Эффективность разных фосфорных удобрений на продуктивность и качество зерна риса и твердой пшеницы

Результаты 3х летнего опыта 2016-2018 гг.

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Introduction

- Heavy metal contamination is increasingly catalysing the attention of food industry and consumers
- In case soils are not contaminated, the solution is simple:
  - ✓ Try to avoid distributing heavy metals with fertilizers and other agro-chemicals
- In case of soil (even partially) contaminated, it is necessary to try to minimize uptake and translocation to grains
  - ✓ Mid-term: development of specific varieties
  - ✓ Today (and mid-term): pay attention to agronomic practices
    - Irrigation
    - Fertilization

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- Results for durum wheat campaigns (2016/17 and 2017/18)
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Objectives

- Evaluating the impact of different phosphate fertilizers on:
  - ✓ Productivity
  - ✓ Quality (heavy metals content in grain)
  - ✓ Heavy metals content in soil
- Treatments:
  - ✓ A: control
  - ✓ B: standard farm fertilization
  - ✓ C: like B but with phosphate fertilizers with low (or not quantifiable) content of heavy metals
  - ✓ D: like C but with phosphate fertilizers enriched with sulfur (6%) and zinc (0.4%)

Element	Phosphate fertilizers			
	DAP site 1	DAP site 2	DAP PhosAgro	NP+S+Zn PhosAgro
As (ppm)	3.32	21.94	2.75	1.69
Cd (ppm)	27.17	21.48	nq	nq
Pb (ppm)	1.49	1.68	1.40	1.55
Zn (ppm)	204.40	370.3	19.42	4256.95
Se (ppm)	nq	nq	nq	nq
K (ppm)	0.981×10^3	0.944×10^3	1.064×10^3	1.807×10^3
P (ppm)	216.48×10^3	225.43×10^3	203.73×10^3	151.17×10^3
Mg (ppm)	7.90×10^3	10.49×10^3	0.87×10^3	8.87×10^3
Cd/P_2O_5 (ppm)	54.81	41.60	nq	nq

nq: not quantifiable (<1 ppm)

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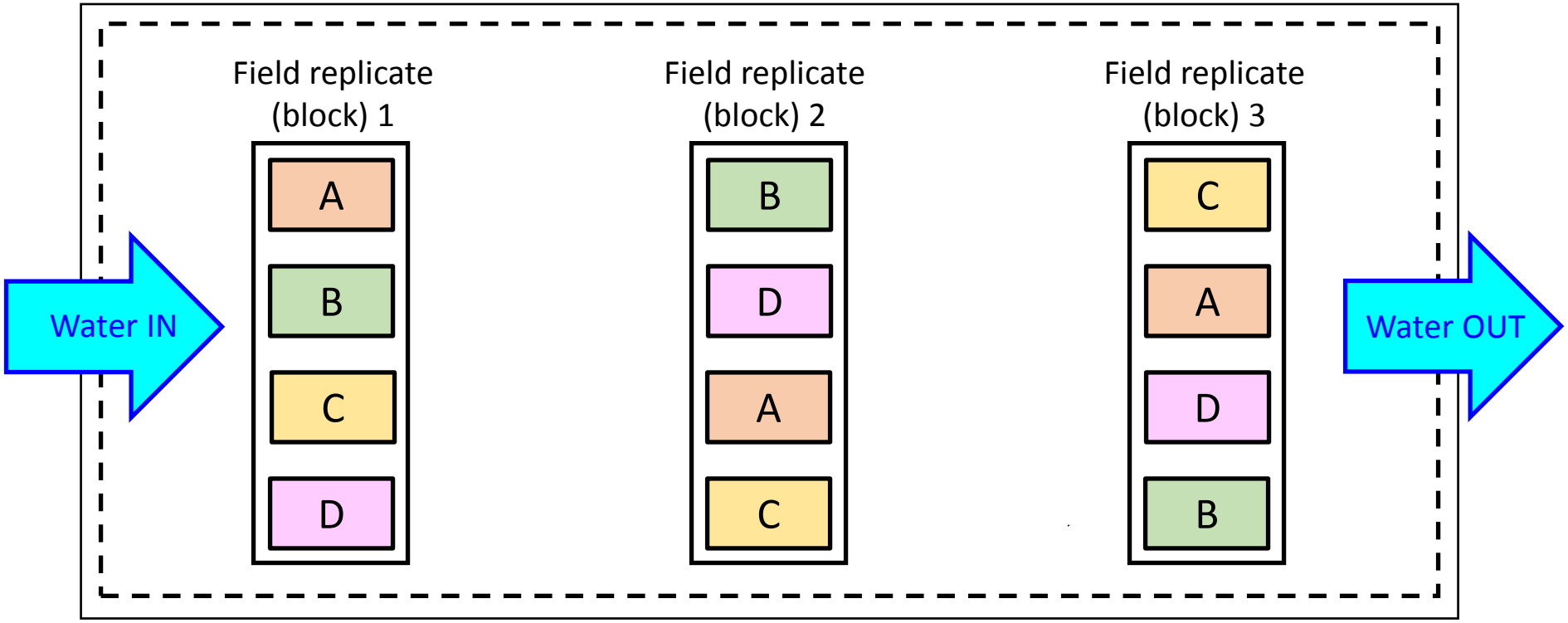
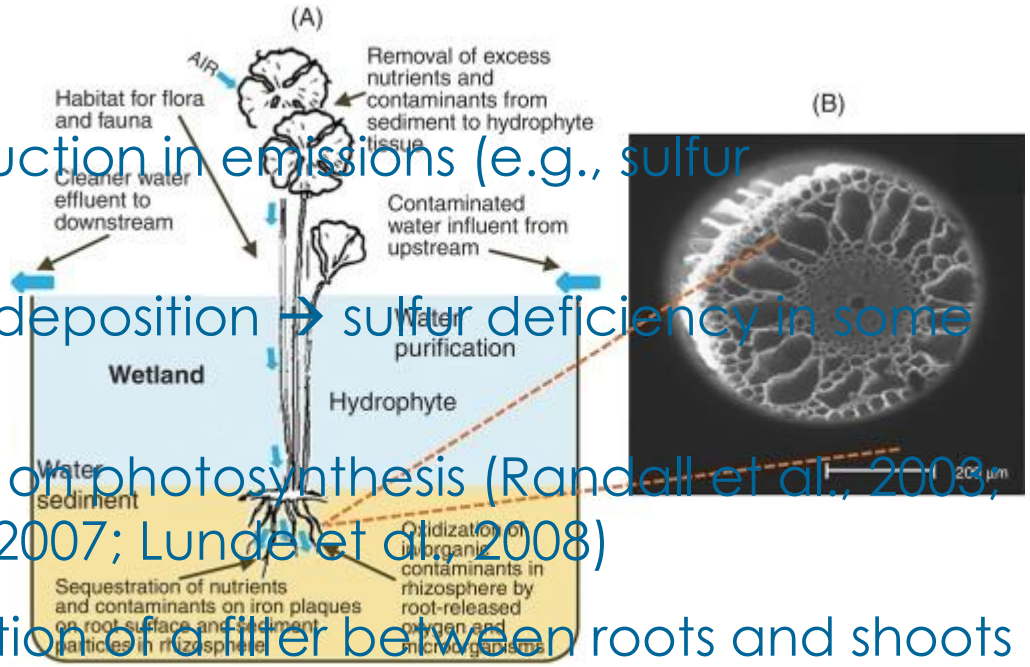
Experimental design



- Experiment replicated (for each crop):
  - ✓ In two farms
  - ✓ For three years

Experimental design

- Why sulfur?
  - ✓ Policy targeting a reduction in emissions (e.g., sulfur hexafluoride)
    - Decrease in sulfur deposition → sulfur deficiency in some areas
  - ✓ It has a positive effect on photosynthesis (Randall et al., 2003; Srivastava and Singh, 2007; Lunde et al., 2008)
  - ✓ It supports the generation of a filter between roots and shoots that limit heavy metals translocation
  - ✓ In case of rice (low oxygen in soil) it creates a barrier (iron plaque) that limits metals uptake (especially arsenic)
- Why zinc?
  - ✓ Competition with cadmium (same channels to enter in roots)



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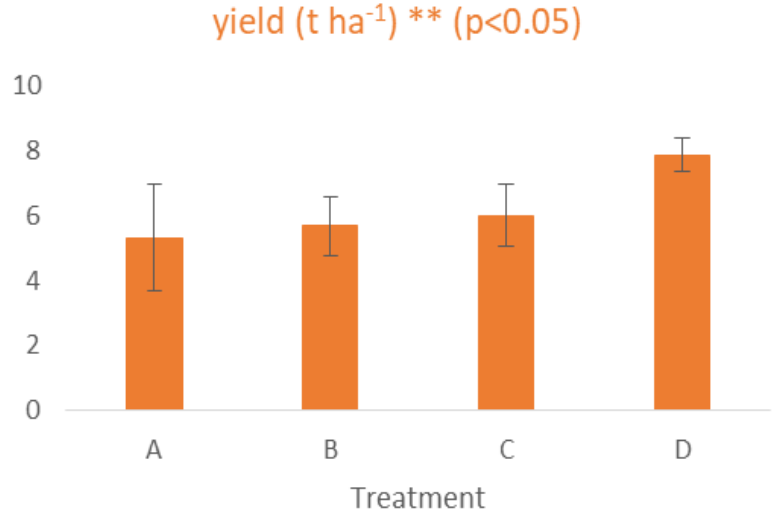
Rice - productivity

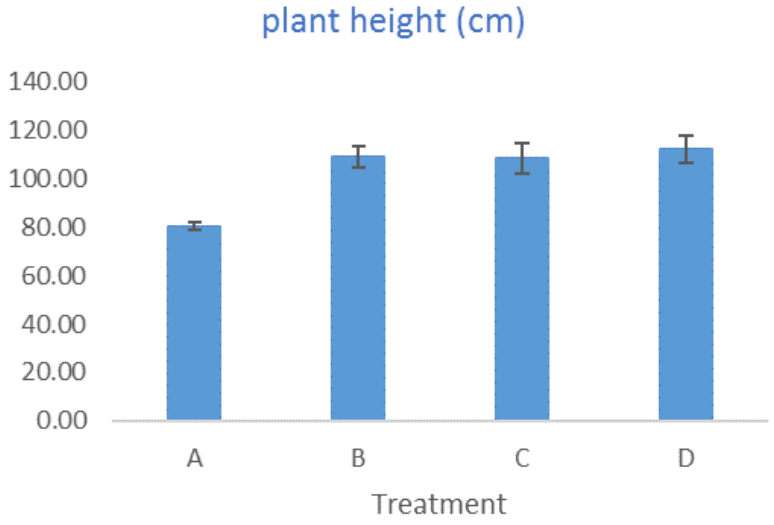
- **Treatment D** (+ sulfur and zinc) obtained **higher yields** in 3 cases (site × year combinations) out of 6 (differences significant in one case)
- In all cases because of a **higher number of panicles per plant**
- In 5 cases no increase in plant height

→ **No** increase in **susceptibility to lodging**

2018 – site 1

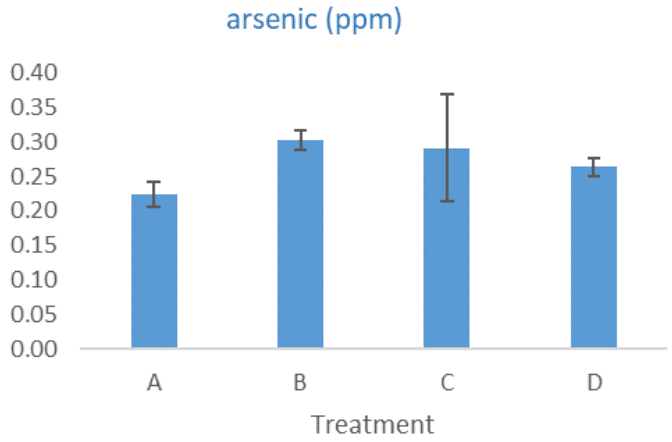


2017 – site 2



Rice - quality

- In 3 cases out of 6 **lower arsenic** concentrations were achieved for treatment D
- In 2 cases out of 6 for **cadmium**
- In 4 cases out of 6 for **lead**
- Differences not always significant because of variability among replicates



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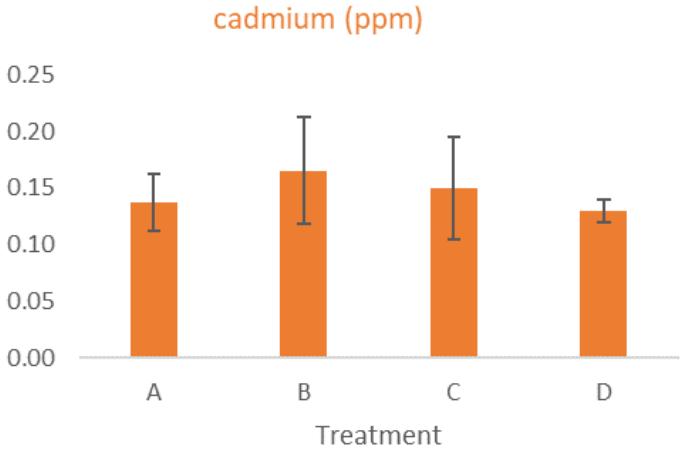
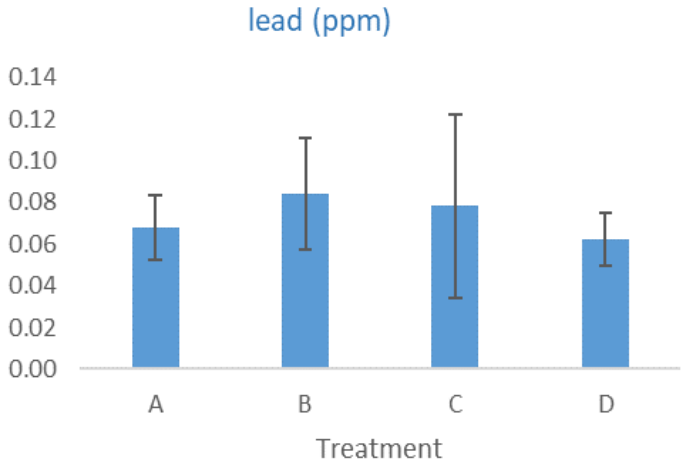
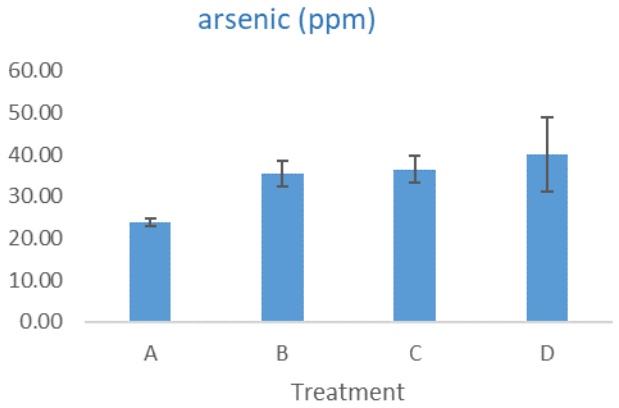


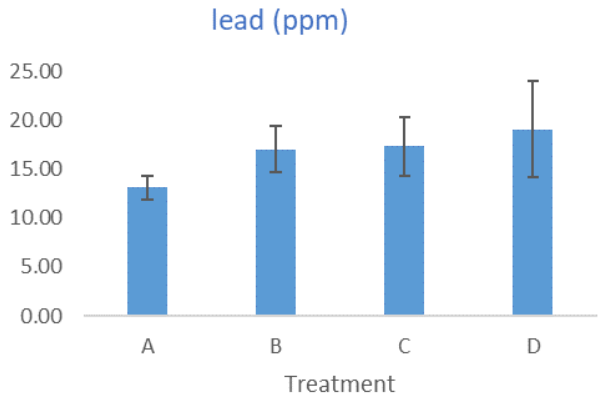


Rice - quality

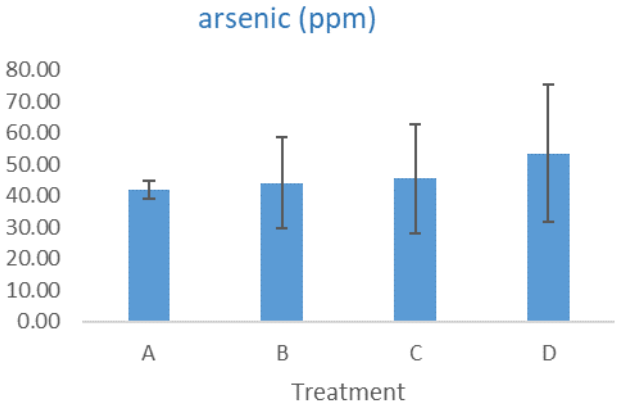
- Effect of sulfur (iron placque + root/shoot filter):
  - ✓ Low content in shoots
  - ✓ High content in **roots**

2017 – site 1





2017 – site 2



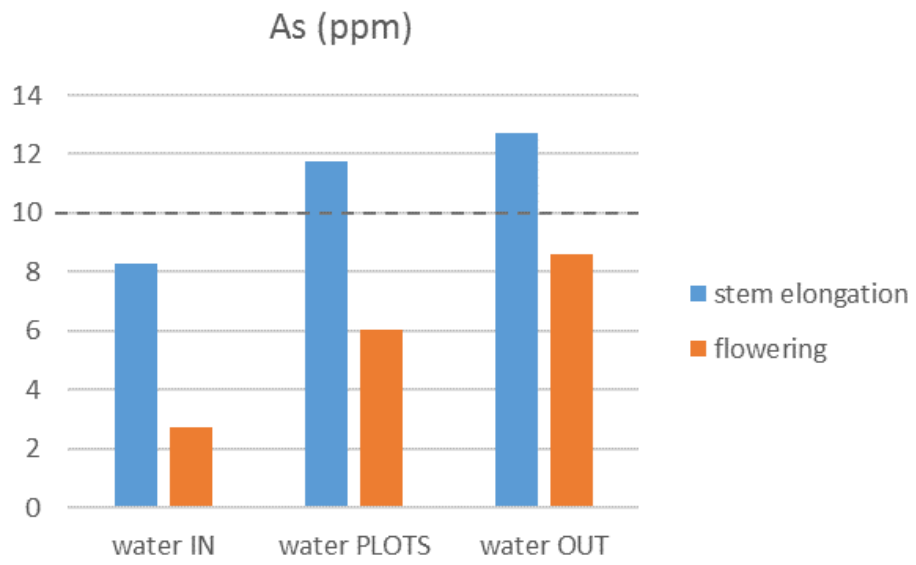
Rice - soil

- Concentrations "not negligible" in soils at the beginning of the experiments
- Treatment D → heavy metals not translocated to grains remain in soil (roots)

- The effect of different fertilizers did not generate relevant dynamics in soils

Rice - water

- Irrigation water was sampled different times during the season
  - ✓ at the entrance of the fields
  - ✓ in the experimental plots
  - ✓ at the exit of the fields
- Water was **usually very clean**
- In rare cases high values of arsenic were measured



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  - ✓ Productivity
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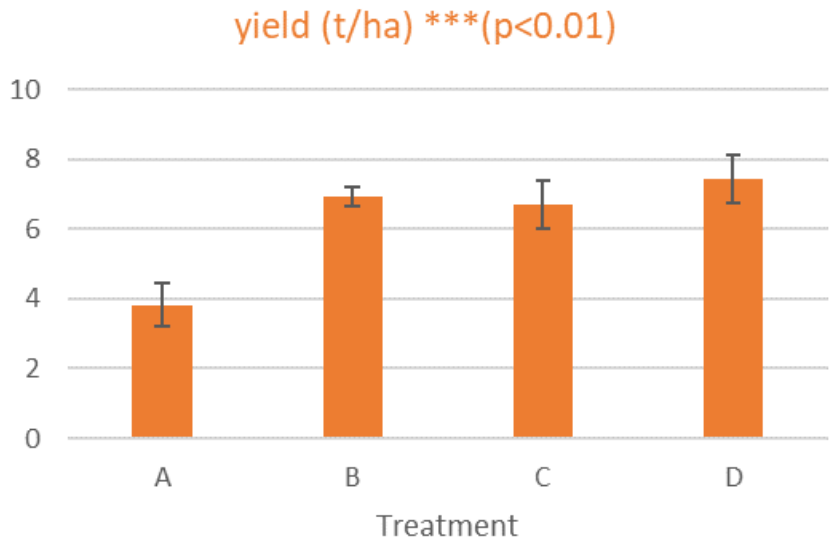
- Conclusions

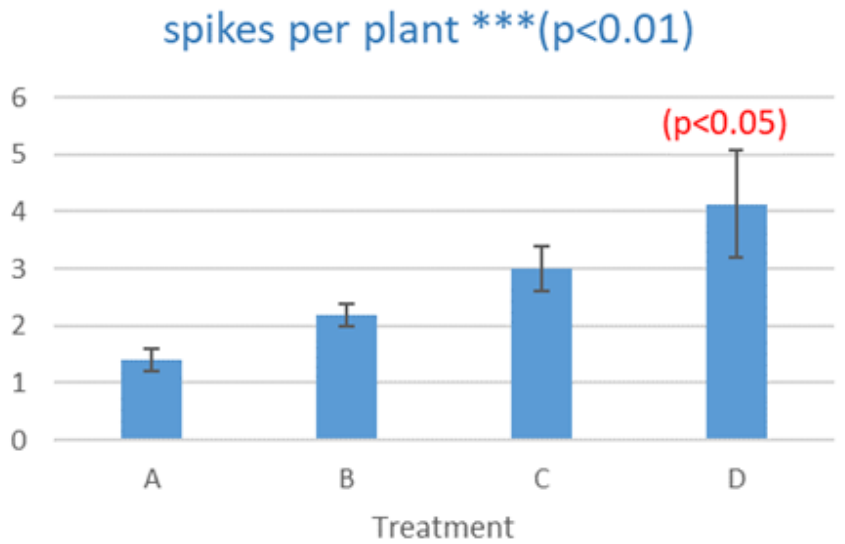
Durum wheat - productivity

- **Treatment D** (+ sulfur and zinc) obtained **highest yields** in 3 cases (site × year combinations) out of 4 (statistically significant)
- This is due to a **higher number of spikes per plant** (3 cases out of 4) **and bigger spikes** (2 cases out of 4)
- In 3 cases no increase in plant height
  - ✓ **No** increase in **susceptibility to lodging**

2017 – site 1



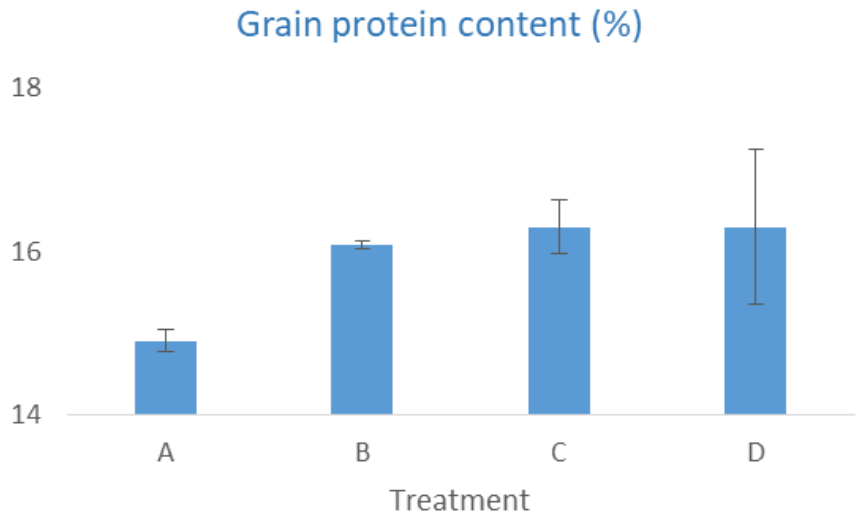
2018 – site 2



Durum wheat - productivity

- **Grain protein content** for treatment **C higher than for B** in 3 out of 4 cases
- Also **higher for D than for B** in 3 out of 4 cases
- **No** relevant **differences between** values for **C and D**

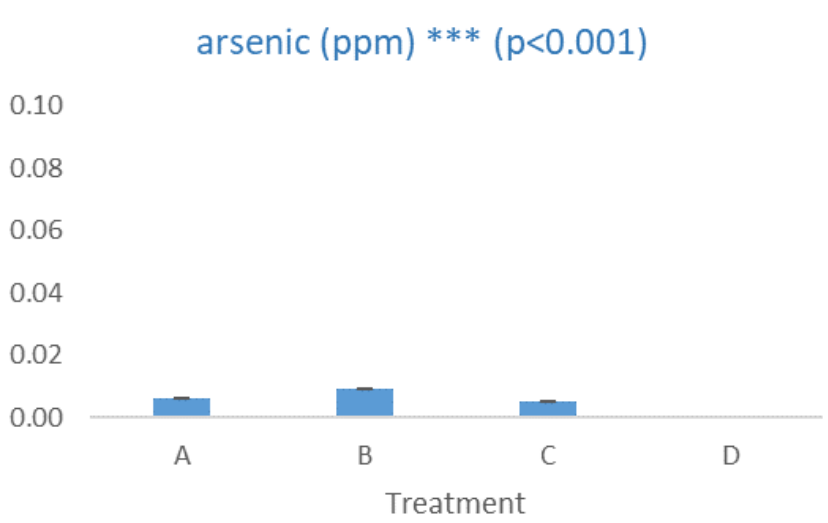
2016/17 – site 1



Durum wheat - quality

- **Arsenic** concentration **lower in treatments C and D** (highest in B) in 3 cases out of 4
- **Cadmium** concentration **always lower** in treatments **C** and **D** (highest in B) and also **lower** in **D** compared to C in 3 cases out of 4 (**sulfur effect** on HM **translocation**)
- **Lead** concentration **lower in treatment C and D** (highest in B) in 3 cases out of 4

2018 – site 2



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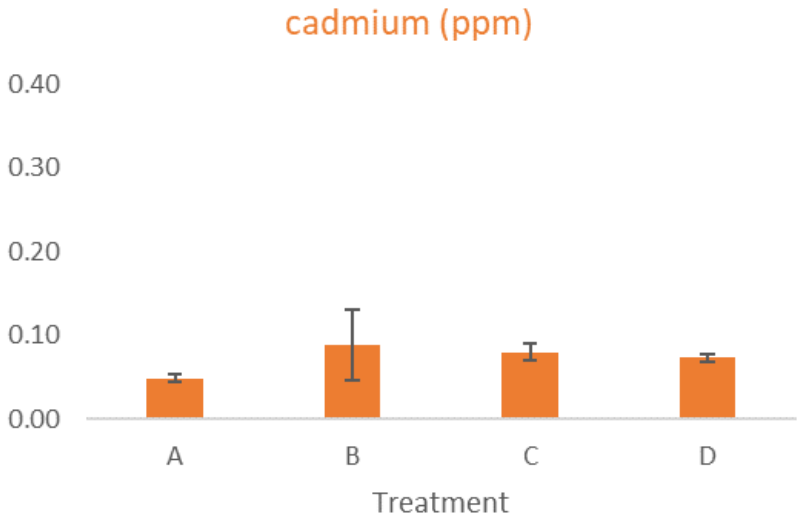
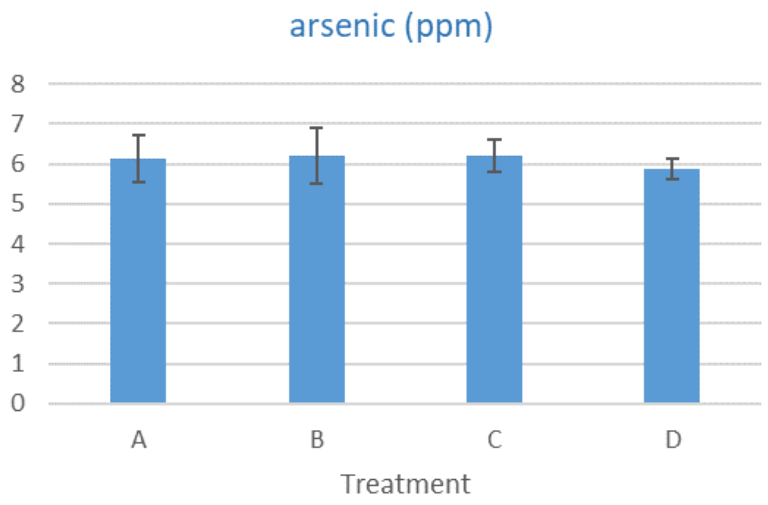


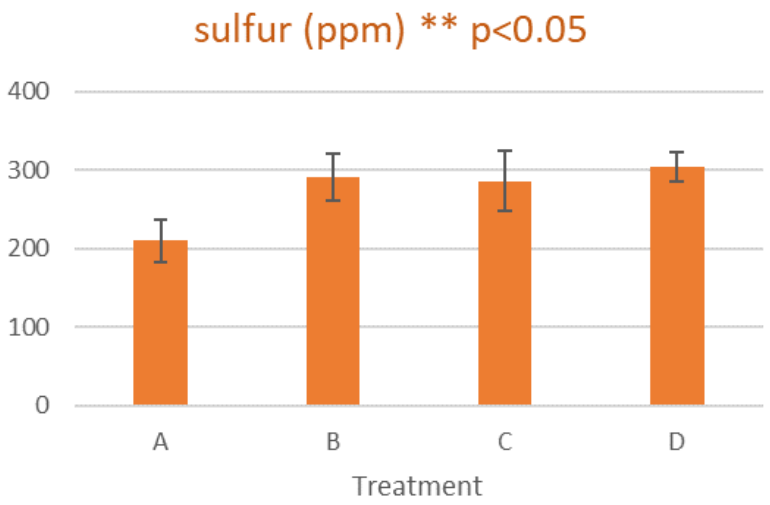
Durum wheat - soil

- **Post-harvest arsenic** concentration was **always lower in treat. D**
  - Lower concentration of arsenic in PhosAgro NP+S+Zn
- **Significant differences** detected **in 2018** for some elements
  - E.g., sulfur higher in treat. D (enriched with S)

2017 – site 1



2018 – site 2



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  - ✓ Heavy metal concentrations in soils
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Conclusions - RICE

- Treatment C ("clean" fertilizers) did not generate differences in terms of grain heavy metal content because of the concentration in soils
- Sulfur and zinc (treatment D) had positive effects on heavy metal contents in grain in 1 case in 2016 (lead in site 2), in all cases (arsenic, cadmium and lead) in 2017, and in 2 cases in 2018 (arsenic and lead in site 2)
  - ✓ Differences were not huge. However, in case of contaminated soils (like those of our experiments), they can make the difference in terms of marketability
- Sulfur had positive effect on productivity in most cases, although differences were not always statistically significant because of variability between replicates
- Yields for treatment C were higher than for B in 4 out of 6 cases

Conclusions - WHEAT

- Treatments C and D (PhosAgro fertilizers) led to better grain quality (As, Cd, Pb concentrations) although HM in grains are in any case decidedly lower than official thresholds
  - ✓ Soils not contaminated
  - ✓ Same dynamics are expected in case of contaminated soils
- Sulfur and zinc (treatment D) had a positive effects on cadmium contents in grain (as in rice)
- Sulfur showed to positively affect productivity in most cases, with an effect that increased with time (more evident in the second season because of the **lower effect of previous crop (tomato) in site 2**)
- Protein content usually higher for treatment C and D than for B

Thank you for the kind attention