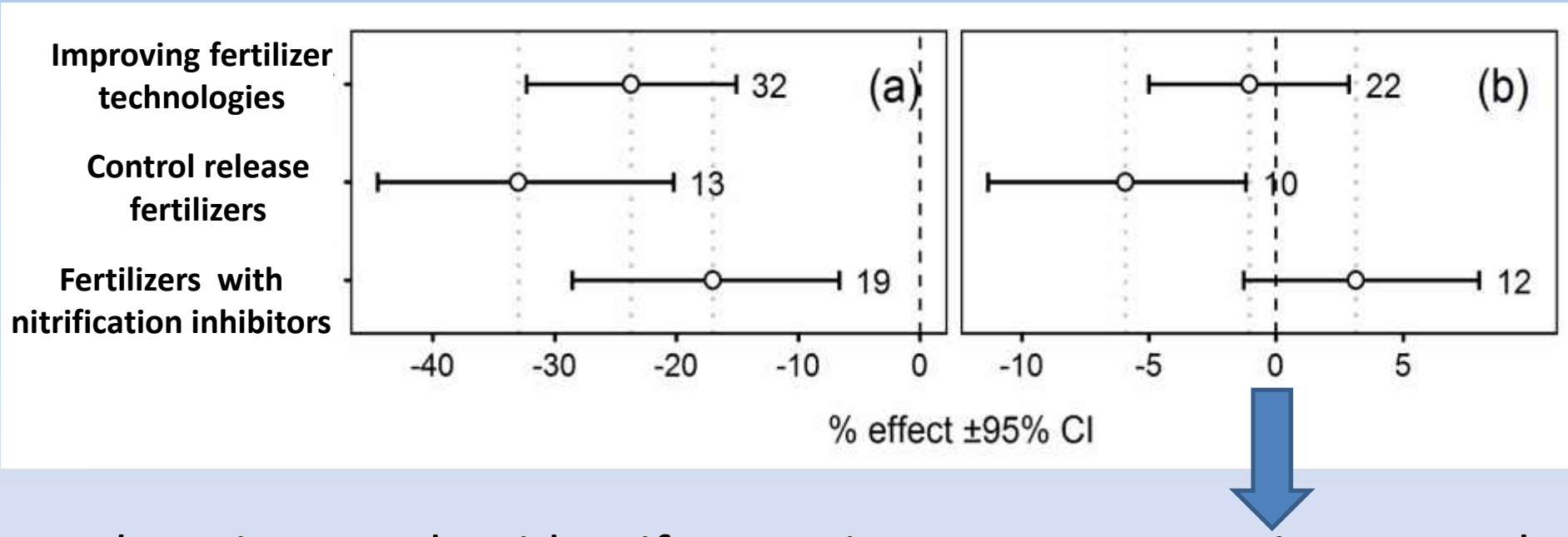
Residual effect of nitrification inhibitors enhances NUE in a cropping system

Miguel Quemada*, Jose Luis Gabriel and María Alonso
Technical University of Madrid

Introduction

The reduction of N losses with NI-fertilizers is widely documented, while the effect on crop yield or N use efficiency (NUE) is still not clear



There is a need to identify cropping systems or environmental conditions in which NI-fertilizers enhance crop yield and NUE

Quemada et al. 2013. Agric. Ecosyst. & Environ. 174: 1-10

Introduction

- Most research focus on the **annual effect** of NI on crop yield
- In a two-year field experiment Sharma and Prasdaq (1996) suggested a possible cumulative effect on wheat yield grown after maize fertilized with DCD
- Increase in soil residual N has been reported in various **laboratory experiments**

Hypothesis: NI could increase the soil N supply capacity over time and contribute to an enhancement of N recovery in the cropping system

Objectives

The objectives were to determine:

1.- The effect of NI-fertilizers applied over maize during two seasons on yield and NUE compared to conventional fertilizers

2.- The soil residual effect of NI-fertilizers, assessed in a non-fertilized sunflower planted during a third season

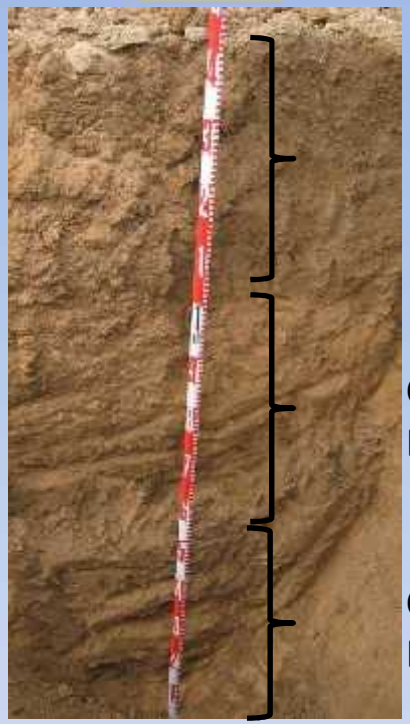
3.- The possible sources of residual N via laboratory determinations

Material and methods

- **Farm "La Chimenea"** **Location: Aranjuez, Taxus river Valley**
- **Climate:** Dry Mediterranean, monoxeric (June-September)
  - Mean temperature: 20.5 ºC, maximum,14 ºC and minimum 6.5 ºC
  - Mean rainfall: 415 mm
  - ETo=750 mm

Material and methods

Soil characteristics



Ocric
Ap: 0-23 cm
A: 23-40 cm

Cambic
B: 40-70 cm

Calcic
Bk: 70-120 cm

Clasification { **Typic calcixerept** (Soil Survey Staff, 2003)
Calcisol háplico (FAO-UNESCO, 1988)

Texture: **Silty clay loam**

Depth (cm)	**0-23**	**23-40**	**40-70**	**70-120**
pH (1:2.5)	8.1	8.1	8.0	7.8
Organic Matter (g kg^{-1})	31	29	21	22
CO_3 (g CO_3^{2-} kg^{-1})	198	201	159	181
Sand (g kg^{-1})	260	250	250	250
Silt (g kg^{-1})	490	510	520	460
Clay (g kg^{-1})	250	240	230	290

Material and methods

Factorial design with two factors (fertilizer type and rate) and two levels

5 Treatments x 3 Replications Plot size = 12 m x 6 m

Treatments:

- Ammonium sulphate nitrate (ASN) at the recommended rate: 170 kg N ha^{-1} — ASN-170
- Ammonium sulphate nitrate (ASN) at a reduced rate rate: 130 kg N ha^{-1} — ASN-130
- ASN + DMPP (ENTEC®) at the recommended rate: 170 kg N ha^{-1} — ENTEC-170
- ASN + DMPP (ENTEC®) at the reduced rate: 130 kg N ha^{-1} — ENTEC-130
- Control: 0 kg N/ha — CONTROL

Material and methods

	MAIZE 2013	MAIZE 2014	SUNFLOWER 2015
Sowing	18 April	7 April	30 April
Fertilizer application	25 May	26 May	----------
Harvest	7 October	25 September	1 September

Material and methods

Water balance (≈ 1.1 x Crop needs FAO)

Crop analysis

- Yield, Biomass
- N concentration
- N content

*In maize, determined at harvest
*In sunflower, at full flowering stage

Soil inorganic N content

Until 1 m depth, 0.2 m depth intervals, at crop sowing and harvest
Soil extraction with 1 M KCL and determination of NH_4^+ and NO_3^-

Residual effect of the NI fertilizers (lab. determinations):

- N mineralization potential
  - aerobic incubation (10 weeks)
  - 1 year after fertilizer application
  - Top soil samples (0-20 cm)
- Non-exchangeable NH_4^+
  - ^{15}N determination and total N
  - 1 year after fertilizer application
  - 0-20; 20-40; 40-60 cm soil

N use efficiency components

Material and methods

Nitrogen use efficiency components

Agronomic efficiency (AE_N)

$$\frac{\text{Grain yield}_{\text{treatment}} - \text{Grain yield}_{\text{control}}}{\text{N fertilizer applied}}$$

Maize

2013

2014

Nitrogen recovery efficiency (RE_N)

$$\frac{\text{N content}_{\text{treatment}} - \text{N content}_{\text{control}}}{\text{N fertilizer applied}}$$

Maize and sunflower

2013 2015

2014

+

Total RE_N

$$\frac{\sum_{2013}^{2015} \text{Ncontent}_{\text{treatment}} - \sum_{2013}^{2015} \text{Ncontent}_{\text{control}}}{\sum_{2013}^{2015} \text{N fertilizer applied}}$$

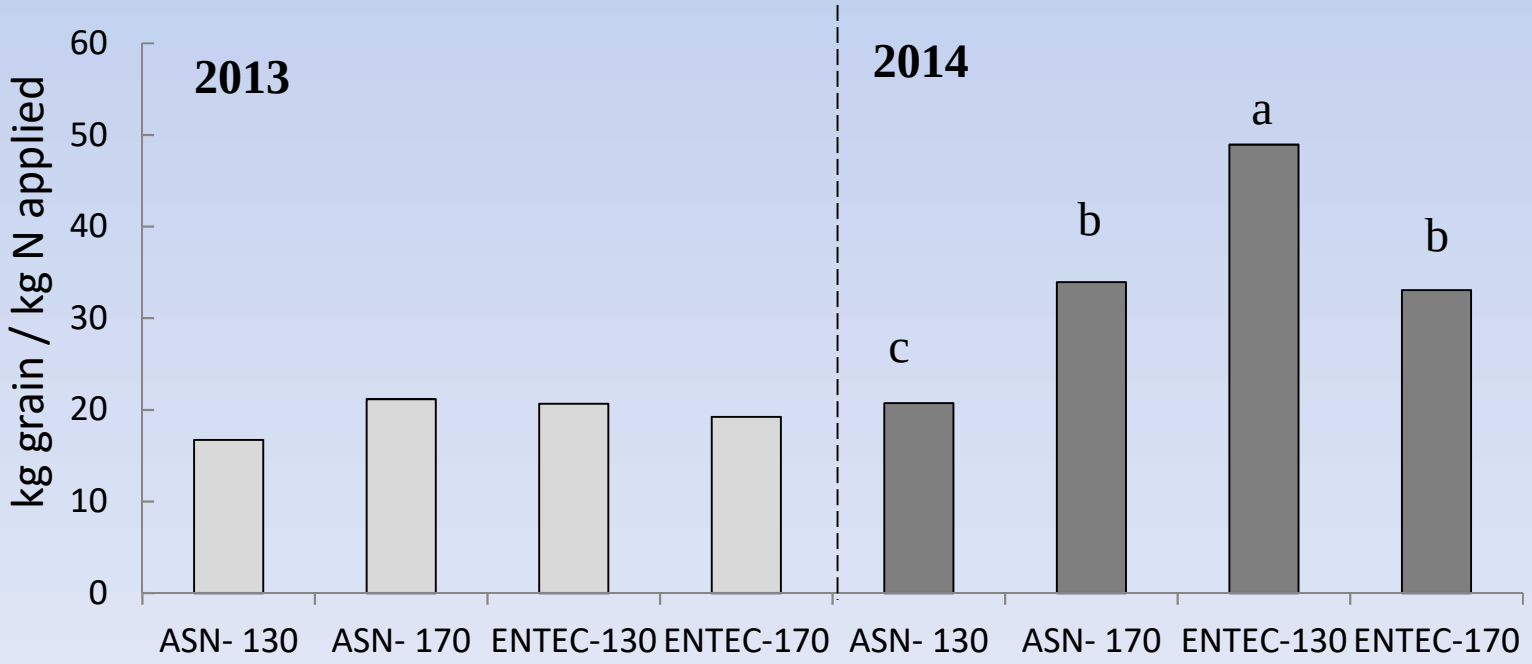
Results: Maize

Treatment	Yield	%N grain	Grain N content	Crop N content
	Mg ha^{-1}	%	kg N ha^{-1}	
			2013	
Control	6.4 b	1.16 b	74.6 b	107.9 b
ASN- 130	8.6 ab	1.34 a	115.8 a	168.2 a
ASN- 170	10.0 a	1.34 a	134.4 a	212.3 a
ENTEC-130	9.1 ab	1.37 a	125.3 a	191.6 a
ENTEC-170	9.7 ab	1.34 a	129.4 a	190.4 a
			2014	
Control	5.0 c	1.14 b	55.8 b	69.1 c
ASN- 130	7.6 b	1.12 b	85.9 b	114.1 bc
ASN- 170	10.7 a	1.15 b	123.4 a	162.8 ab
ENTEC-130	11.3 a	1.33 ab	150.7 a	186.4 a
ENTEC-170	10.6 a	1.46 a	154.8 a	196.2 a

Differences were observed at the second year of fertilizer application

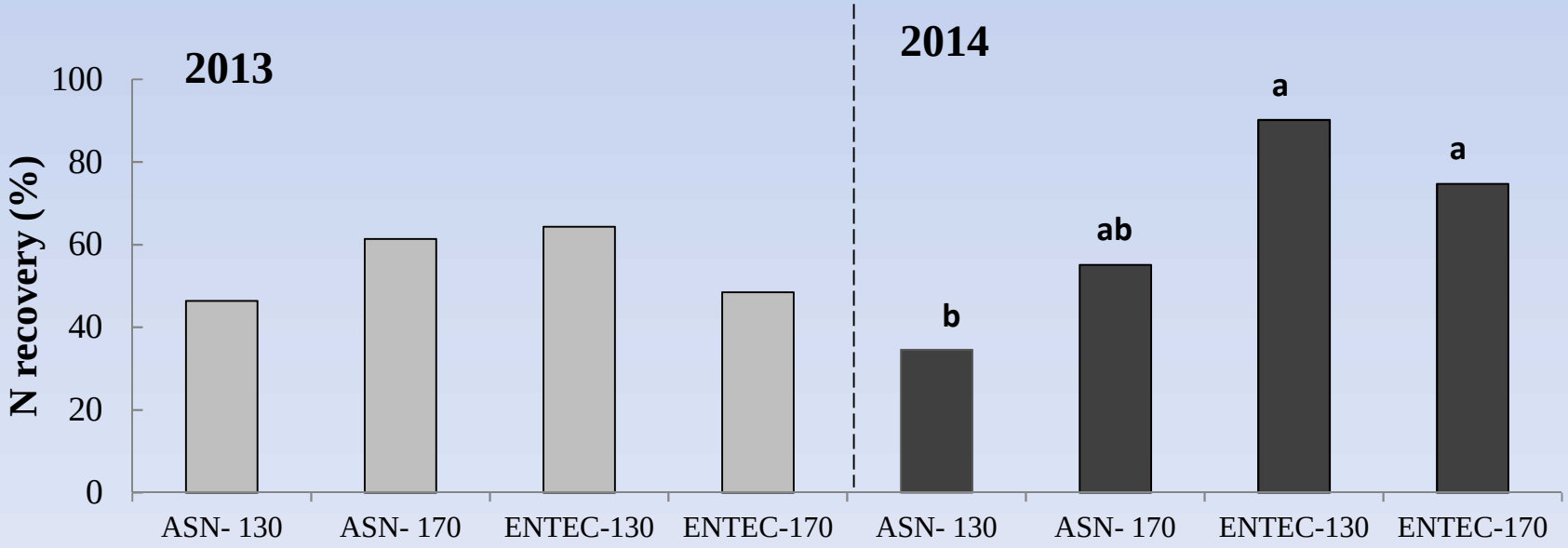
Results: Agronomic efficiency

	Agronomic efficiency	N recovery efficiency
	2013	
Type	ns	ns
Rate	ns	ns
Type x Rate	ns	ns
	2014	
Type	*	*
Rate	ns	ns
Type x Rate	*	ns

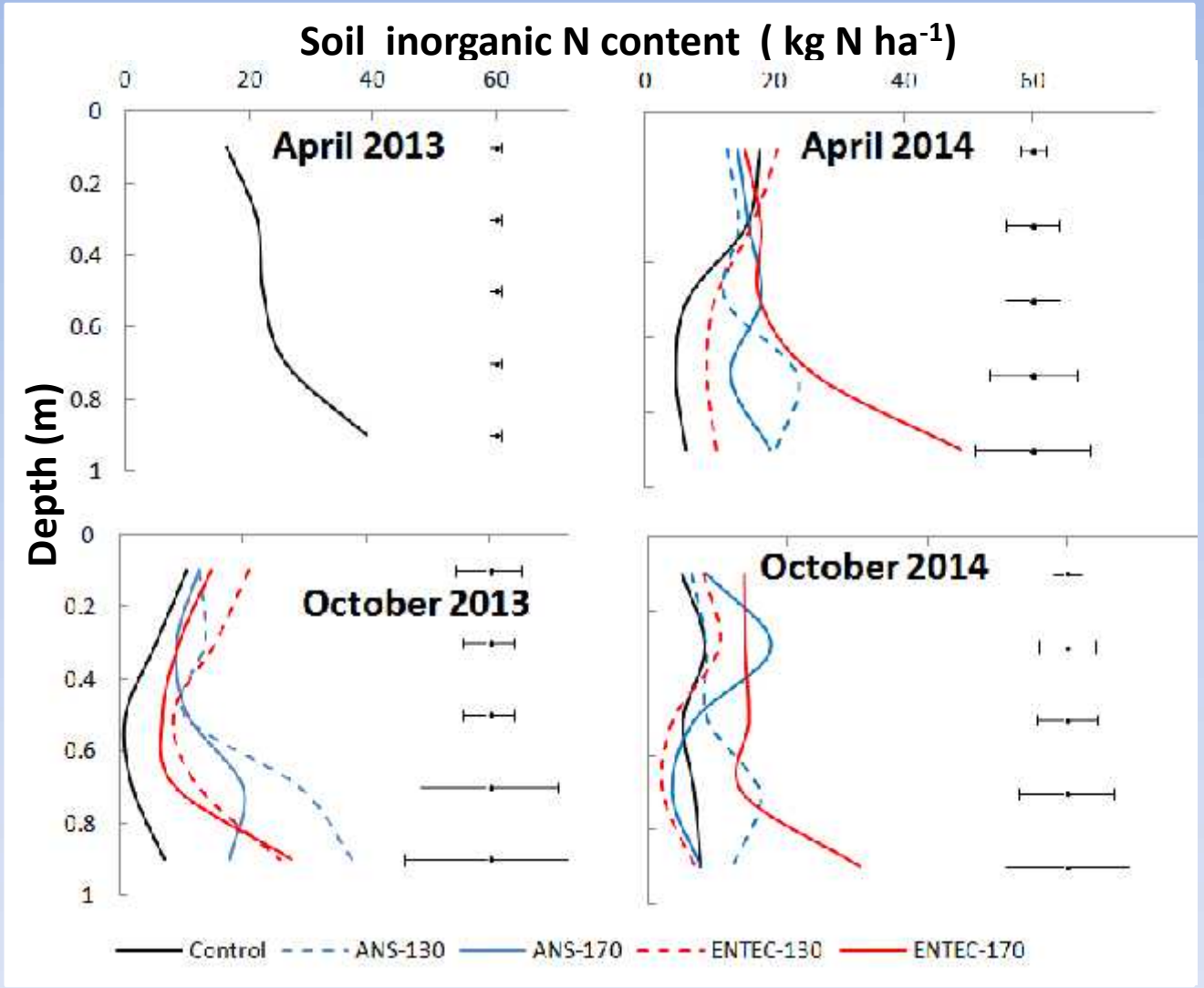


Results: N recovery efficiency

	Agronomic efficiency	N recovery efficiency
	2013	
Type	ns	ns
Rate	ns	ns
Type x Rate	ns	ns
	2014	
Type	*	*
Rate	ns	ns
Type x Rate	*	ns



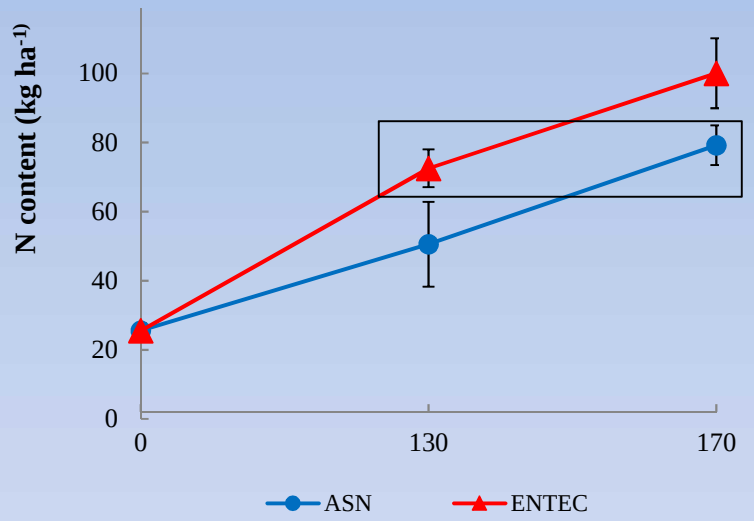
Results: Soil inorganic N content



Results: Sunflower

NON-FERTILIZED SUNFLOWER - 2015

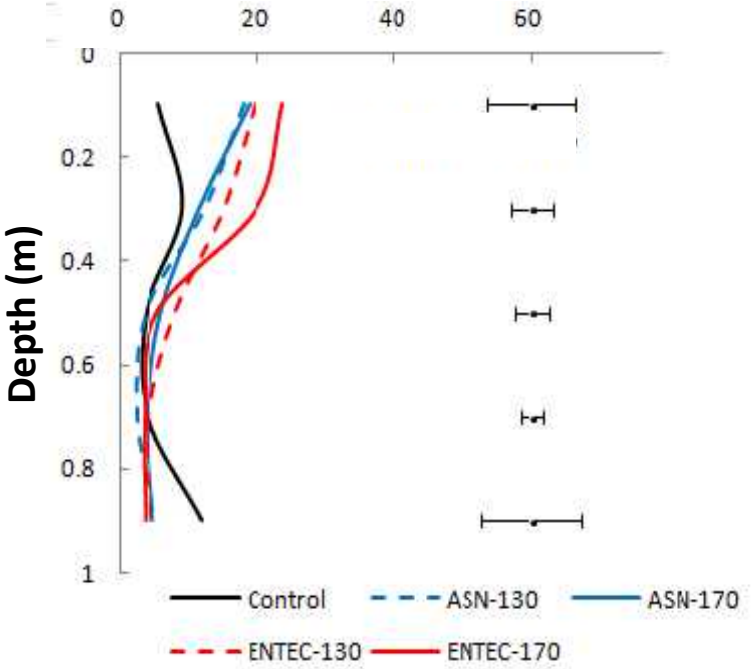
Sunflower N content



Treatment	N content
	kg N ha^{-1}
Control	25.6 d
ASN- 130	50.5 c
ASN- 170	79.2 b
ENTEC-130	72.5 b
ENTEC-170	100.0 a

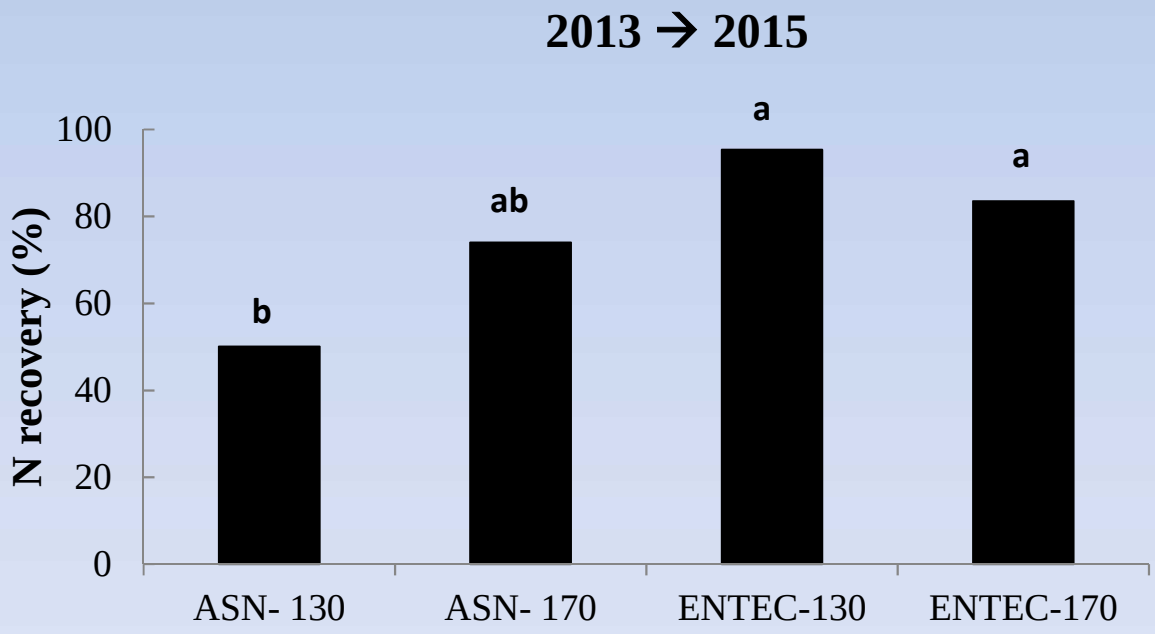
October 2015

Soil inorganic N content (kg N ha^{-1})



Results: N recovery efficiency

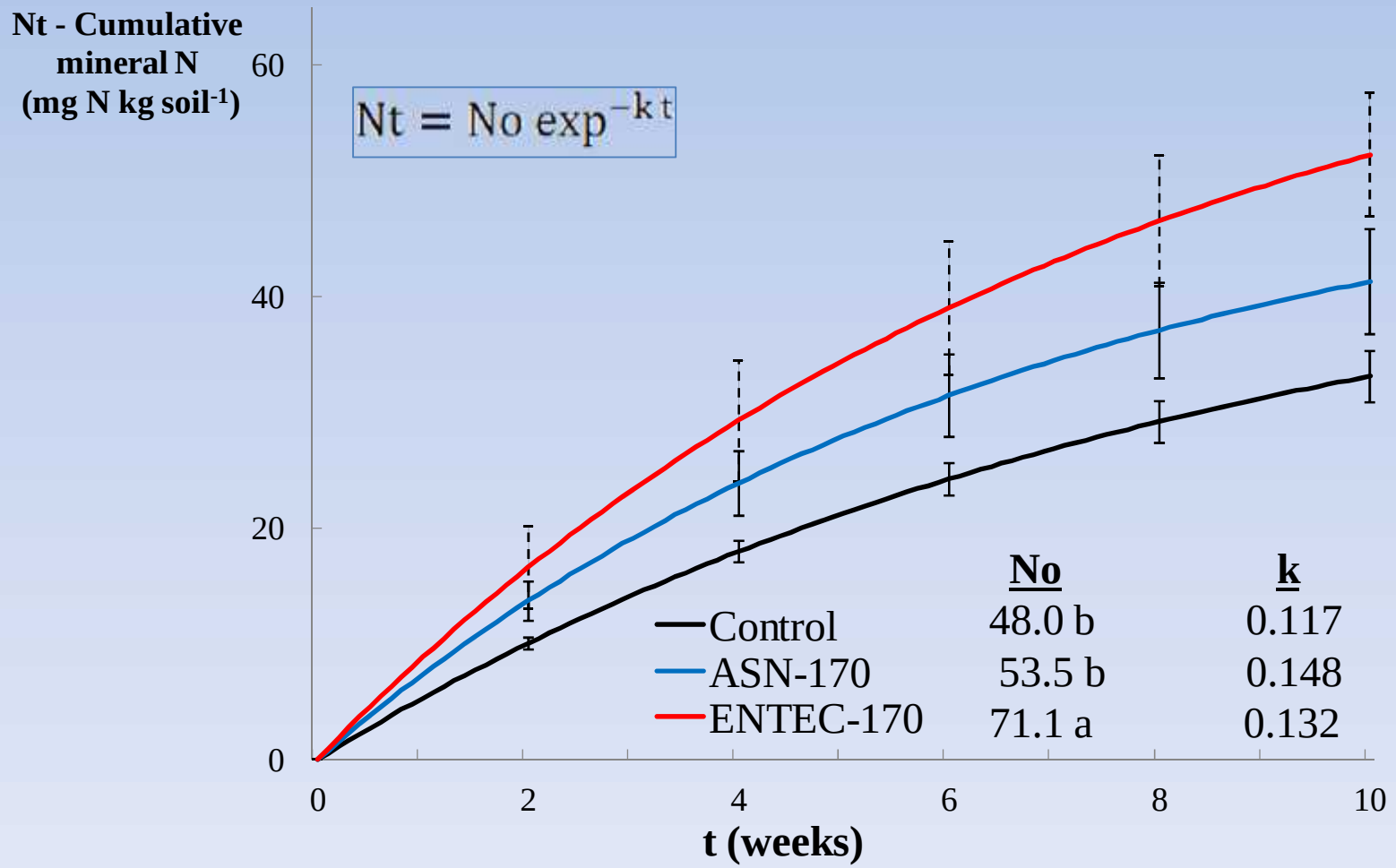
	N recovery efficiency
	2013 →2015
Type	*
Rate	ns
Type x Rate	ns



What are the sources of the residual N effect?

Soil N in microbial biomass increases?

Potential mineralizable N in aerobic incubation (0-20 cm)

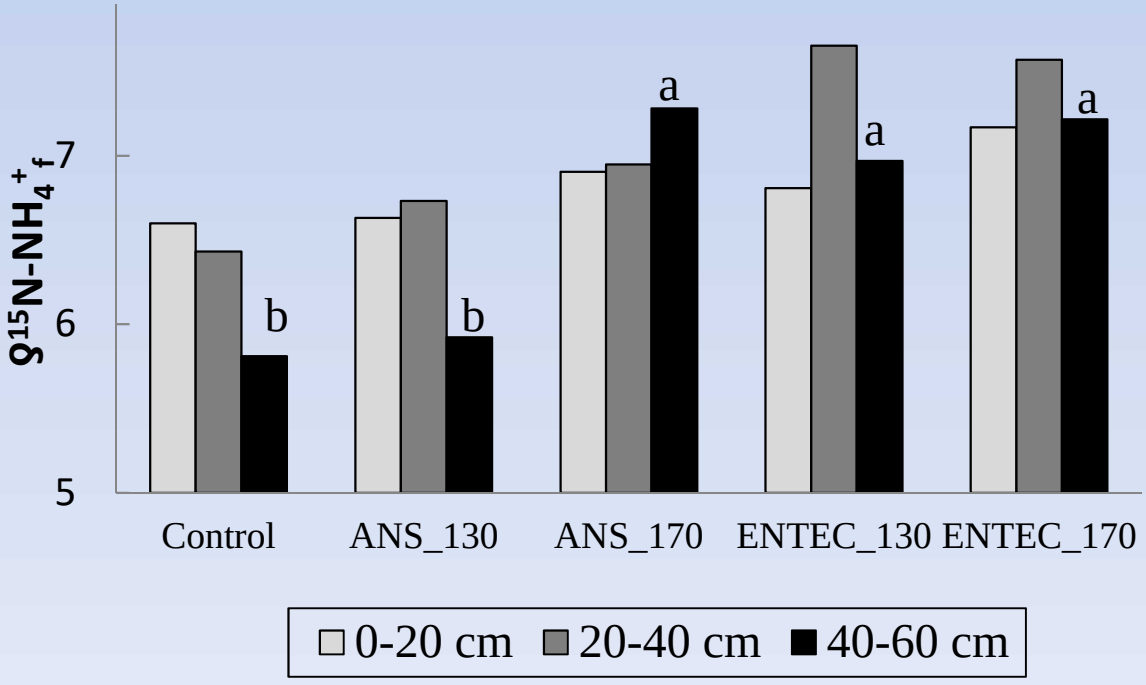


Soil ammonium fixed increases?

Soil texture	Non-exchangeable NH_4^+ (mg kg $^{-1}$)
Coarse-textured soils	10-90
Medium-textured soils	**60-270**
Fine-textured soils	90-460

Avg. ~120 mg kg^{-1}

(Nieder et al., 2011. *Biology and Fertility of Soils* **47**, 1-14)



Does active DMPP remain in the soil 1 year after application?

Conclusions

• ENTEC® (ASN blended with DMPP nitrification inhibitor **) increased the N use efficiency** in a three year rotation with respect to conventional ASN

• In the following year after application, the ENTEC® fertilizer rate was reduced 23% from the recommended rate in the region without decreasing maize yield

• The non-fertilized sunflower planted after the maize was able to scavenge more N in treatments previously treated with ENTEC®

• The **residual effect** of ENTEC® treatments was explained by an increase in non-ready soil N available forms during at least one year, that were subsequently released to meet crop demand. These forms were soil N microbial biomass and non-exchangeable NH_4^+ pools.

• **Multi-year studies** of the residual effect of fertilizers with NI in different soils and cropping systems may contribute to the best practice of this fertilizer technology

Alonso-Ayuso et al. 2016. European Journal of Agronomy, 80:1-8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