International Sugar Organization

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EXECUTIVE DIRECTOR

Press Release(19)43
(English only)

23 August 2019

PHOSAGRO - Safer Phosphates

The Executive Director would like to call your attention to the valuable information collected from the firm "Phosagro" regarding fertilizers that are environmentally friendly and contain lower levels of phosphorus and other metals. (Please see attached annexes). This technology is setting the pace for the future and represents a good alternative to develop sustainable agriculture in congruence with demands and tendencies emanating from food manufacturers and consumers.

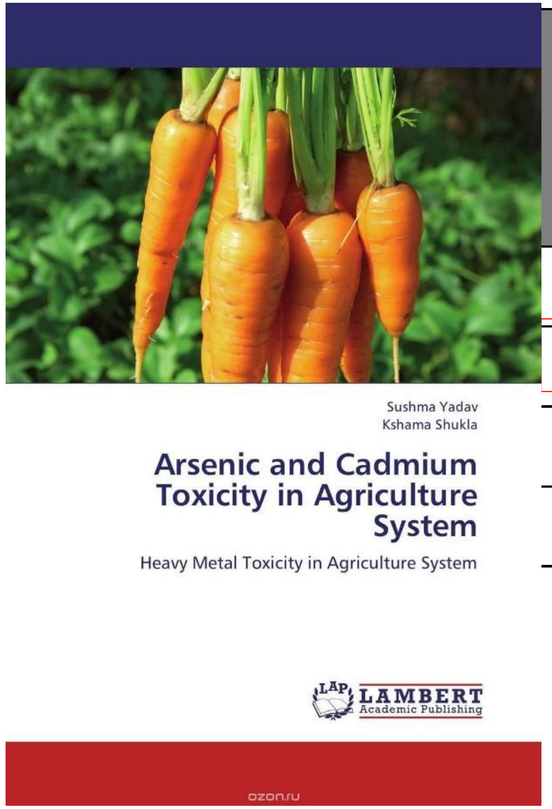
If any ISO Member and/or contact wishes more details ISO would be pleased to put them in touch with the right people at "Phosagro" who can answer their questions".

PHOSAGRO fertilizers

Lidia Dubrovskikh

Head of Agronomic service

ANALYSIS OF DIFFERENT FORMS OF PHOSPHATE FERTILIZERS



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

CADMIUM

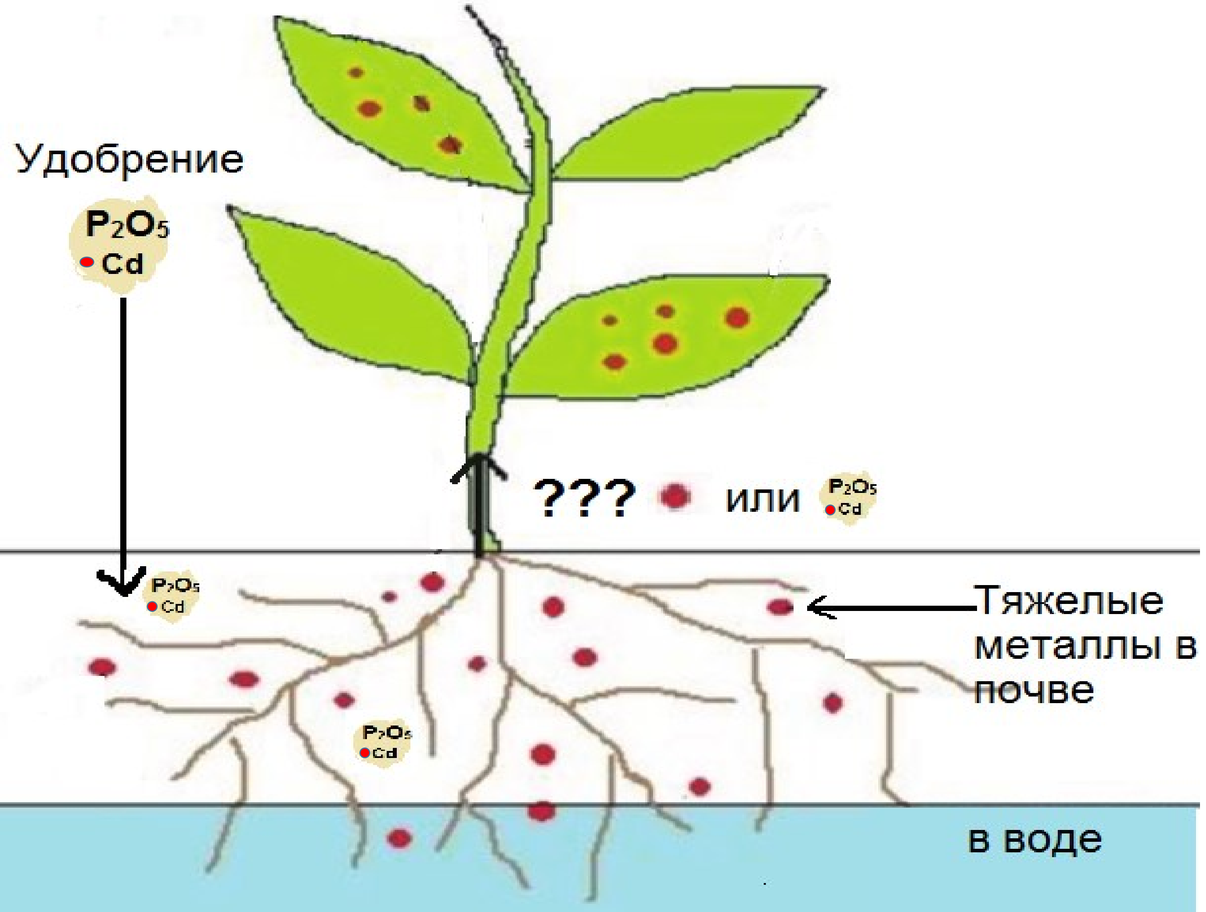
- ✓ is one of the heavy metals
- ✓ can accumulate in the soil
- ✓ getting into soil together with mineral fertilizers,
- ✓ from the soil can move into the fruits and grains, which we then consume.

In the human, cadmium can also accumulate and cause significant diseases

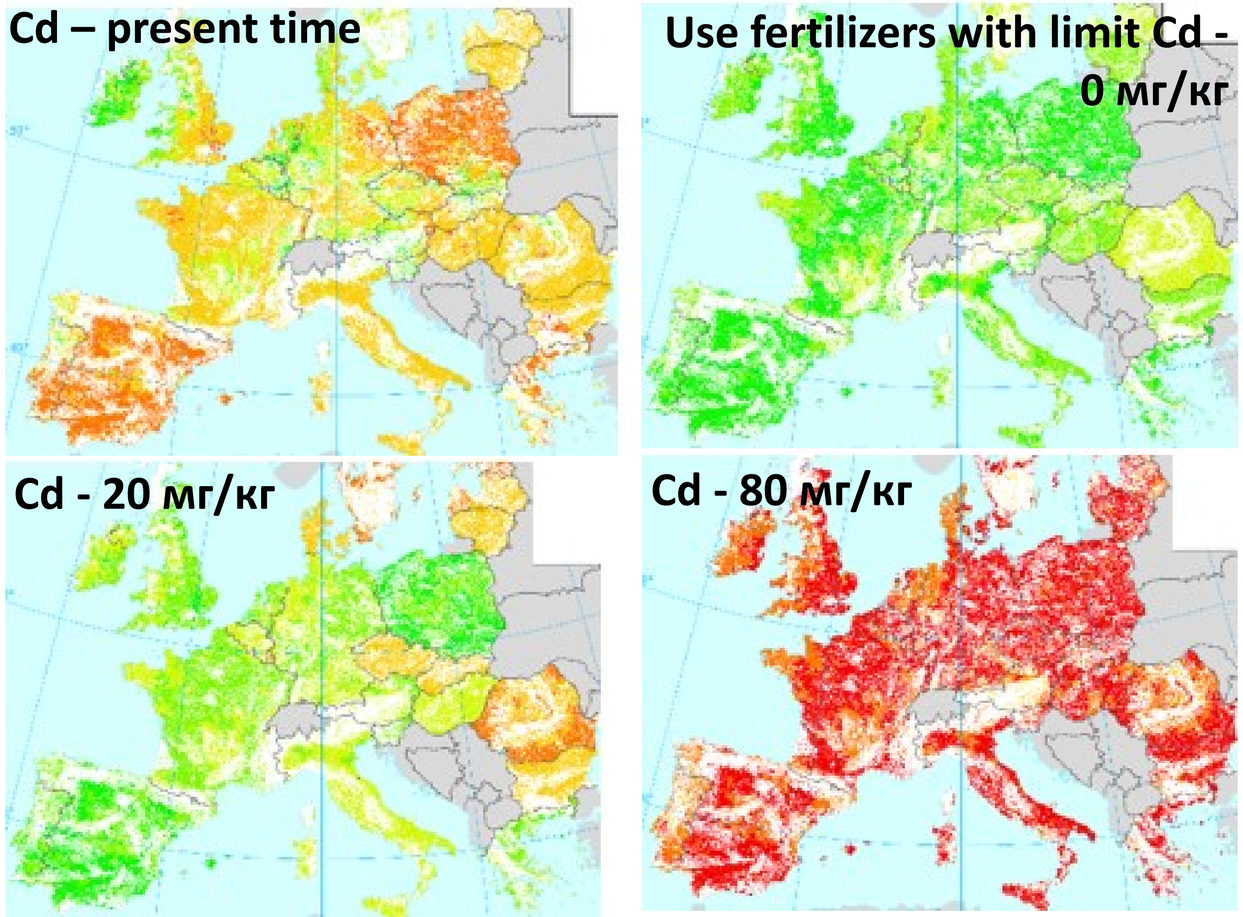
Wageningen – trials for Cd accumulation in soils

Trials was in greenhouse for two OBJECTIVES.
Short term goal: research heavy metal absorption from soil into plant in first year
Long time goal: forecast Cd contamination in soils throat 50—100 depends fertilizers use with different Cd limit.

Cd uptake in first year into plant .



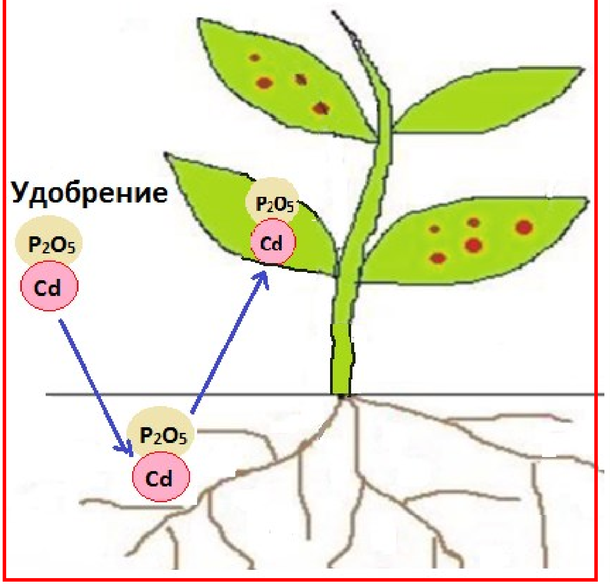
Long time modeling



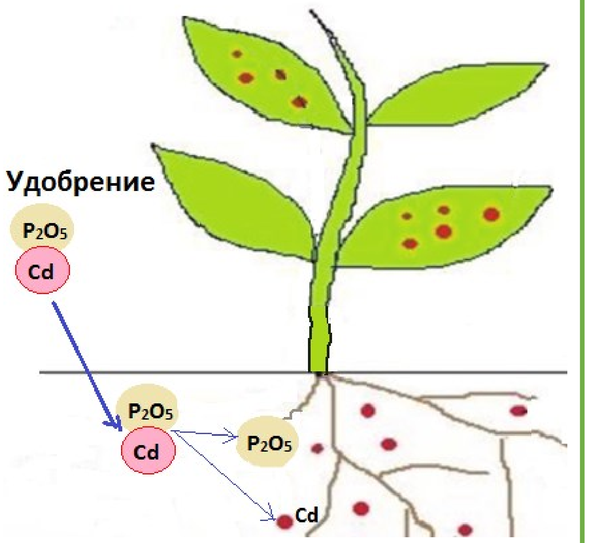
Trials results

Uptake Cd into plants, 1 year results

No link between Cd content in fertilizers and Cd uptake in plants

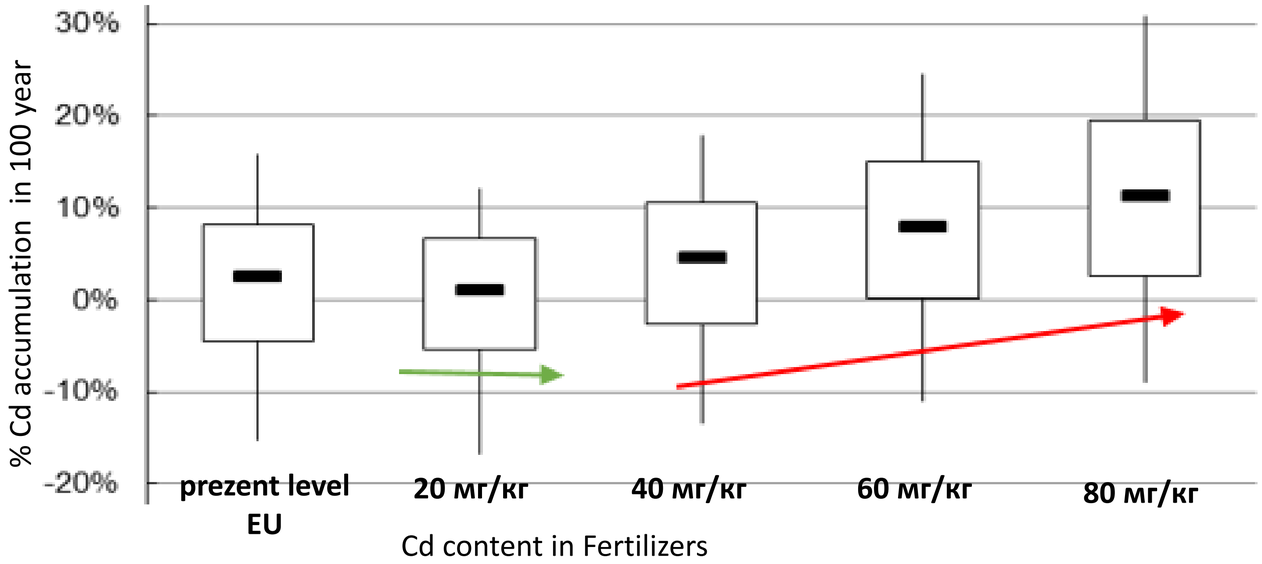


Strong link with Cd content in soil and Cd content in plants



Long term modelling (50/100 years)

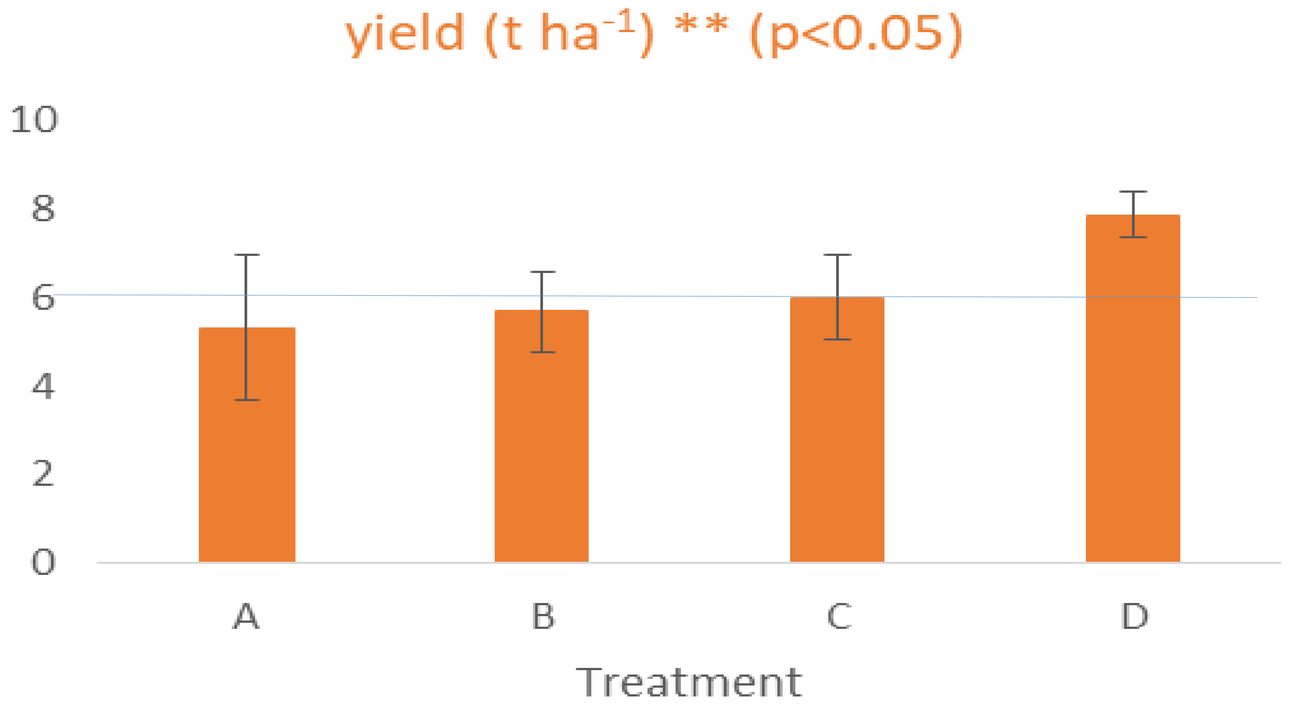
This is model Cd contamination in soil are innovative. This model is scientific data for limitation Cd content in Fertilizers.



«If we will use fertilizers with Cd content more than 20 mg/kg we can see increase heavy metal contamination in the soil.

How row material influence to phosphorus uptake from different grades fertilizer and yield?

Yield rice,



A
Control

B – DAP
(fosforit)

C – DAP
(apatite)

D – NPS +Zn
(apatite),

University degli study a Milano, 2016-2018

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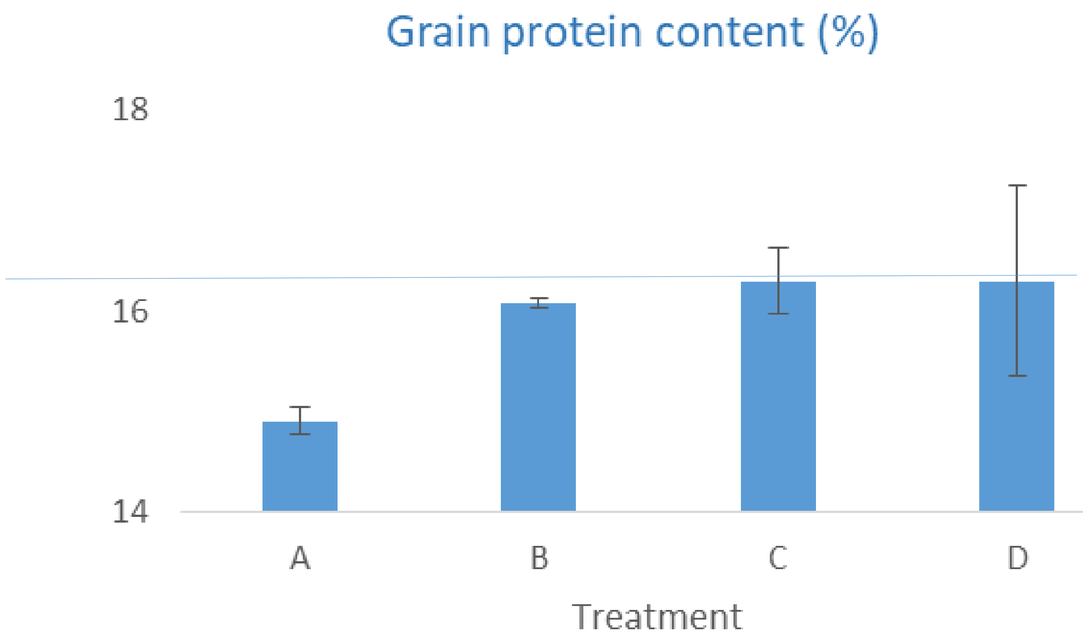
How row material influence to quality grain from different grades fertilizers use



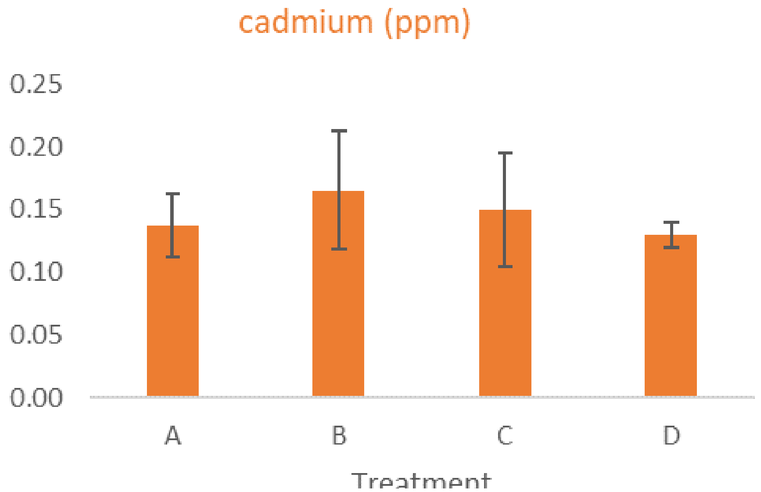
A – CONTROL

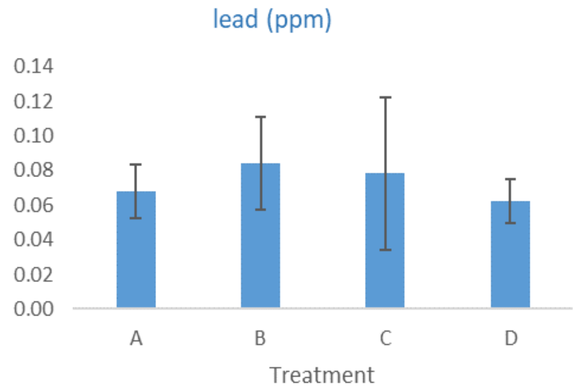
B – DAP (fosforit),

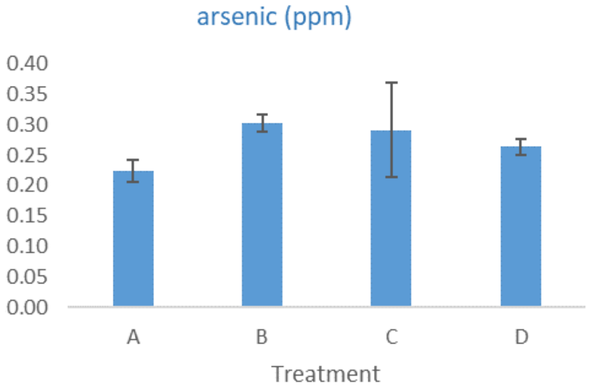
C – DAP (apatite),

D – NPS (apatite),

Applying fertilizer in one granule with Zinc and Sulfur, we see the least amount of heavy metals in production.







A – CONTROL,

B – DAP (fosforit),

C – DAP (apatite),

D – NPS (apatite),

In the experiment on rice, soils were contaminated with heavy metals and cadmium, and in that case, using fertilizers from pure phosphates, we reduce the accumulation of heavy metals in products.

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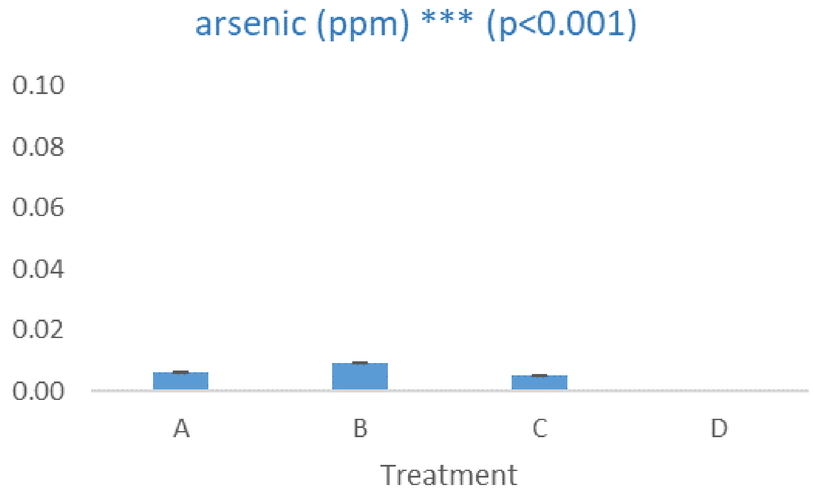
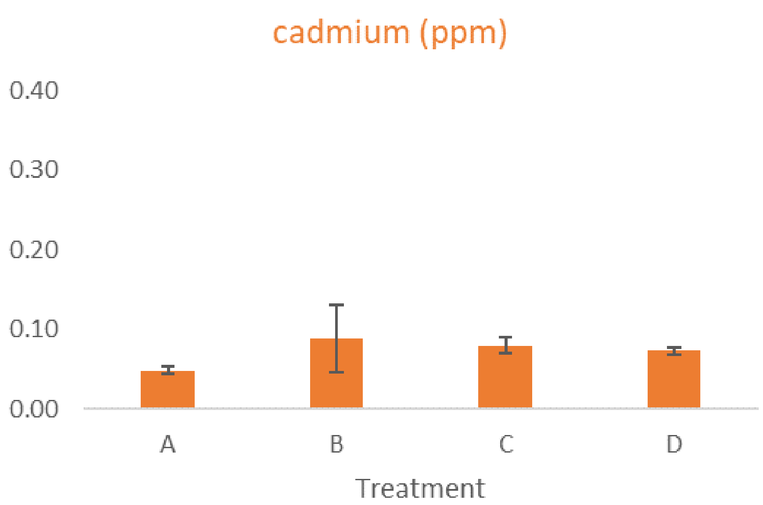
Durum wheat - quality

- **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





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Thank you!

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LDubrovskikh@phosagro.ru

Safer Phosphates: a digital marketing campaign on heavy metals

BACKGROUND

Safer Phosphates is a **digital media campaign aimed at raising awareness of heavy metals in fertilizers**, and the dangers they could pose to soil, crops, animal and human health.

DIGITAL MEDIA

The campaign is communicated through a **website** (www.saferphosphates.com), **Twitter** (@saferphos) and **LinkedIn** (Saferphosphates). Each house a wide range of media, including: 9 special insight reports, 8 videos & 8 news items covering developments in the EU.

PARTNERS

Four partners have signed up to the campaign, including Foskor (South African phosphate producer), Kropz (South African phosphate project), Arianne Phosphates (Canadian phosphate project) & Tradient (a trader of Egyptian Phosphate rock).

The benefits of Safer Phosphates

- The campaign has provided PhosAgro with a **platform to communicate** our research/offering & address the concerns over the new fertilizer legislation to a wider (public) audience.

- **It has helped to raise the profile of Heavy Metals:** Since going live, www.saferphosphates.com has been visited on 18,000 occasions.

- **We have built a stronger bargaining position in the EU:** The SPhos partnership alleviates fears of over dependence on Russia (…given that we have partners from different parts of Africa and North America) and the possible cost implications (…as we have some partners offering lower cost sedimentary based phosphates that meet the strictest limits proposed by the European Union).

- The involvement of a digital media partner (Blueprint) has enabled us to **limit our Ad-spend, while reaching out to influential stakeholders** in the decision-making process.

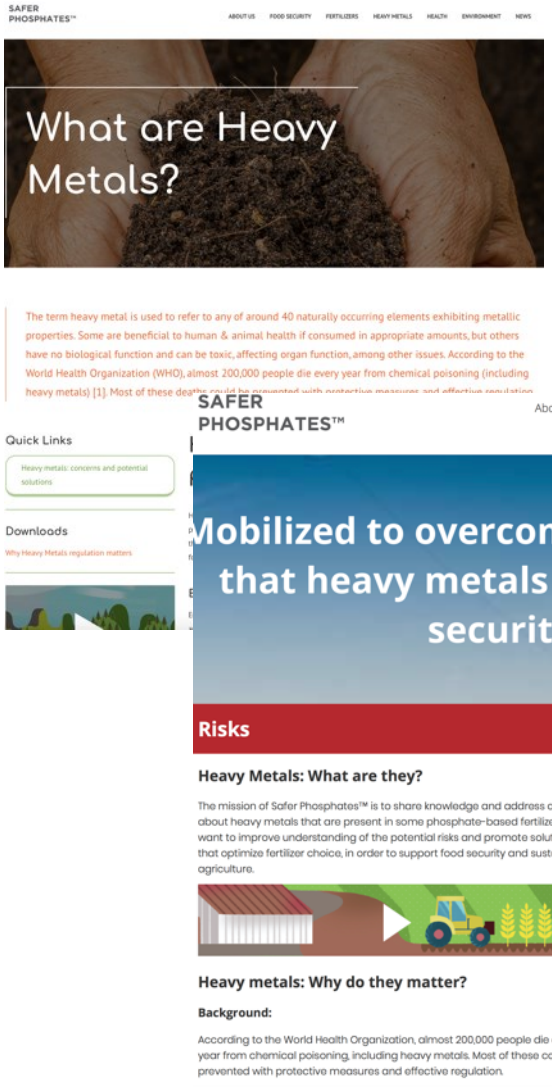
- We use **targeted social media posts** to deliver content to stakeholders' Twitter and LinkedIn feeds directly, with **monthly reporting** on traffic and interactions

Bringing EM Communications into the picture

EM is a well respected firm based in London that has been working with PhosAgro for their Financial PR. They have a good understanding of the subject matter, as they helped prepare content for the original website (launched in H1 2017). Em Communications' involvement in the campaign has the following achievements:

1. **Social media re-boot:** Our LinkedIn and Twitter communications have been managed by Blueprint since launch in 2017. Throughout this time, the sites have been improved and a larger number of stakeholders has been attracted.
2. **Raising the profile of SPhos through social media:** EM scans the web several times a week, recommending that we "interact" with any supportive material to the Safer Phosphates digital media campaign. A larger amount of content encourages a greater amount of traffic through the different platforms.
3. **Engage with general public:** To date, communication has been reactive and impersonal. EM looks to engage more actively with key stakeholders and the general public (although in a controlled and targetted manner).
4. **Involve SPhos partners more actively:** We've not had much involvement from the partners yet. With EM managing communications, we hope to change this, which should be beneficial to the campaign in Europe and elsewhere.

Website update



New website:

- Redesigned with easier-to-navigate layout and clearer messages
- Content has been adapted to be more targeted to the current EU cadmium debate
- EM includes more content from and about Safer Phosphates partners
- EM supports more regular text updates, in addition to new videos and informational graphics that is shared via social media accounts

SAFER PHOSPHATES ROAD MAP 2018

Period:	Description:
Q1	• Site restructure: the site was created about a year ago and needed to be updated (design, simplification, optimization, etc.) Works were carried out to update and modernize the site
Q2	• Analyzing Twitter Topics and Accounts • Updating design pages on Twitter and LinkedIn, added text and new visual images • Increasing SaferPhosphates campaign activity in social networks
Q3	• Launch of the system for regular posting • Preparing the Q3 Newsletter • An increase in the number of subscribers to social media accounts has been recorded.
Q4	• Publication and distribution of Q3 newsletter • Content development for the website and social media continued • Conference call with BluePrint and EM representatives, meeting with EM to exchange views and agree on an algorithm for further website promotion • Promotion on the site and in the social networks of A. Ulrich's article published in September on the regulation of cadmium content in EU fertilizers • BluePrint and EM prepared monthly reports including statistics

Making Safer Phosphates more appealing

Engaging with potential allies

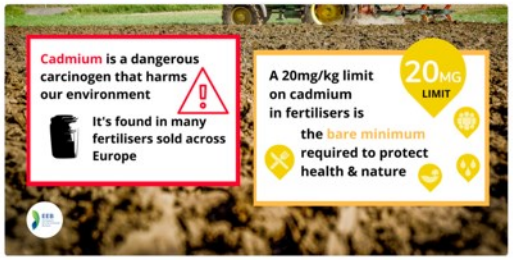
The Organic Guy
@The_Organic_Guy
Follow

lower Toxic metal;Studies have shown significantly lower cadmium levels in organic grains. Cadmium is a toxic chemical naturally found in soils and absorbed by plants. lower cadmium levels in organic grains related to the ban on synthetic fertilizers in O.F #OrganicTuesdayKE

9:00 AM - 24 Apr 2018

EEB
@Green_Europe
Follow

It's time to #ControlCadmium and get it out of our #soil! The EEB is leading calls on MEPs to defend a limit of 20mg/kg on the amount of cadmium in chemical fertilisers sold in Europe. Read more: bit.ly/2F63cDh #FutureofCAP #agri



1:35 PM - 24 Jan 2018

Florent Marcellesi
@fmarcellesi
Follow

On my initiative a group of 38 MEPs (5 different political groups and 11 countries) denounce to @EU2018BG the conflict of interest of the Spanish Agriculture Minister Tejerina in the EU fertiliser negotiations. + info partidoequo.es/4438-2/

5:40 PM - 22 Feb 2018

Cadmium

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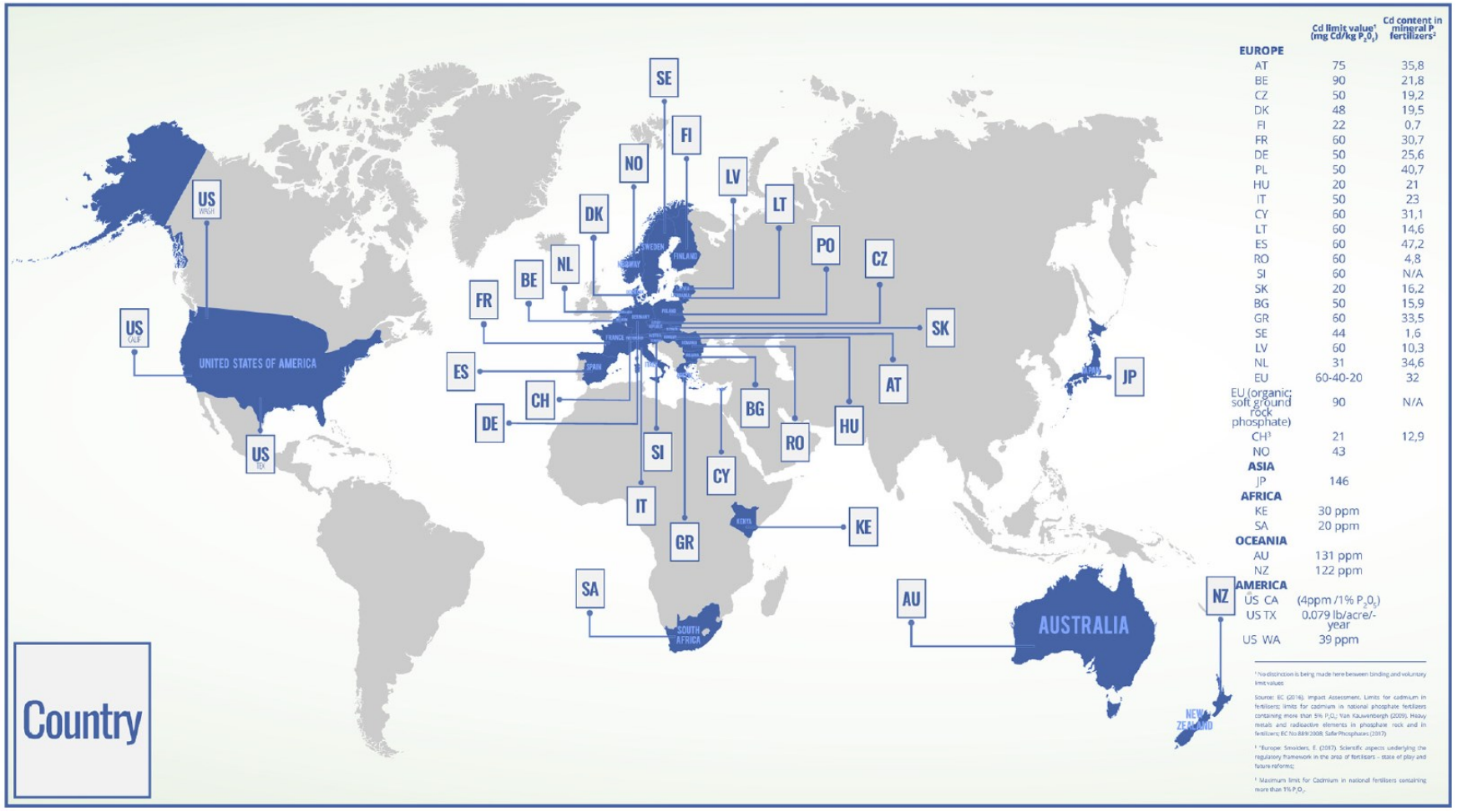
Cadmium properties and uptake pathways

- Cadmium is a toxic chemical element, one of heavy metals (HMs) group due to its physical, chemical and pharmacological properties bearing most resemblance to zinc (Zn) and mercury (Hg)
- Cadmium tends to accumulate in human body throughout life. It may cause cancer and damage to organs (in particular kidney dysfunction and skeletal damage), and is suspected of causing genetic defects and of damaging fertility and the unborn child. The negative impacts of cadmium on human health are gradual, and could appear only after 50 years of exposure.
- European Food Safety Authority (EFSA) has established a tolerable weekly intake (TWI) for most of the EU population at the level of 2.5 µg/kg body weight (2.5 micrograms of cadmium per kilogram body weight), which is substantially lower than the limit recommended by FAO and WHO (7 µg/kg body weight, Codex Alimentarius)
- Most cadmium in the human diet comes from agricultural products (90% for non-smokers). The greatest dietary exposure to cadmium in the EU comes from grains and grain products (26.9 %), vegetables and vegetable products (16.0 %) and starchy roots and tubers (13.2 %)
- Plants, for their part, take up cadmium from soil. This process is influenced by a number of factors (see the next slide)
- Phosphate fertilizers sold in the EU are contaminated with cadmium, currently on average somewhere around 32-36 mg/kg P2O5. Cadmium is of no benefit to plants, and its presence in phosphate fertilizers is only the result of use of contaminated phosphate rock in the production process.
- Fertilization with phosphate fertilizers is by far the main cause of cadmium-contamination of agricultural soils in the EU. The cadmium load from phosphate fertilizers on European farmland is currently more than twice as high as that of atmospheric deposition (0.8 g Cd/ha per year and 0.35 g Cd/ha per year respectively)

Source: European Commission, 2016. Factsheet on Cadmium in Fertilizers

What are the current limits for cadmium in fertilizers?



	Cd limit value[1] (mg Cd/kg P_2O_5)	Cd content in mineral P fertilizers[2]
EUROPE		
AT	75	35,8
BE	90	21,8
CZ	50	19,2
DK	48	19,5
FI	22	0,7
FR	60	30,7
DE	50	25,6
PL	50	40,7
HU	20	21
IT	50	23
CY	60	31,1
LT	60	14,6
ES	60	47,2
RO	60	4,8
SI	60	N/A
SK	20	16,2
BG	50	15,9
GR	60	33,5
SE	44	1,6
LV	60	10,3
NL	31	34,6
EU	60-40-20	32
EU (organic; soft ground rock phosphate)	90	N/A
CH[3]	21	12,9
NO	43	
ASIA		
JP	146	
AFRICA		
KE	30 ppm	
SA	20 ppm	
OCEANIA		
AU	131 ppm	
NZ	122 ppm	
AMERICA		
US CA	(4ppm /1% P_2O_5)	
US TX	0.079 lb/acre/-year	
US WA	39 ppm	

[1] No distinction is being made here between binding and voluntary limit values

Source: EC (2016). Impact Assessment. Limits for cadmium in fertilisers: limits for cadmium in national phosphate fertilizers containing more than 5% P_2O_5; Van Kauwenbergh (2009). Heavy metals and radioactive elements in phosphate rock and in fertilizers; EC No 889/2008. Safer Phosphates (2017).

[2] *Europe Sewickers, E. (2017). Scientific aspects underlying the regulatory framework in the area of fertilisers – state of play and future reforms;*

[3] Maximum limit for Cadmium in national fertilisers containing more than 1% P_2O_5.

Probably the oldest and still strictest limit value was established by Switzerland in **1986**, at **21 mg/kg P_2O_5**. A recent reevaluation of the necessity of such a limit confirmed that limits are an effective and actionable steering tool to address the problem of soil accumulation and crop transfer and to mitigate risks. Switzerland also established a legal obligation in 2016 to recycle P from its waste streams within the next 10 years. A current legislative proposal for Cd limits in these recycled products foresees an even stricter limit than that for mineral fertilizers, at **11 mg/kg P_2O_5**, which may enter into force as early as January 2019. The rationale behind this approach is the 'as low as reasonably achievable' safety principle, which takes into account the evidence-based need (grounded in a 500-year soil accumulation modelling approach compared to 100 years in the EU) and the technical potential of available recycling technologies in order to set ambitious yet still realistic thresholds.

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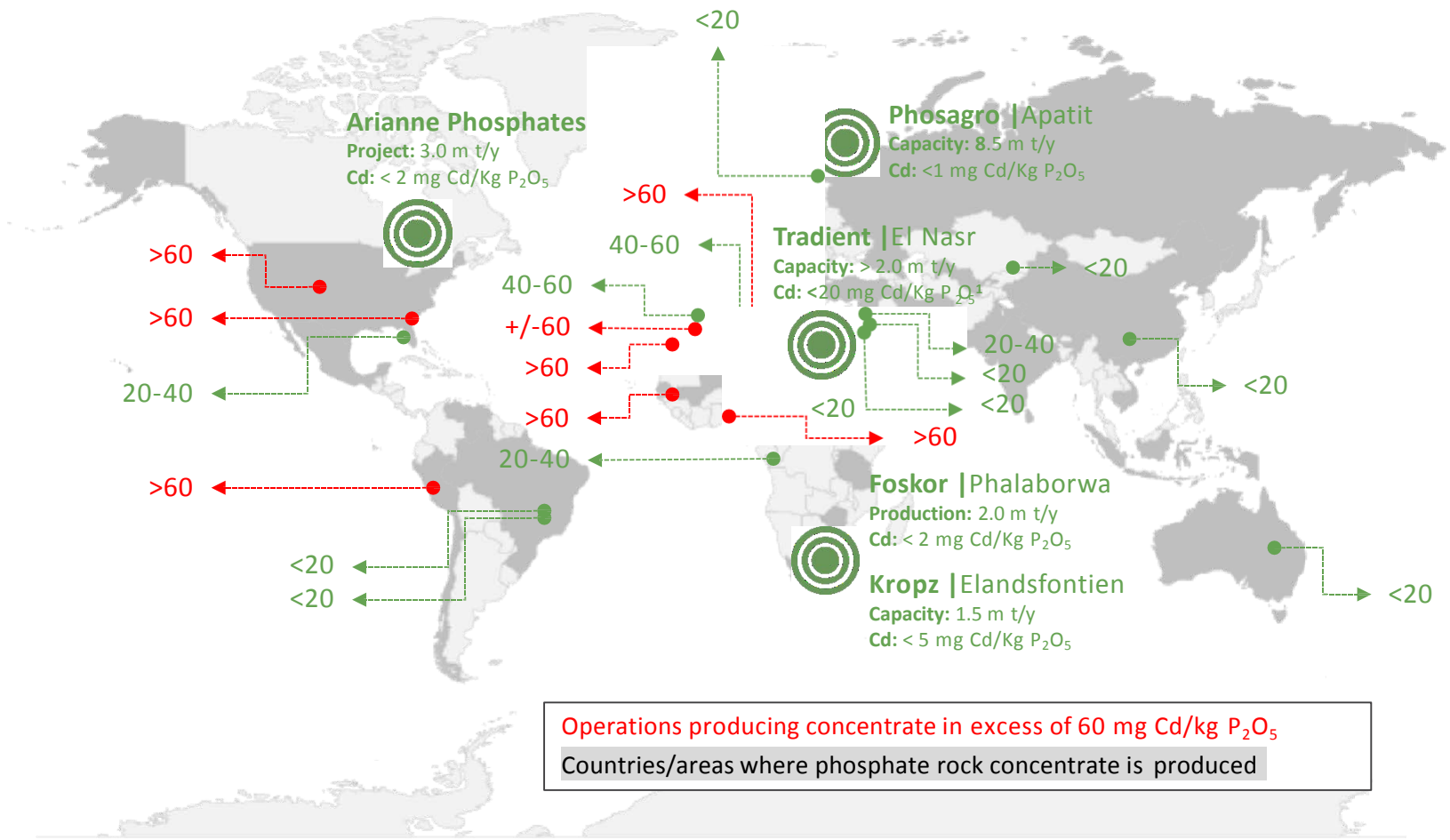
Source: Ulrich A.E. Cadmium governance in Europe's phosphate fertilizers: Not so fast? *Sci. Total Environment*, **2019**, *650*, 541.

Phosphate rock sources and their Cd content



Significant opportunities exist to increase the substitution of high-cadmium products with others, including from developing markets such as Canada. Several new low-Cd mines and greenfield projects around the world are currently being developed and can contribute to the diversity of supply of low heavy-metal feedstock. Today, a number of rock producers are standing ready to satisfy demand.

However, barriers to free trade of P-based fertilizer products hamper trade patterns in the EU. In fact, high-Cd rock from African producers currently has a competitive advantage due to its duty-free status, while trade barriers in the form of import duties are applied to low-impurity rock. This barrier could be removed by cancelling the 6.5% import tax on P containing fertilizer products from certain countries.

Source: A. Willem Schipper (2016). Cd in phosphate rock and fertilizers: removal technologies. Netherlands: Willem Schipper Consulting. pp 1-13. B. CRU (2016). Heavy Metals in the European Phosphates Market. London: CRU International. Kemworks (2012). C. Pocket Fertilizer Manual – 12th Edition. Lakeland: Kemworks. pp 10-11. D. ML2R Consultancy. Phosphate rock product analysis. Data downloaded from http://ml2rconsultancy.com/phosphate-rock-analysis/ (28/07/2017). E. Allan Pickett. (2016). What does the future hold for the supply of high-grade phosphate rock?. London: Agribusiness Intelligence, Informa. pp 6. **NOTES:** 1 When converted to WPA. 2. Mapping function powered by Bing (Microsoft), DSAT for MSFT, Geonames, Thinkware Extract, Wikipedia

What is the main reason behind new EU fertilizer regulation, including cadmium limits?

In 2016 the European Commission put forward a legislative proposal on fertilizing products, as part of the Circular Economy package. It establishes more sustainable and environmentally friendly industry, thus focusing on consumer interests.

- Up to 90% of phosphate rock used for production of mineral fertilizers is imported to EU
- The 2003 Fertilisers Regulation (Regulation (EC) No 2003/2003) defines different types of fertilizers, which have been approved as 'EC fertilizers' and can circulate freely on the EU market. Although the current regulation covers various types of fertilizers, current 'EC fertilizers' are essentially conventional and mineral fertilisers sourced from primary raw materials, some of which require energy and CO2-intensive production processes. In addition, the Regulation does not include limits to the content of heavy metals and other contaminants, such as pathogens and physical impurities.
- In March 2016, the Commission put forward a legislative proposal on fertilizing products, as part of the Circular Economy package. The proposal covers a wider range of fertilizing products (including those manufactured from secondary raw materials), and also sets limits on heavy metals and contaminants present in fertilizing products.
- The proposed regulation aims to establish the standard cadmium limits for all types of phosphate fertilizers and harmonize the EU fertilizer market thus reducing the import dependence

PHOSAGRO®

Source: Gardini E. Draft opinion of the Committee on the Environment, Public Health and Food Safety on the proposal for a regulation of the European Parliament and of the Council laying down rules on the making available on the market of CE marked fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 (COM(2016)0157 – C8-0123/2016 – 2016/0084(COD))

The EU trilogue: provisional agreement on cadmium

EU Institutes:

European Parliament

European Commission

Council of the European Union

AGREED Cd LIMITS:	
60 mg / kg P_2O_5	3 years after entry into force (ca. 2022 r.)
40 mg / kg P_2O_5	Possibly 7 years after entry into force after the EC assessment
ADDITIONAL PROVISIONS:	
Voluntary labeling for fertilizing products with Cd < 20 mg / kg P_2O_5	Yes

In addition, limits on the maximum content of other heavy metals – arsenic, mercury, chromium, lead and nickel - have been introduced

After 20-11-18: European Parliament and Council provisional agreement on Cd limits

Cadmium limits

The agreed text introduces limits for heavy metals, such as cadmium, in phosphate fertilizers to reduce health and environmental risks.

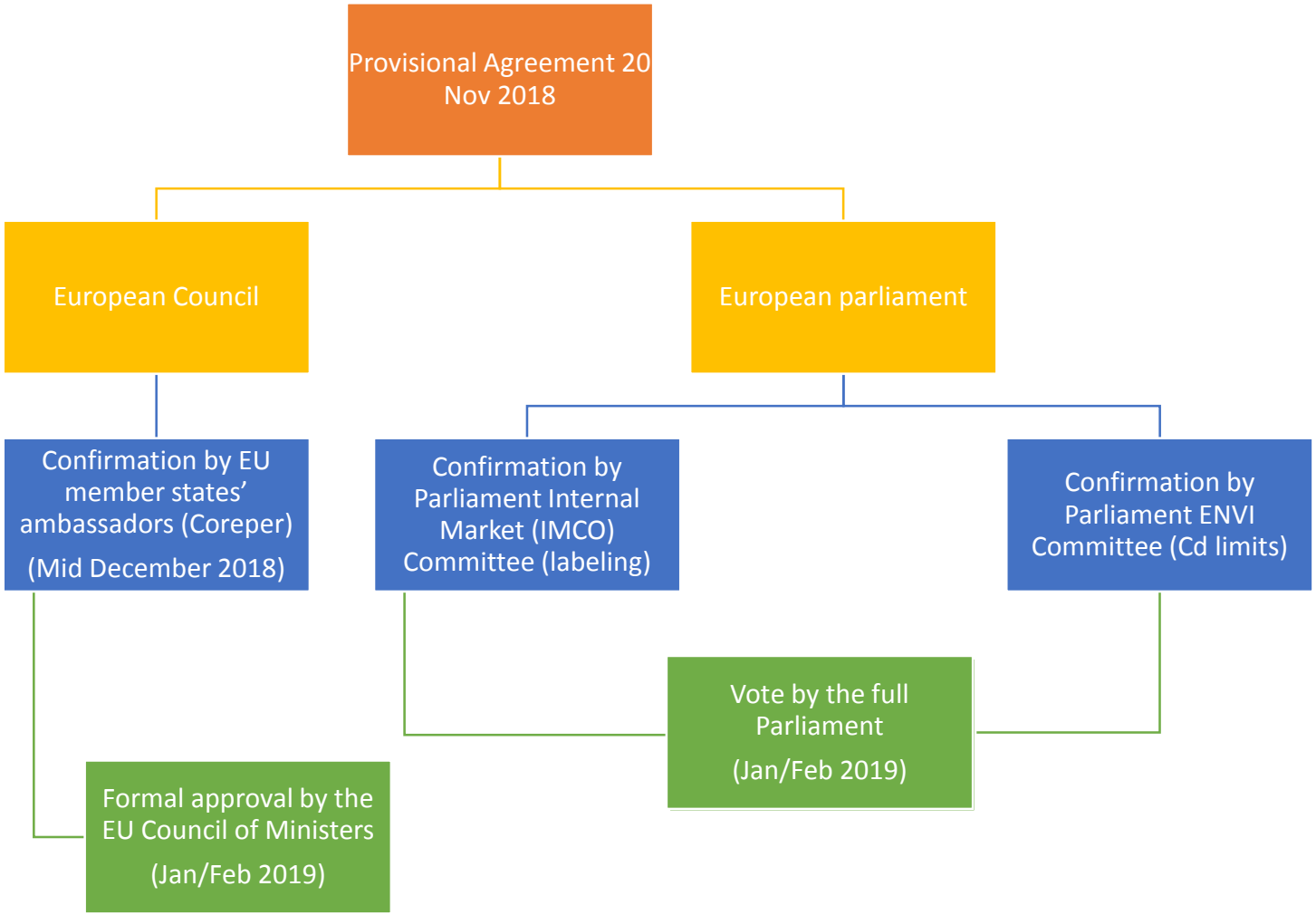
- The limits for cadmium content in "EU marked" phosphate fertilizers will be 60 mg/kg P_2O_5 as from the date of application of the regulation (i.e. **three years after its entry into force**).
- A review clause requires the European Commission *to review the limit values*, with a view to assessing the feasibility of reducing them, **four years after the date of application of the new rules** (i.e. seven years after entry into force).
- The co-legislators also agreed on a voluntary "low cadmium" label. Where the fertilizing product has a cadmium content lower than 20 mg/kg P_2O_5, the statement **"Low cadmium (Cd) content"** or similar, or a visual representation to that effect, may be added.
- Sufficient incentives should be provided to develop *decadmiation technologies* and to manage cadmium-rich hazardous waste by means of relevant financial resources.

Benefits

A limit of 60 mg/kg Cd P2O5 will affect Senegalese, Togolese and importantly also Tunisian deliveries for both phosphoric acid & other fertilizers. It will also partly impact Algerian, Israeli and Moroccan supplies;

- A preliminary estimate suggests around 12-15% of trade into Europe will be impacted by the 60 mg/kg Cd P2O5 limit. A further 20-30% would be impacted by a move to 40 mg/kg Cd P2O5 (should that go ahead).
- **The Labelling of products with Cd level below 20 mg is very important. We will be able to clearly and formally distinguish its products from its competitors.**

Next steps


Provisional Agreement 20 Nov 2018
European Council
European parliament
Confirmation by EU member states' ambassadors (Coreper)
(Mid December 2018)
Confirmation by Parliament Internal Market (IMCO) Committee (labeling)
Confirmation by Parliament ENVI Committee (Cd limits)
Vote by the full Parliament
(Jan/Feb 2019)
Formal approval by the EU Council of Ministers
(Jan/Feb 2019)

Effects of different phosphate fertilizers on productivity and grain quality

Results from rice and durum wheat experiments

Roberto Confalonieri, Livia Paleari

Università degli Studi di Milano

Cassandra lab

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www.cassandralab.com

Contents

- Introduction
- Objectives of the project
- Experimental design
- Results for rice campaigns (2016, 2017 and 2018)
  - ✓ Productivity
  - ✓ Heavy metal concentrations in grains
  - ✓ Heavy metal concentrations in soils
  - ✓ Heavy metal concentrations in irrigation water
- Results for durum wheat campaigns (2016/17 and 2017/18)
  - ✓ Productivity
  - ✓ Heavy metal concentrations in grains
  - ✓ Heavy metal concentrations in soils
- Conclusions

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

Contents

Objectives

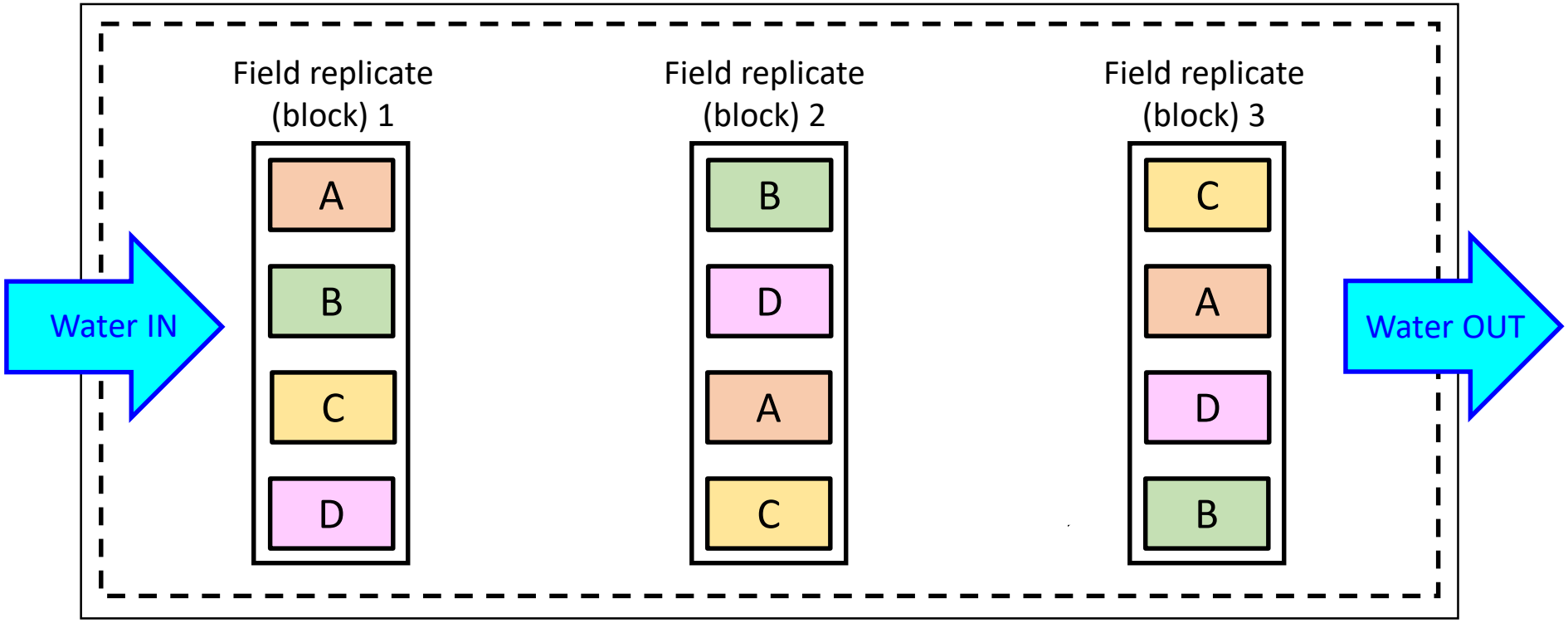
- Evaluating the impact of different phosphate fertilizers on:
  - ✓ Productivity
  - ✓ Quality (heavy metals content in grain)
  - ✓ Heavy metals content in soil
- Treatments:
  - ✓ A: control
  - ✓ B: standard farm fertilization
  - ✓ C: like B but with phosphate fertilizers with low (or not quantifiable)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

Contents

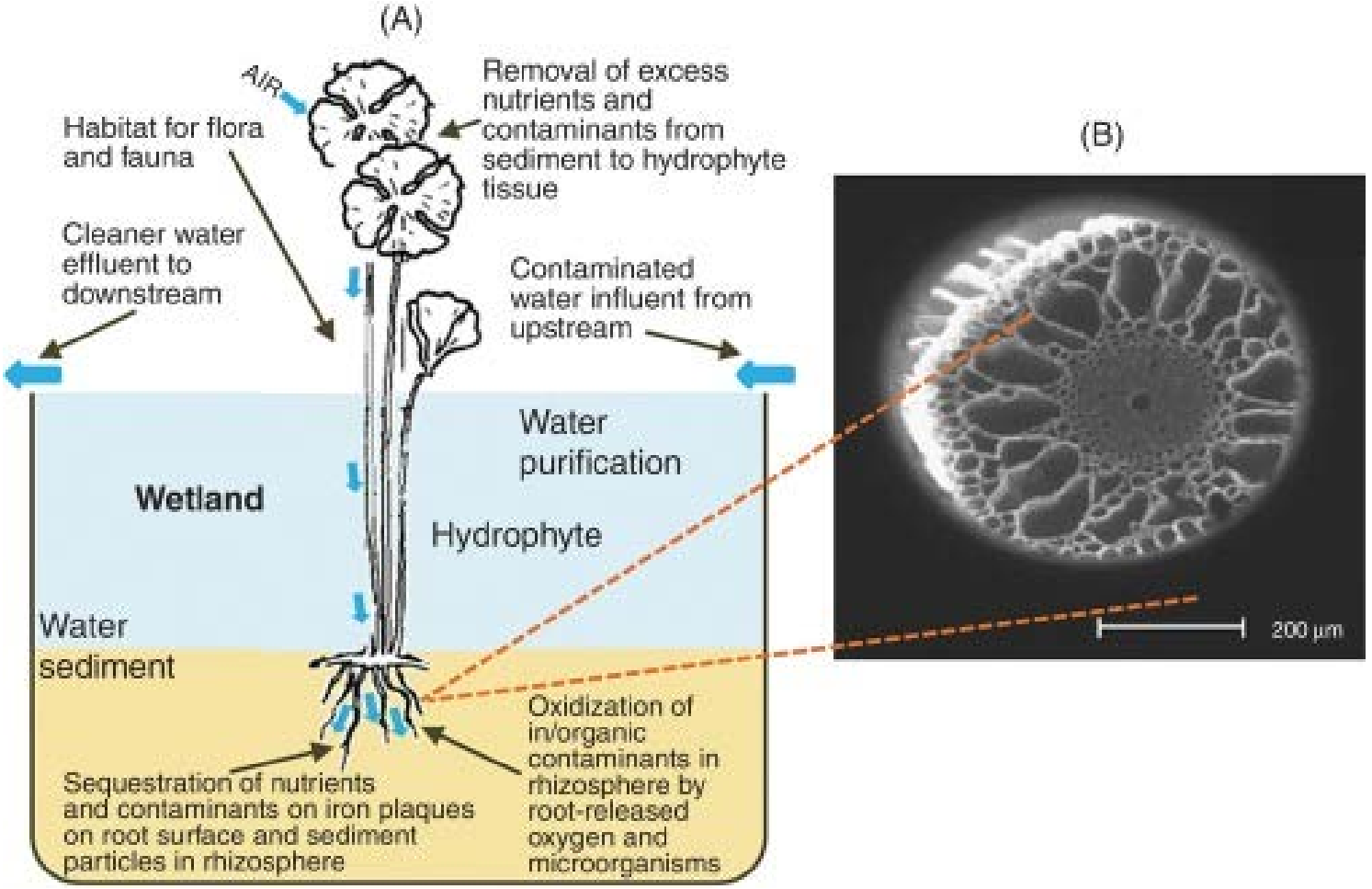
Experimental design



- 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)


(A)
AIR
Removal of excess nutrients and contaminants from sediment to hydrophyte tissue
Habitat for flora and fauna
Cleaner water effluent to downstream
Contaminated water influent from upstream
Water purification
Wetland
Hydrophyte
Water
sediment
Sequestration of nutrients and contaminants on iron plaques on root surface and sediment particles in rhizosphere
Oxidization of in/organic contaminants in rhizosphere by root-released oxygen and microorganisms
(B)
200 µm

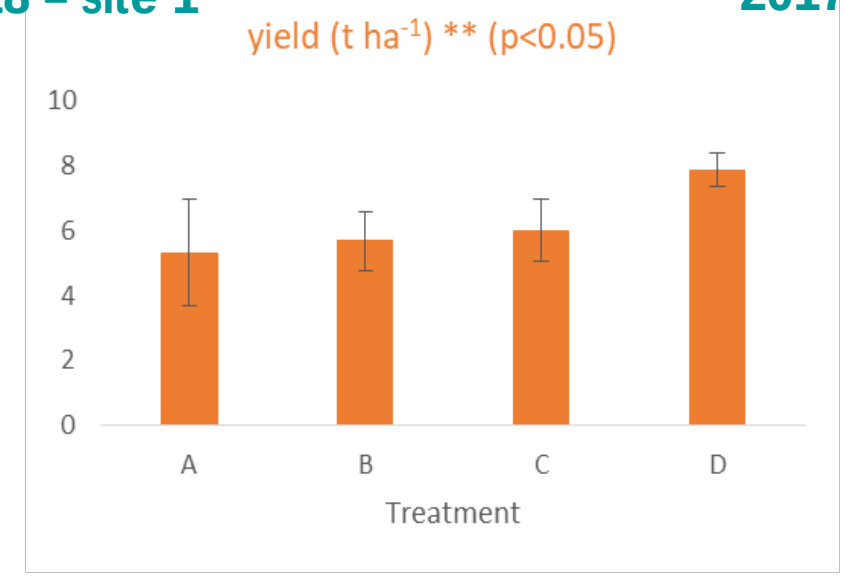
Contents

Rice - productivity

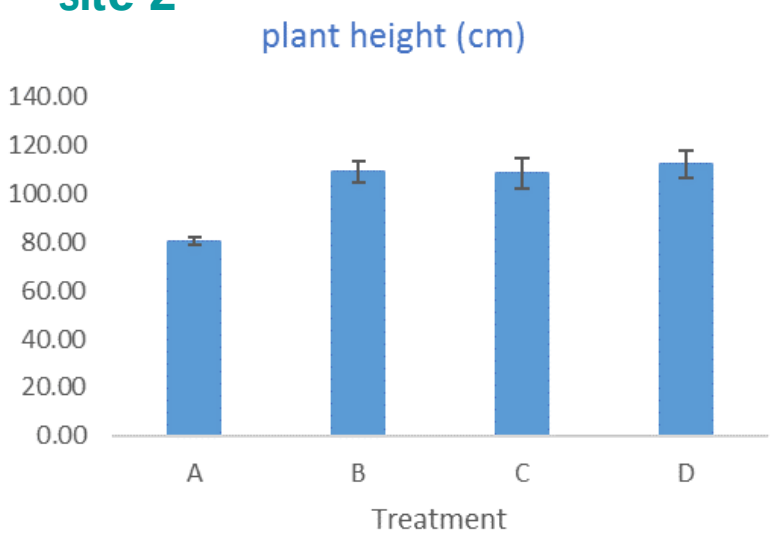
- **Treatment D** (+ sulfur and zinc) obtained **higher yields** in 3 cases (site × year combinations) out of 6 (differences significant in one case)
- In all cases because of a **higher number of panicles per plant**
- In 5 cases no increase in plant height

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

2018 – site 1

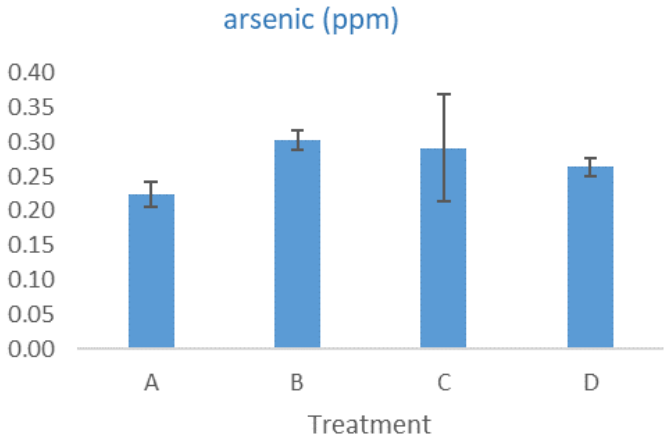


2017 – site 2

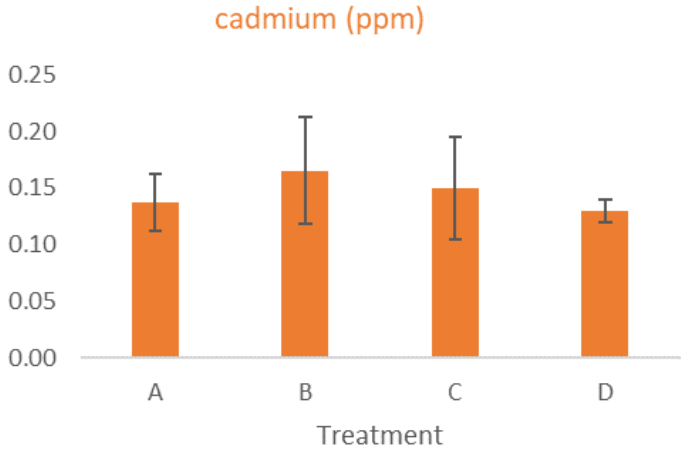


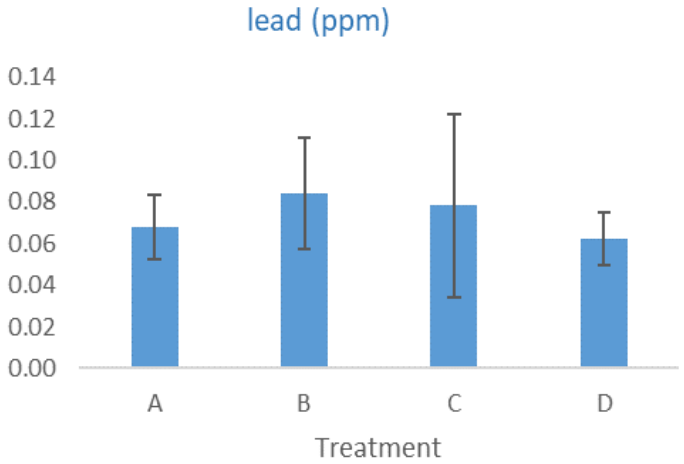
Rice - quality

- 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



2017 – site 1

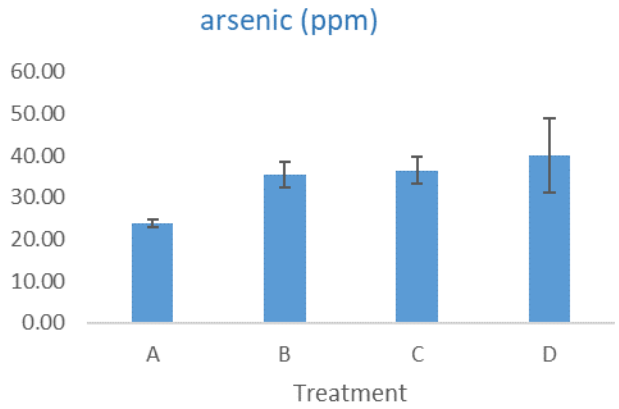


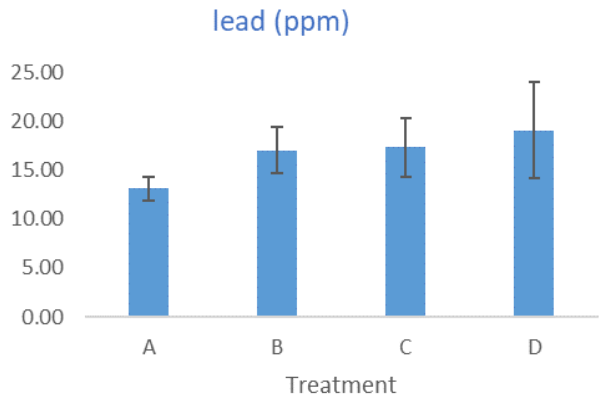


Rice - quality

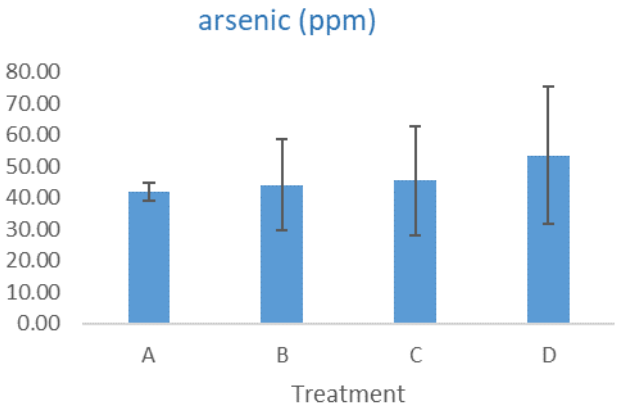
- Effect of sulfur (iron placque + root/shoot filter):
  - ✓ Low content in shoots
  - ✓ High content in **roots**

2017 – site 1



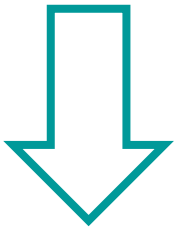


2017 – site 2



Rice - soil

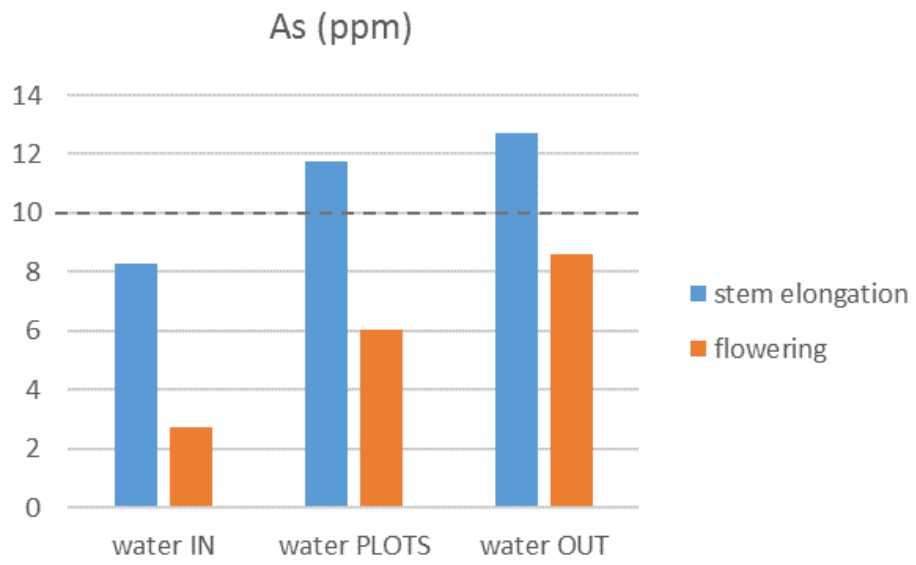
- Concentrations “not negligible” in soils at the beginning of the experiments
- Treatment D → heavy metals not translocated to grains remain in soil (roots)



- 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

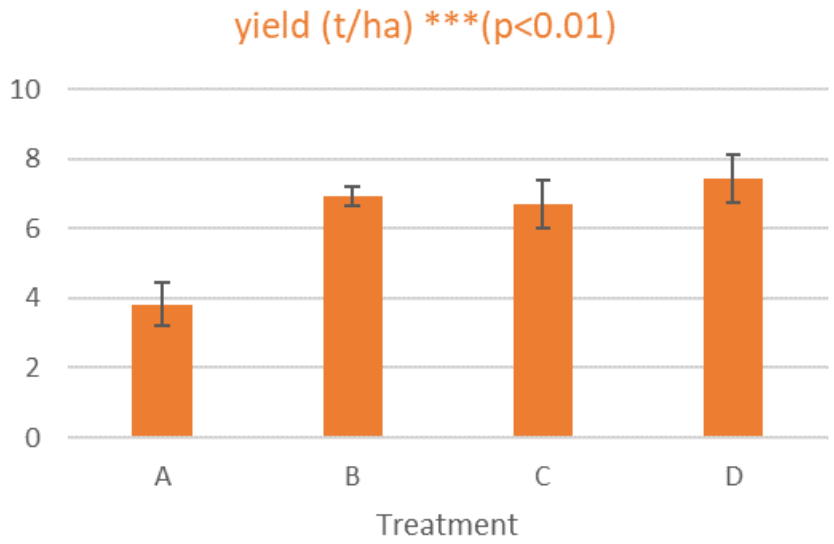


Contents

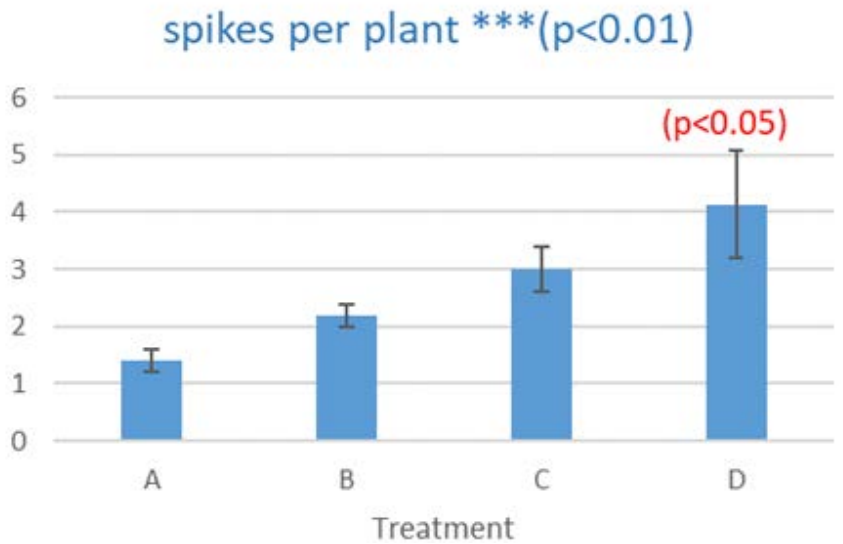
Durum wheat - productivity

- **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



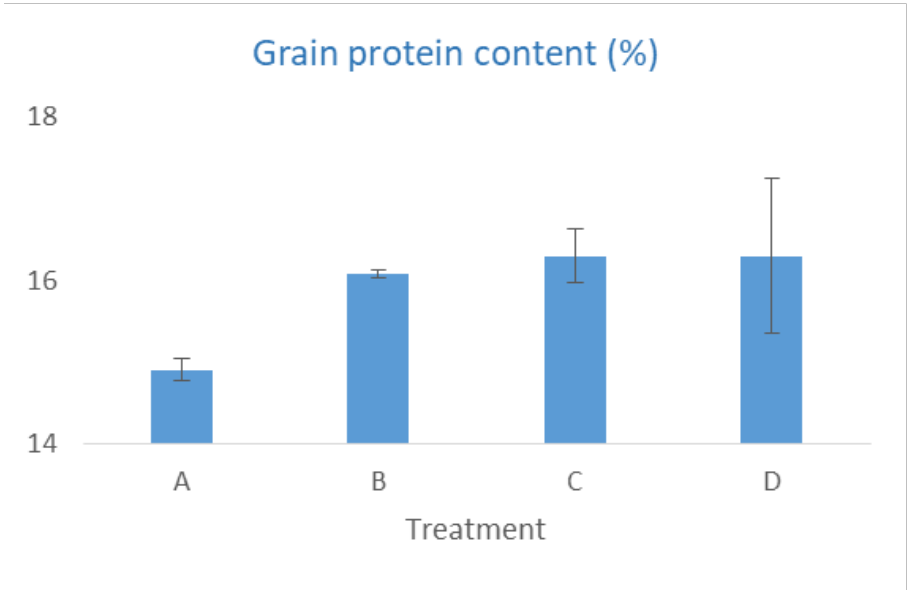
2018 – site 2



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**

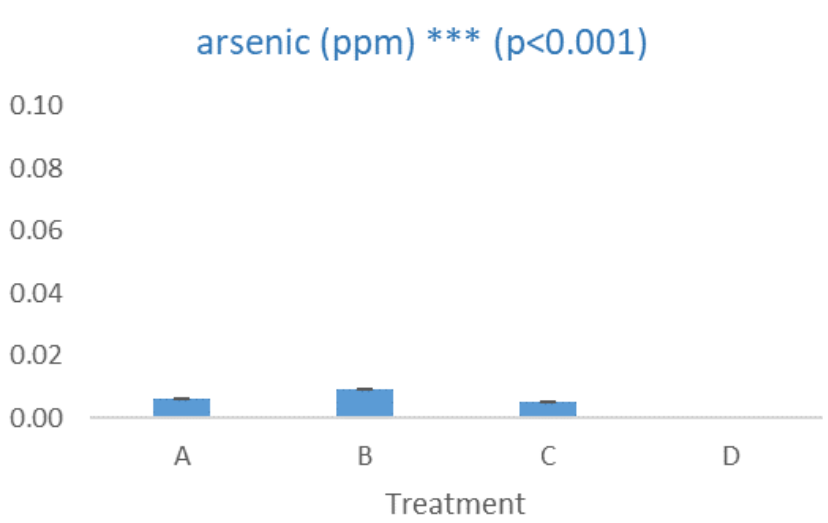
2016/17 – site 1



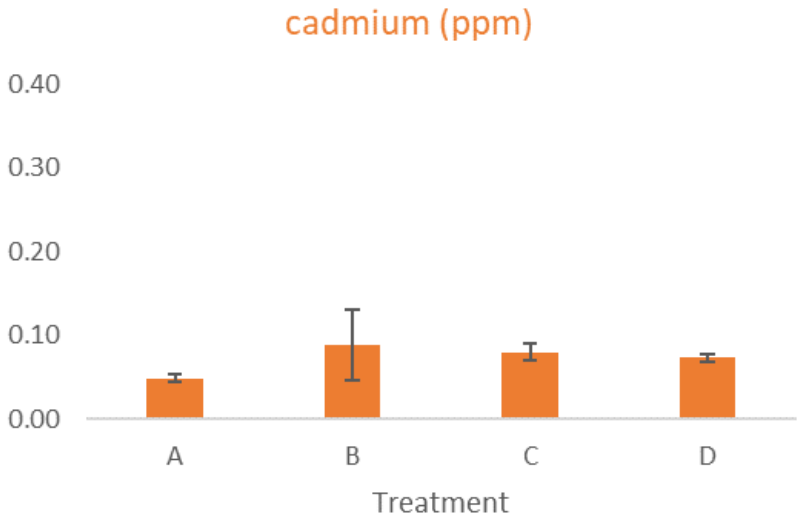
Durum wheat - quality

- **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



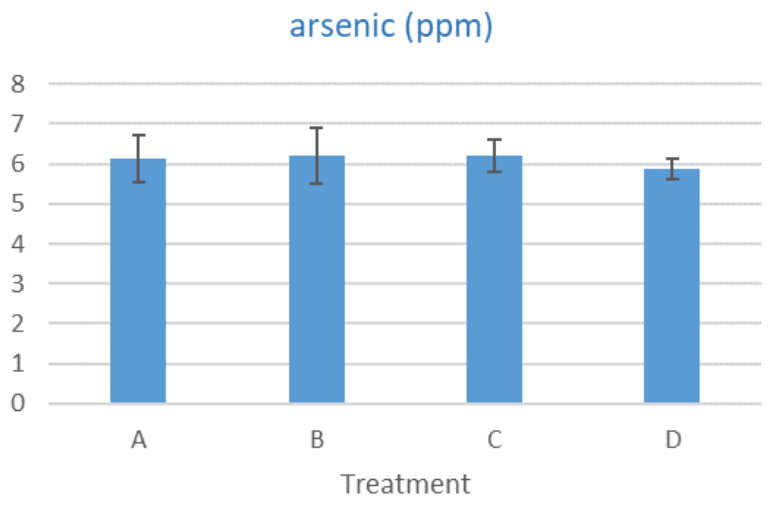
2017 – site 1



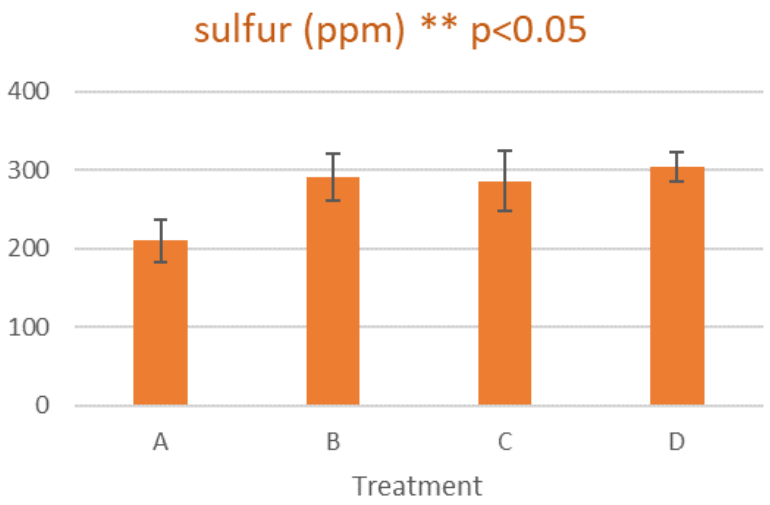
Durum wheat - soil

- **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



Contents

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