

Multicomponent hydrogel fertilizer technology for sustainable agriculture

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Global food crisis looms as fertilizer supplies dwindle

Fertilizer crisis

↓

Food security

Fertilizers are blended at Golden Fields in Lagos, Nigeria. A fertilizer shortage is threatening the success of the world's farmers and could lead to widespread food shortages, experts say.

PHOTOGRAPH BY PETER ESSI / GETTY IMAGES COLLECTION

ENVIRONMENT

Global food crisis looms as fertilizer supplies dwindle

Sanctions on Russia, bad weather, and export cuts have fueled a severe fertilizer shortage that has farmers scrambling to keep the world fed.

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Hanna Grzeleńska

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Katarzyna Chojnacka

Dzień dobry, dziękuję za inform. Wyślane

Hanna Grzeleńska

Szanowna Pani Profesor, Chciałam

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David Skrzypczak, Konstantinos Iv

Invitation for contributing a review

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Z powołaniem David Skrzypczak

Katarzyna Uziogowska

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Dzień dobry, czy mogłabym podje

ResearchGate

Katarzyna, your co-author Justyn

1021

Katarzyna, your co-author Justyn

Rada Uczeń

Invitation: Rada Uczeń Politechn

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You have been invited to the folk

Julia Bumos

Kolokwium -- pomyłka

0941

Szanowna Pani Profesor, chciałaby

Martyna Chwarska

Kolokwium

0934

Konsultowałam się z koleżanką, kt

Claudio Colombo

HORIZON GreenAMMS Evaluatio

0928

Dear colleagues, bel news, the p

Grzegorz Bydortczyk

Obawy - Uwaga rezerwent odno

0916

4. Regulations and guidelines for e

David Skrzypczak

Skrytka odbiorcza

Ocena z zaliczenia

Do katarzynachojnacka@pwr.edu.pl

Szanowna Pani Profesor,

Chciałem zgłosić, że zasła chyba pomyłka, ponieważ wiem, że pisała do Pani Profesor Pani Agneta Gugler z zapytaniem, że nie ma wpisanej oceny z wykładu z Metod Biotechnologicznych w oc

środkowiska, a zaliczyła na ocenę 3.0. Za to ja sprawdziłem w swoim indeksie, że mam wpisaną ocenę 3.0 właśnie z wczorajszego zaliczenia, kiedy to ja nie zaliczyłem wczoraj i poinformowałem i

przysłała na drugi termin. Przypuszczam, że ocena w moim indeksie jest oceną Pani Agnety Gugler, byliśmy w tej samej grupie. Dodatkowym problemem jest to iż, omyłkowo zaakceptowałem i

po zaakceptowaniu zobaczyłem jaki to jest przedmiot. Za co bardzo przepraszam było to po prostu pomyłka z mojej strony i niedopatrzenie.

Z poważaniem

Hanna Grzeleńska

Industry-Facts-and-Figures-2021-1.pdf - Adobe Acrobat Reader DC (64-bit)

Strona główna

Narzędzia

Industry-Facts-and-...

draft CORFU 2022 a...

draft CORFU 2022 a...

Fertilizer consumption by crop in the European Union

Nitrogen fertilizer consumption by product

16% Fertilized grassland

6% Fodder

6% Perm. crops

5% Other arable crops

2% Sugar beet

3% Potatoes

10% Oilseeds

25% Coarse grains

26% Wheat

Global 2018

103.7 million tonnes (of nutrient)

EU-28 2019/20

11.2 million tonnes (of nutrient)

Global

EU-28

Nitrates

Urea

UAN

Compound fertilizers

Others

Note: Due to rounding, figures may not add up to 100%.

Source: Fertilizers Europe

Note: Due to rounding, figures may not add up to 100%; Agricultural use only

Source: Fertilizers Europe/ IFA

Fertilizer consumption and use in the European Union

Agricultural land use in the European Union

Skrytka odbiorcza

Ocena z zaliczenia

Do katarzynachojnacka@pwr.edu.pl

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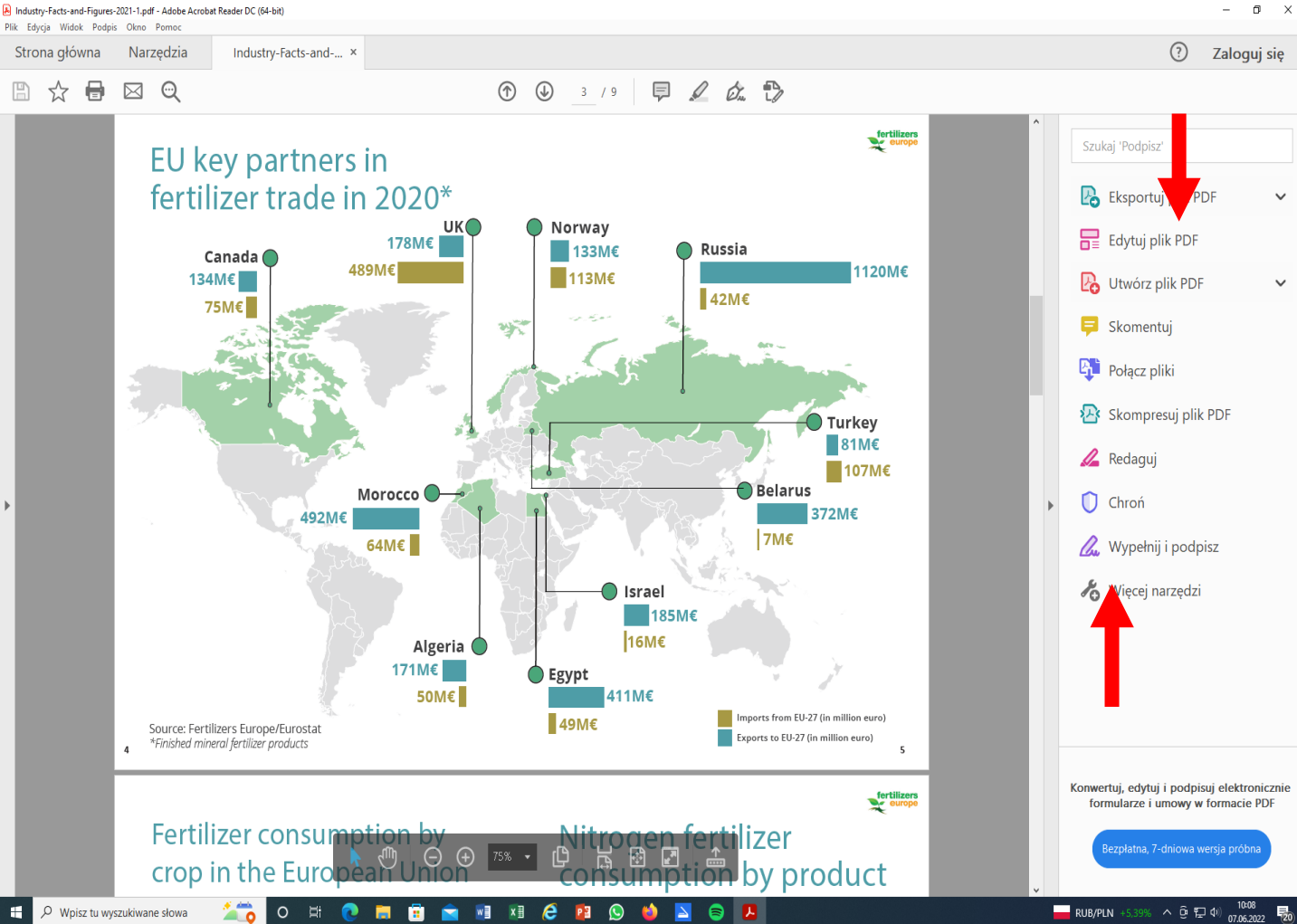
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Z poważaniem

Hanna Grzeleńska



- IFA:
 - 46% ammonium nitrate,
 - 23% ammonia,
 - 14% of the urea volume,
 - 11% ammonium phosphate,
 - 21% of the global potassium trade,were retained as the consequence of Ukraine-Russia war.
- Europe is more dependent on Russia in this regard. Russia and Belarus have been key EU partners in fertilizer trade.
- It is estimated that it will take 10 years to rebuild the mineral fertilizer market.
- According to the IFA, it is currently not possible to meet the global demand for fertilizers.

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Strona główna Narzędzia Industry-Facts-and-... x

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Zaloguj się

Production of main fertilizer products

Raw materials Intermediate products Mineral fertilizers

Air (N₂) Natural gas Ammonia Nitric acid Carbon dioxide Ammonium nitrate (AN) Urea UAN

Phosphate rock Phosphate concentrate Sulphuric acid Phosphoric acid Ammonia Single superphosphate (SSP) Mono- and diammonium phosphate (MAP/DAP) Triple superphosphate (TSP)

Potash rock Potash concentrate Potassium chloride solution Nitric acid Sulphuric acid Muriate of potash (MOP) Potassium nitrate (KN) Sulphate of potash (SOP)

Members CORPORATE

Major fertilizer plants in Europe

12 13

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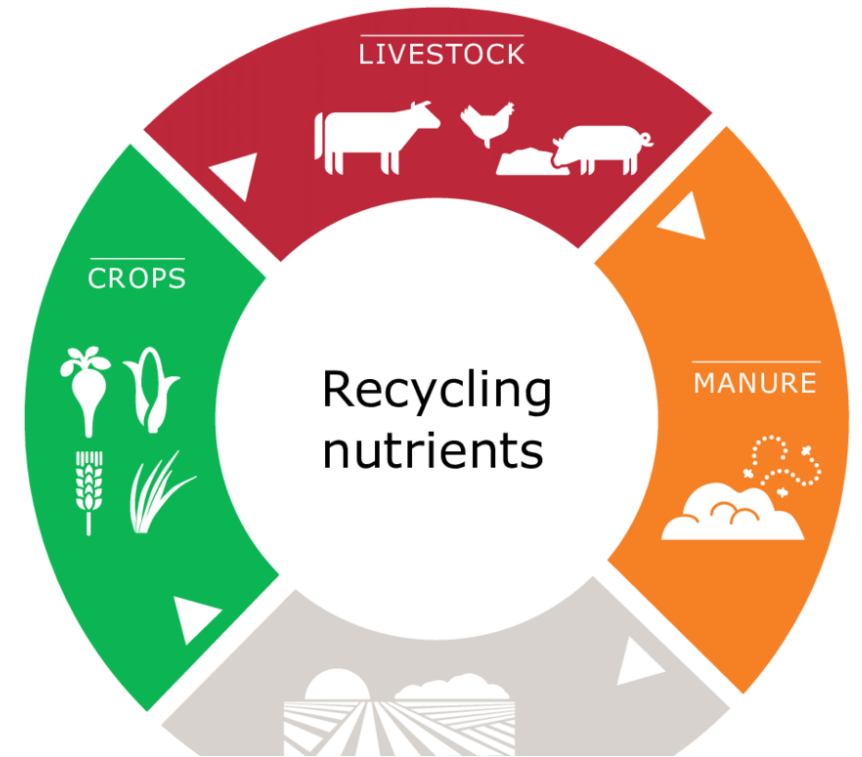
20°C Słonecznie 10:09 07.06.2022

Russia and Belarus have supplied:

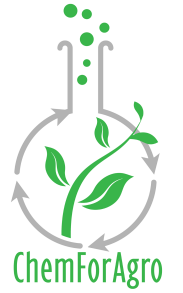
- natural gas
- 35% of phosphates
- 60% of potash and to the EU market.

Solution:

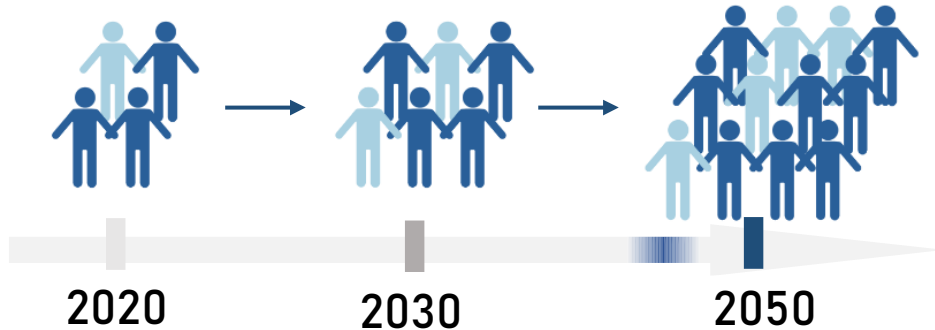
- Sustainable agriculture
- Locally available feedstock
- Circular economy – waste as a resource
- Integrated crop-livestock system
- Precision agriculture



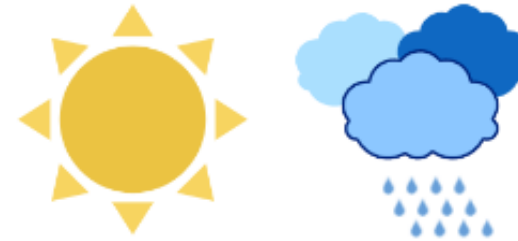
Challenges and problems in agriculture



population growth



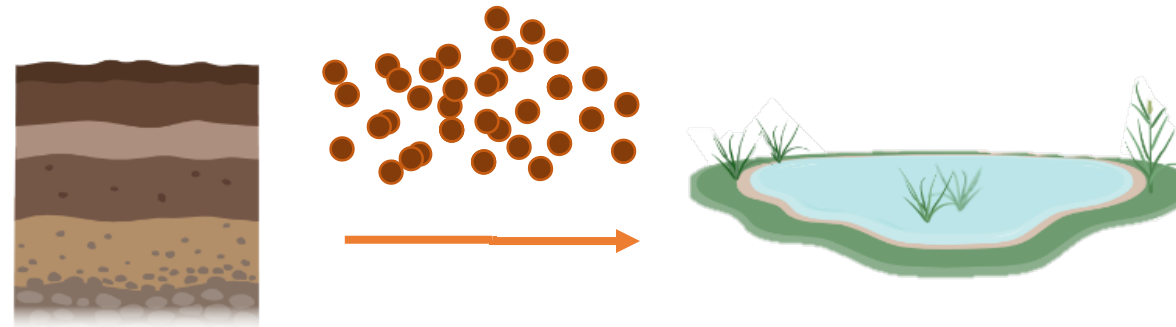
climate change



overfertilization

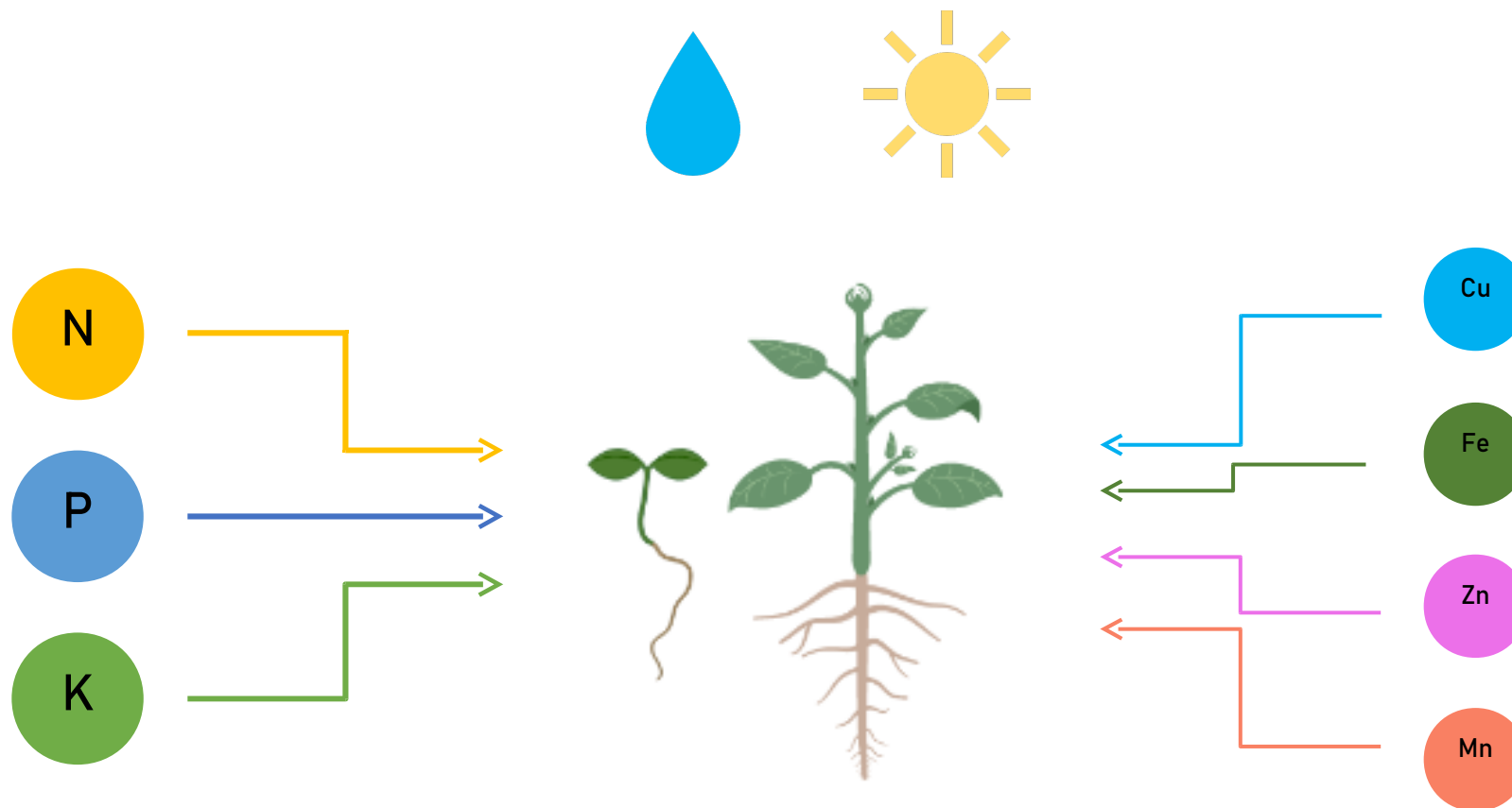


nutrients leaching to groundwater

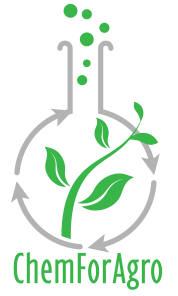


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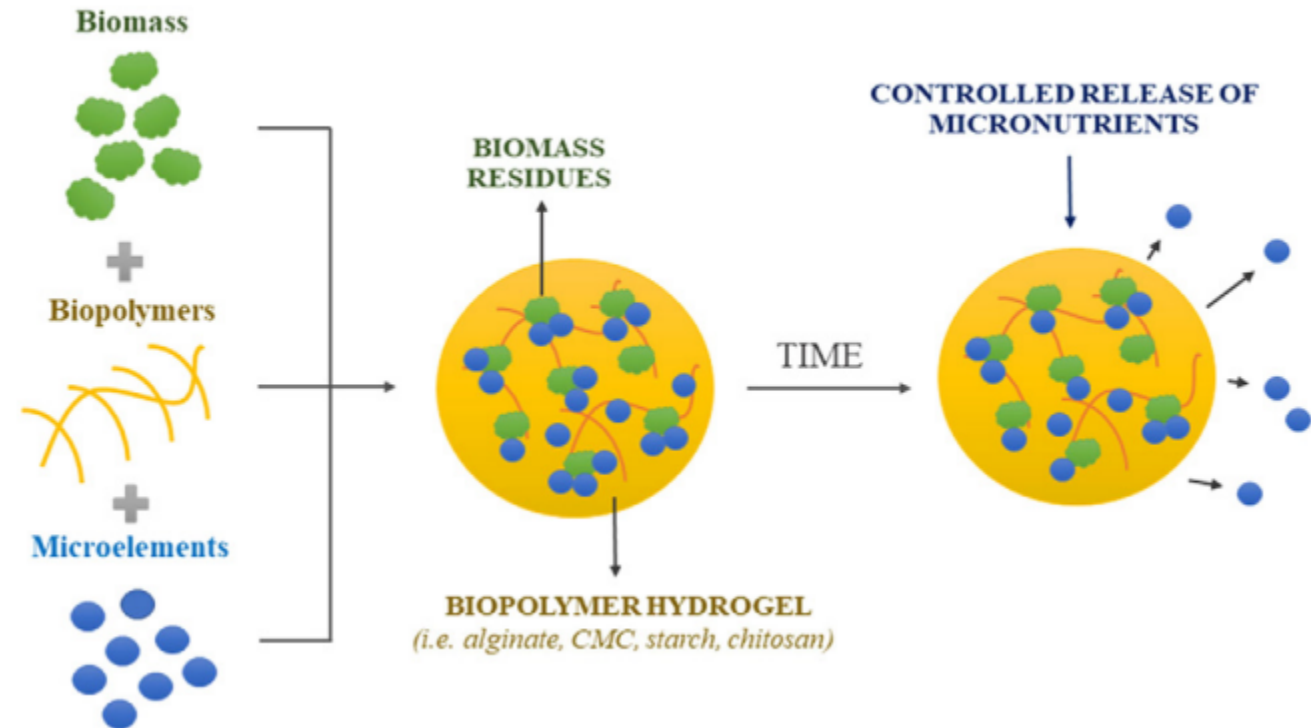
Nutrients for healthy plant growth



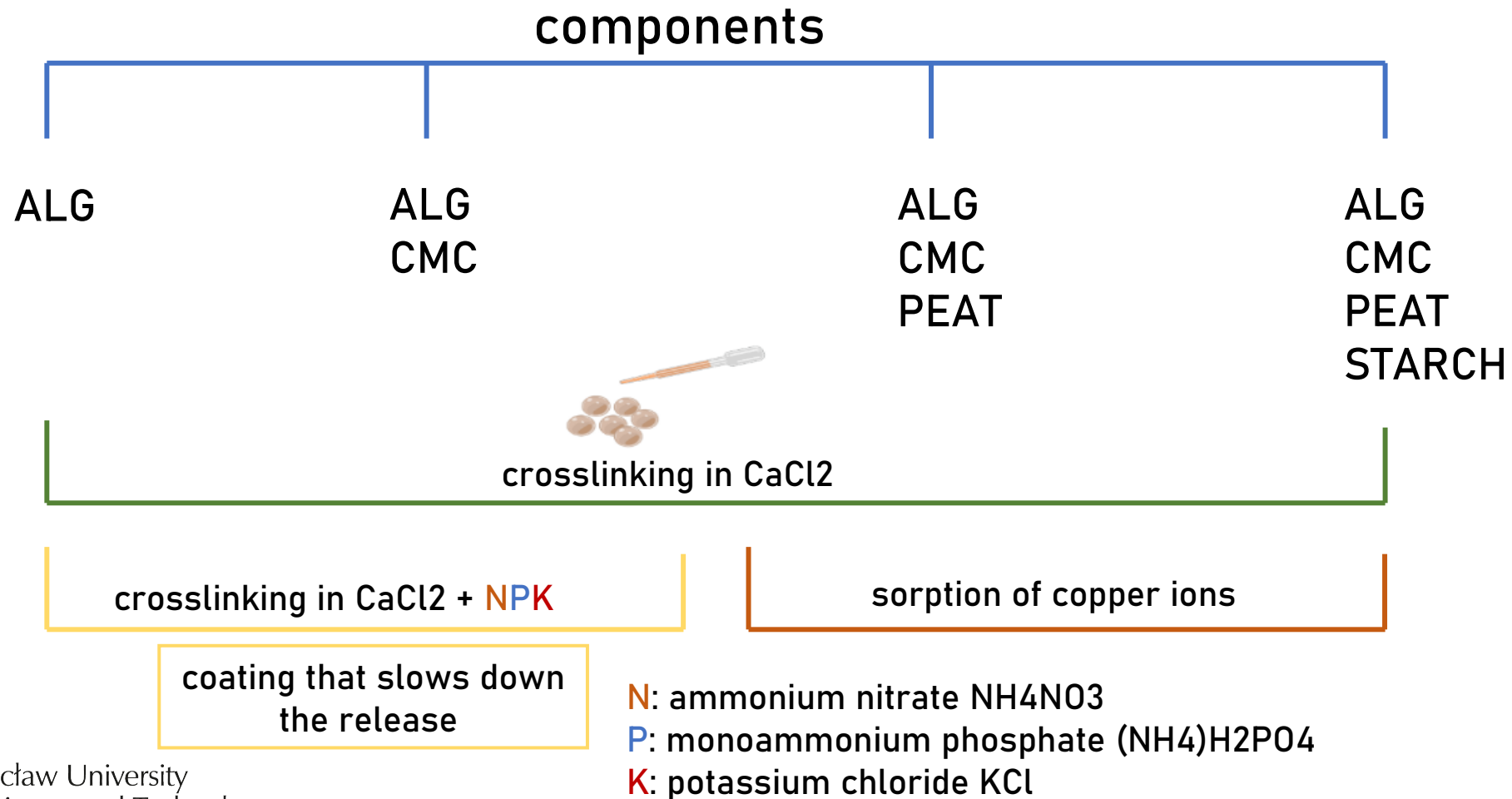
Hydrogel fertilizers - key to sustainable agriculture



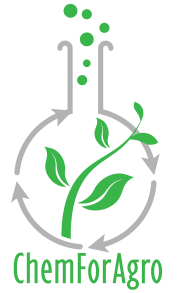
- natural material
- high moisture storage capacity
- biocompatibility
- biodegradability
- controlled release of nutrients



Matrix based hydrogels



Matrix based hydrogels

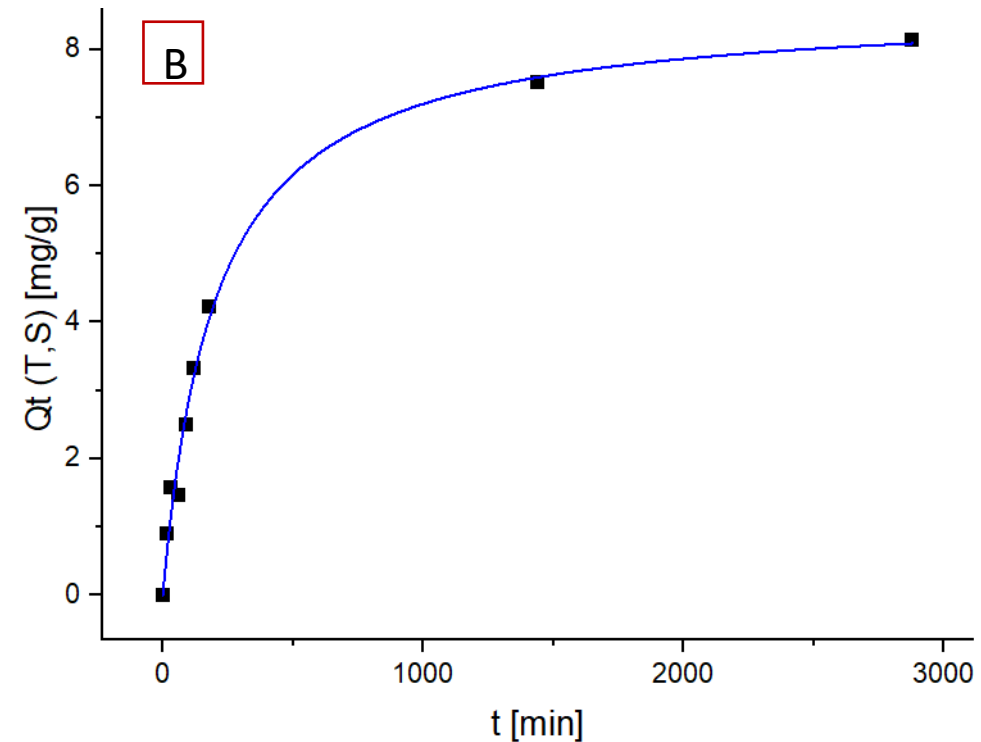
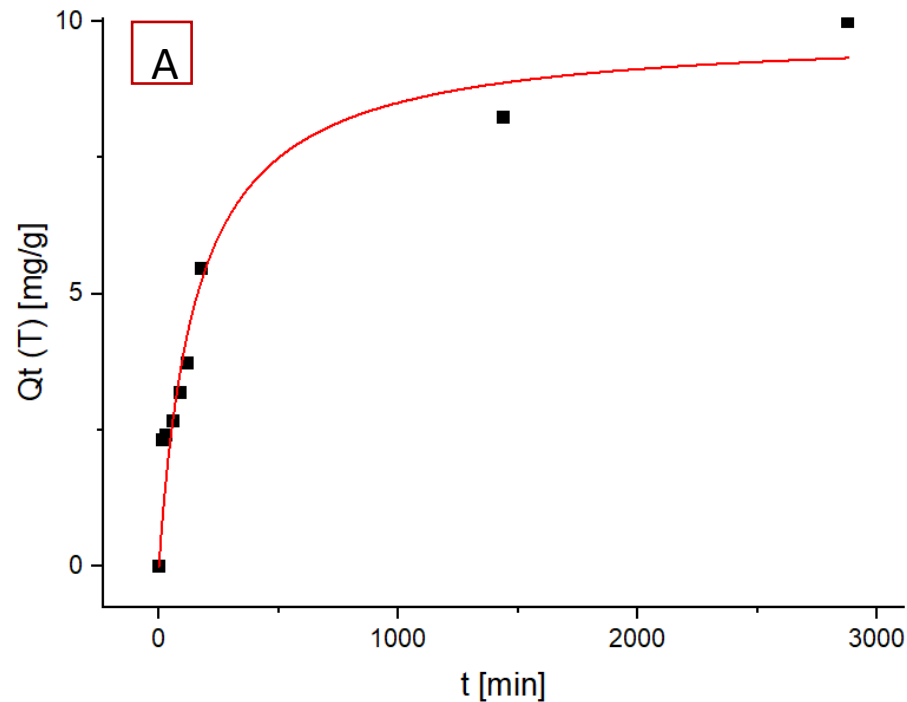


components	function
sodium alginate	non-toxic, biocompatible, abundantly available and relatively cheap natural material
sodium carboxymethylcellulose	additional building component of hydrogel structures, increases strength, mechanical, stability, swelling properties
peat	rich in many functional groups, high affinity for ion sorption
starch	low-cost and biodegradable coating material, improves mechanical properties



Sorption kinetics of copper ions

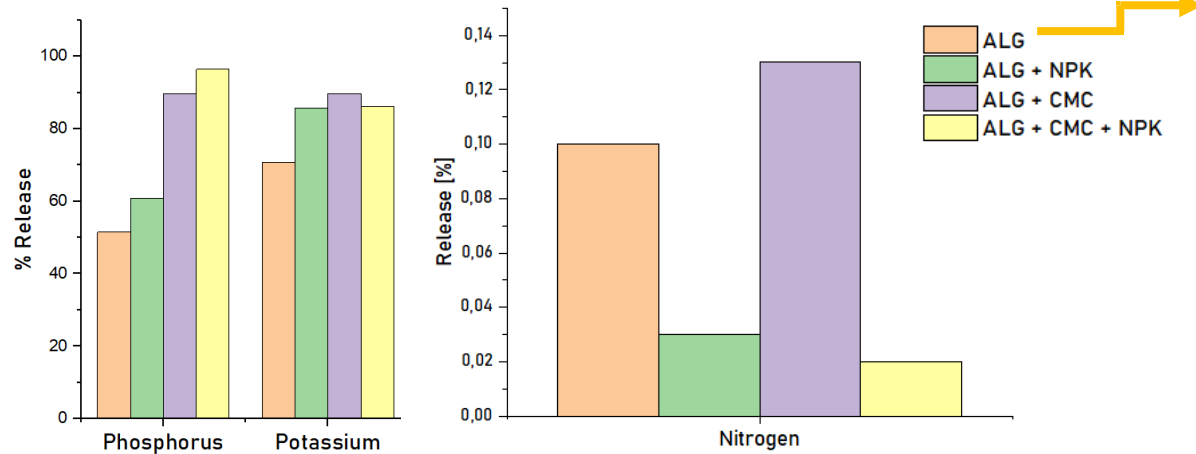
$$Q_t = Q_e - (Q_e^{1-n_1} + (1 + n_1)k_u t)^{\frac{1}{1-n_1}}$$



Sorption kinetics determined by generalized model for nutrients with:
peat (A) and starch (B)



NPK release

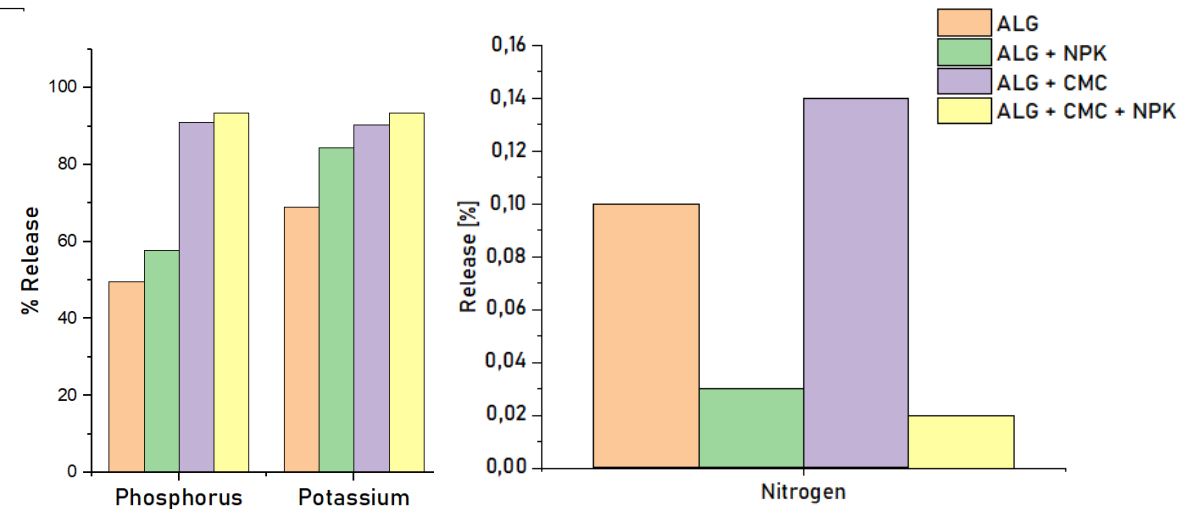
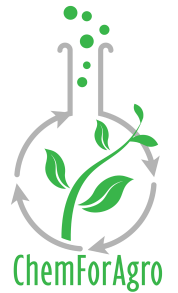


NPK release in water after 24h

the release of nitrogen occurs during the degradation of alginate (about 2 weeks)

slow release of nitrogen

through electrostatic interactions, nitrogen binds to the matrix

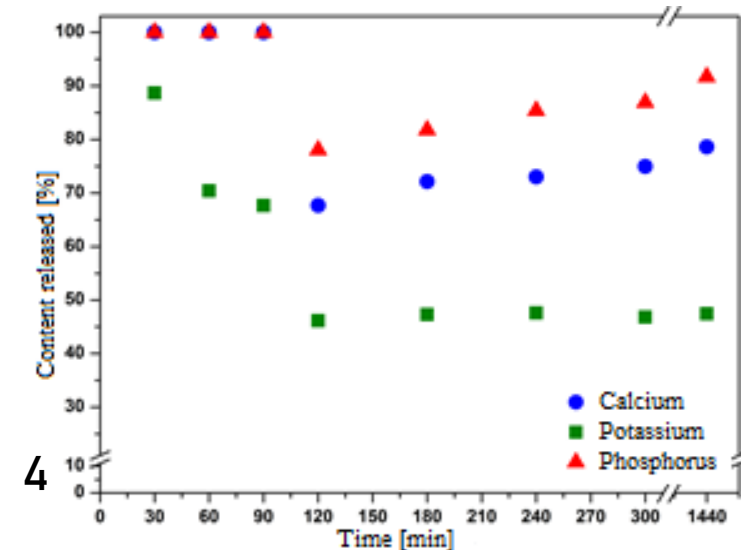
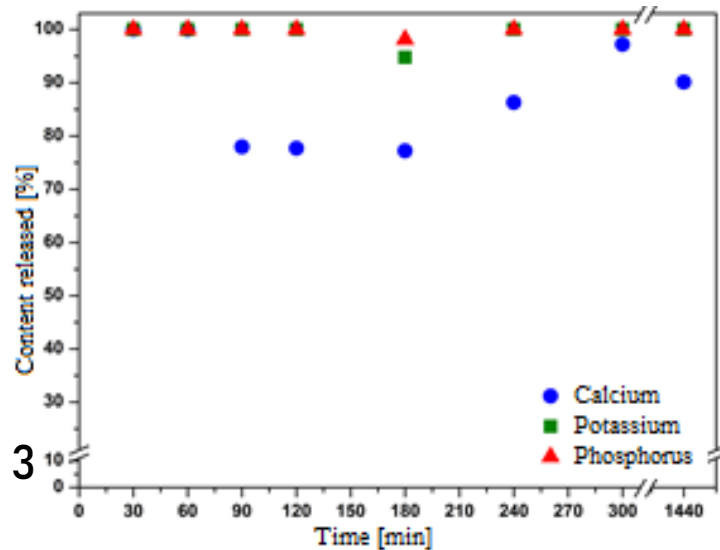
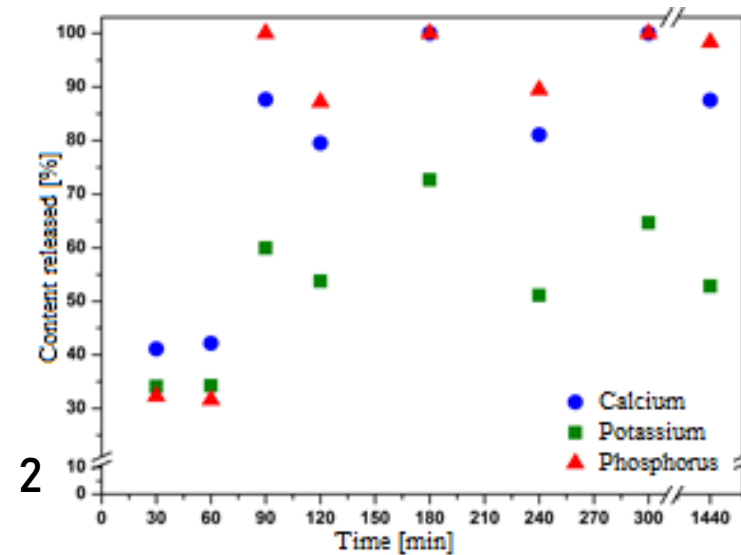
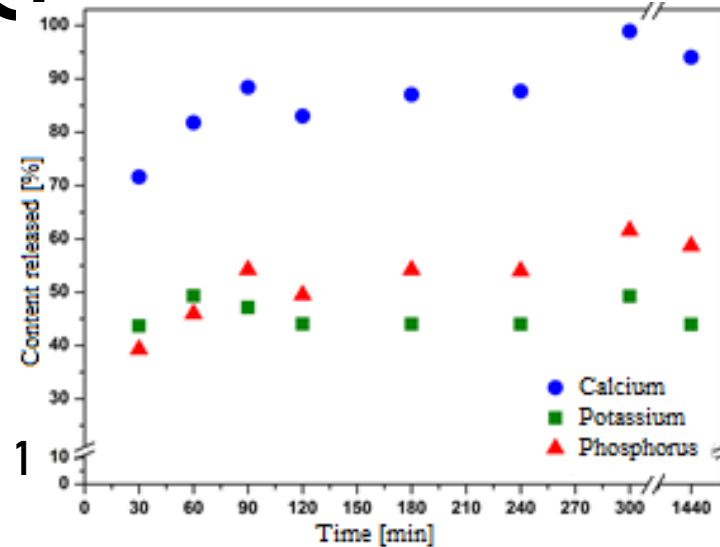


NPK release in sodium citrate after 24h



Release kinetics from coated composites

- 1 – ALG coated
- 2 – ALG + NPK coated
- 3 – CS coated
- 4 – hybrid coated



Germination tests

Legend:

K1 - Control test without fertilizer

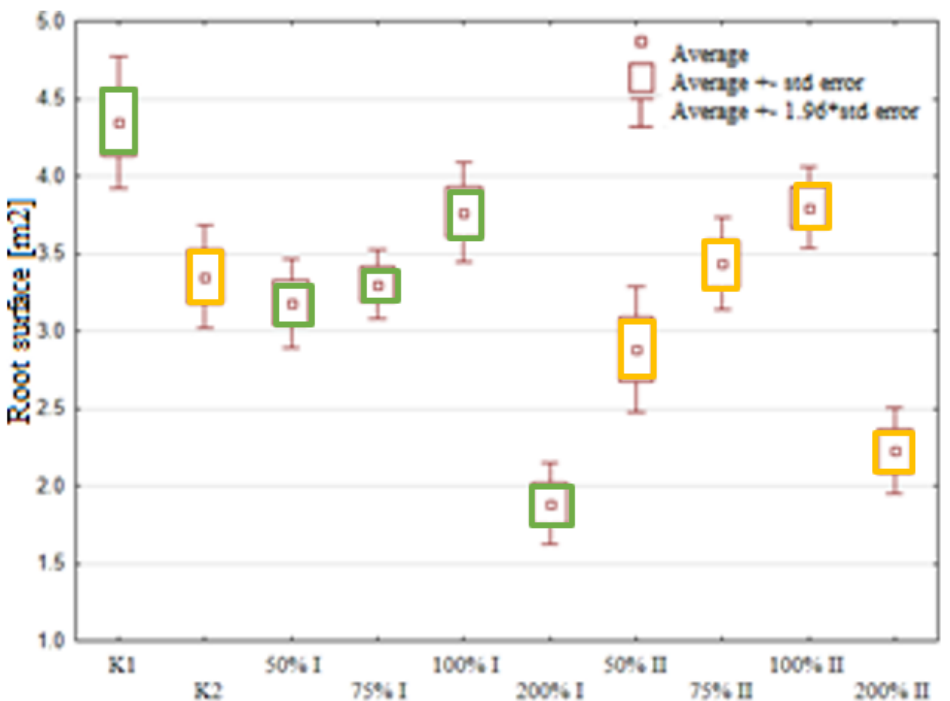
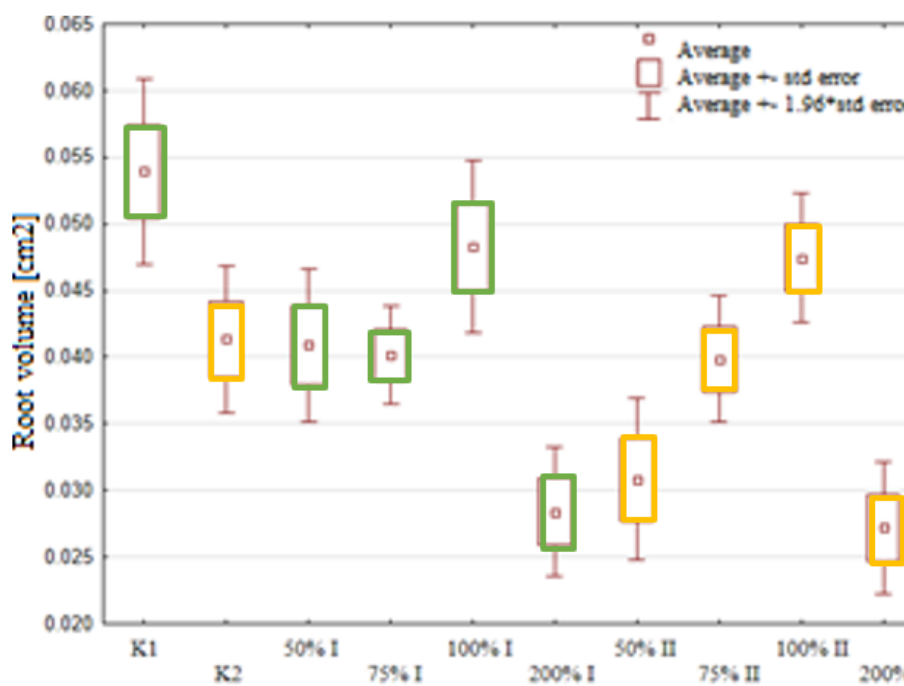
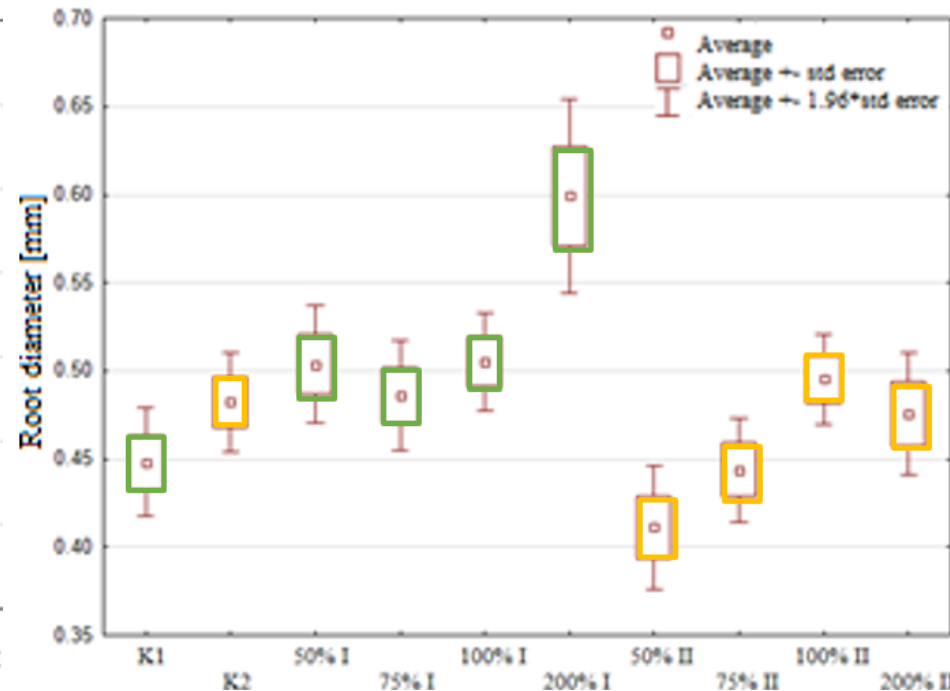
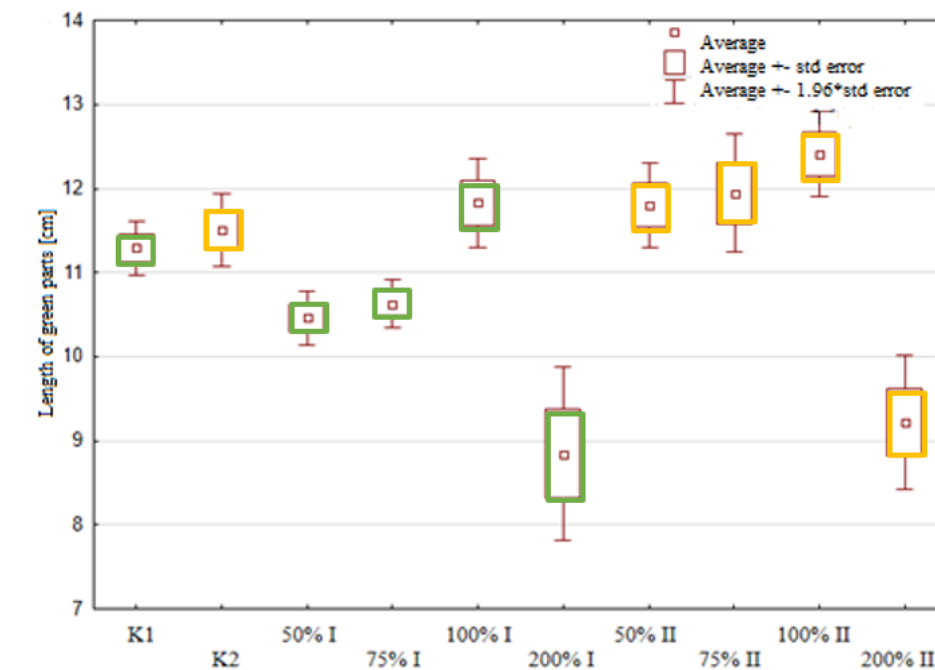
K2 - Control test with liquid NPK fertilizer

% - the dose of applied fertilizer, where

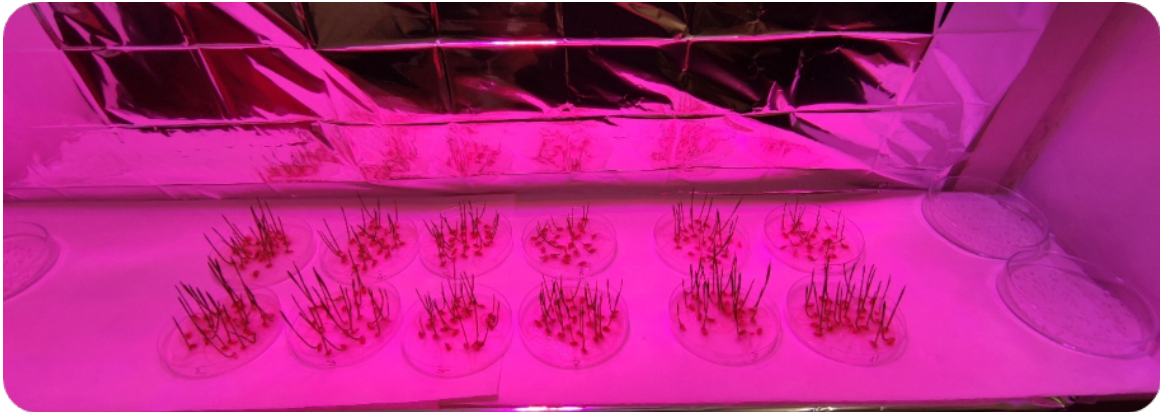
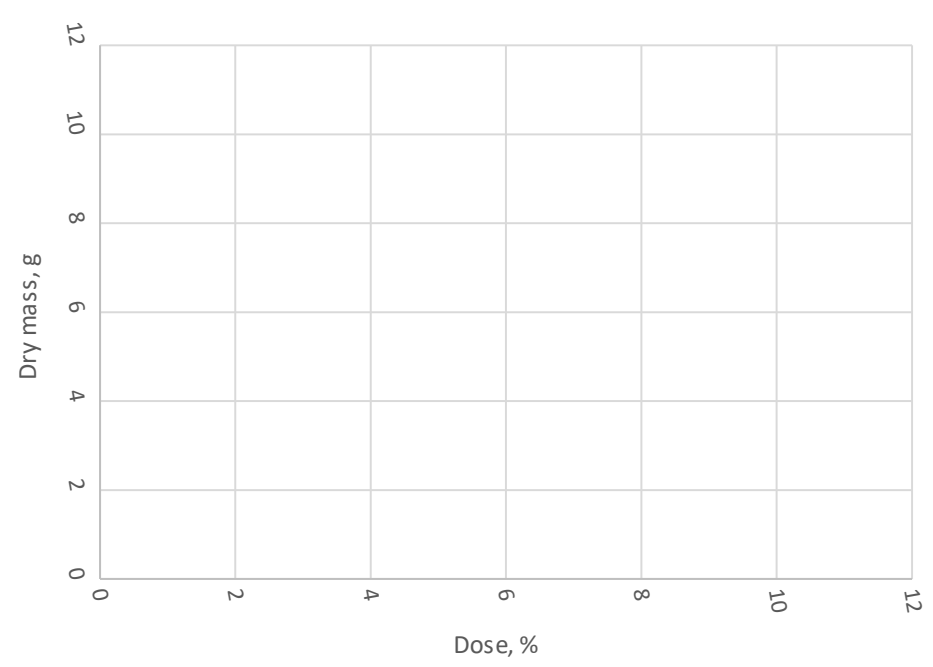
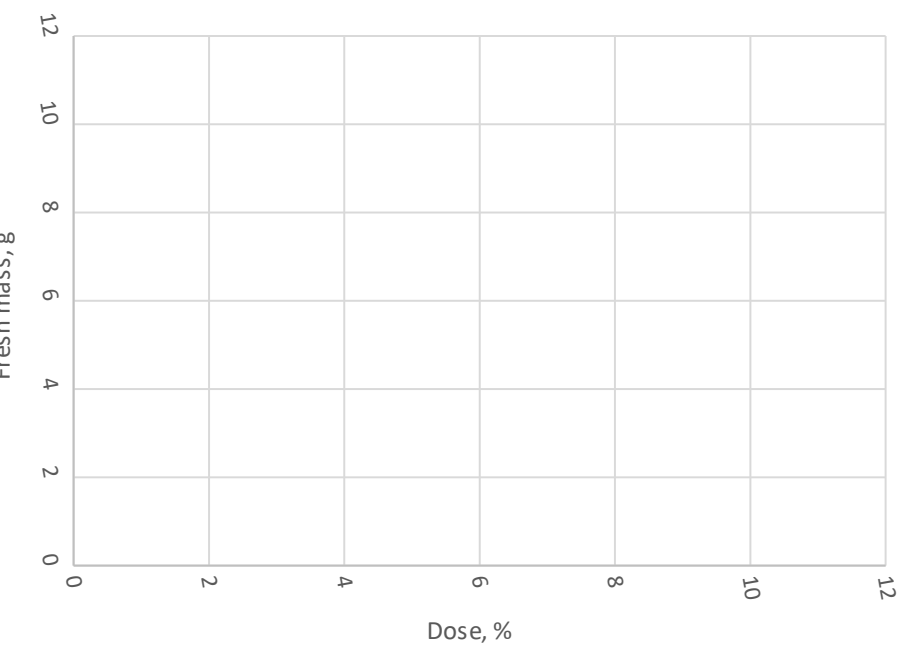
100% = 140kg nitrogen/ha

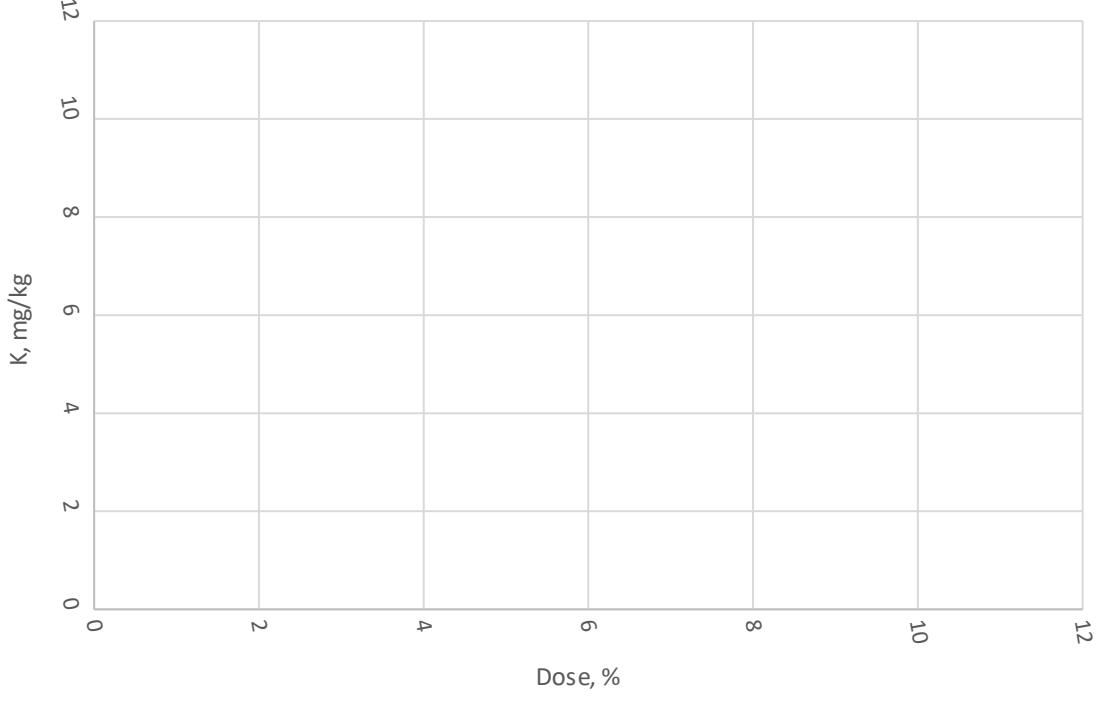
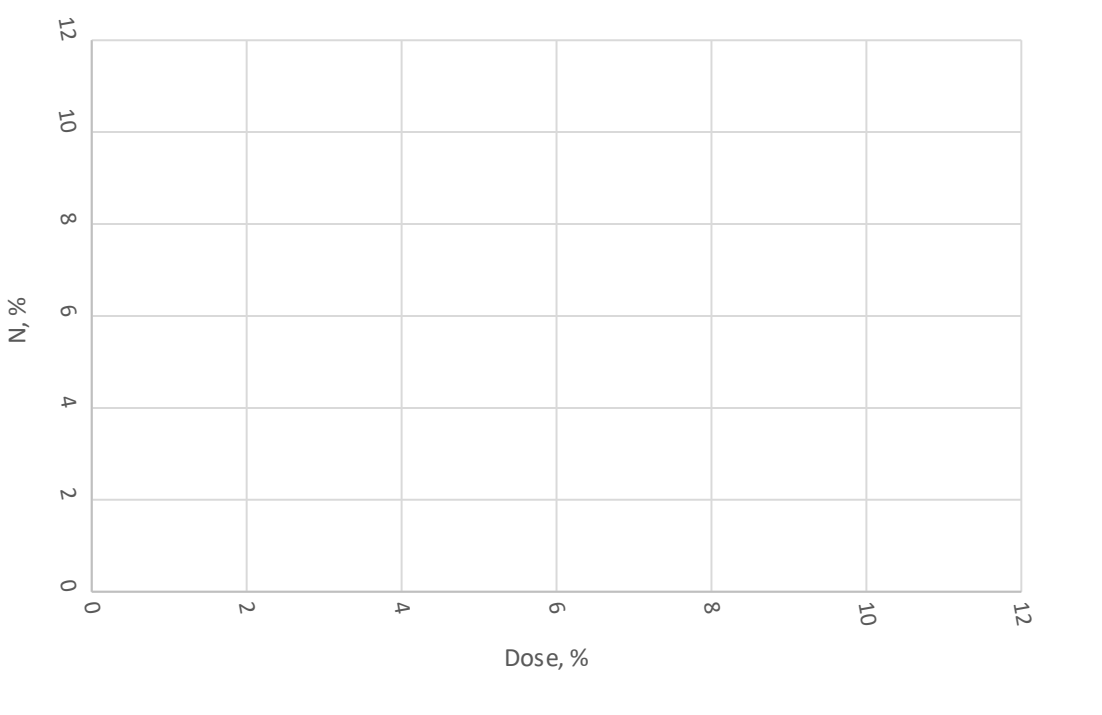
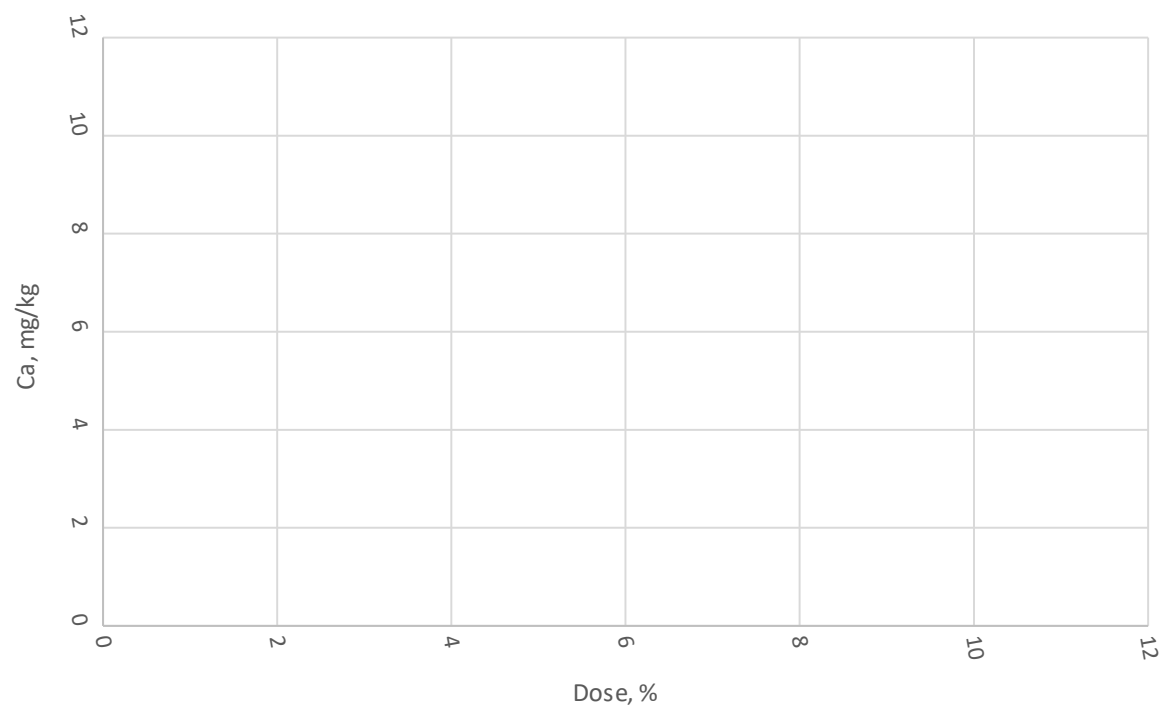
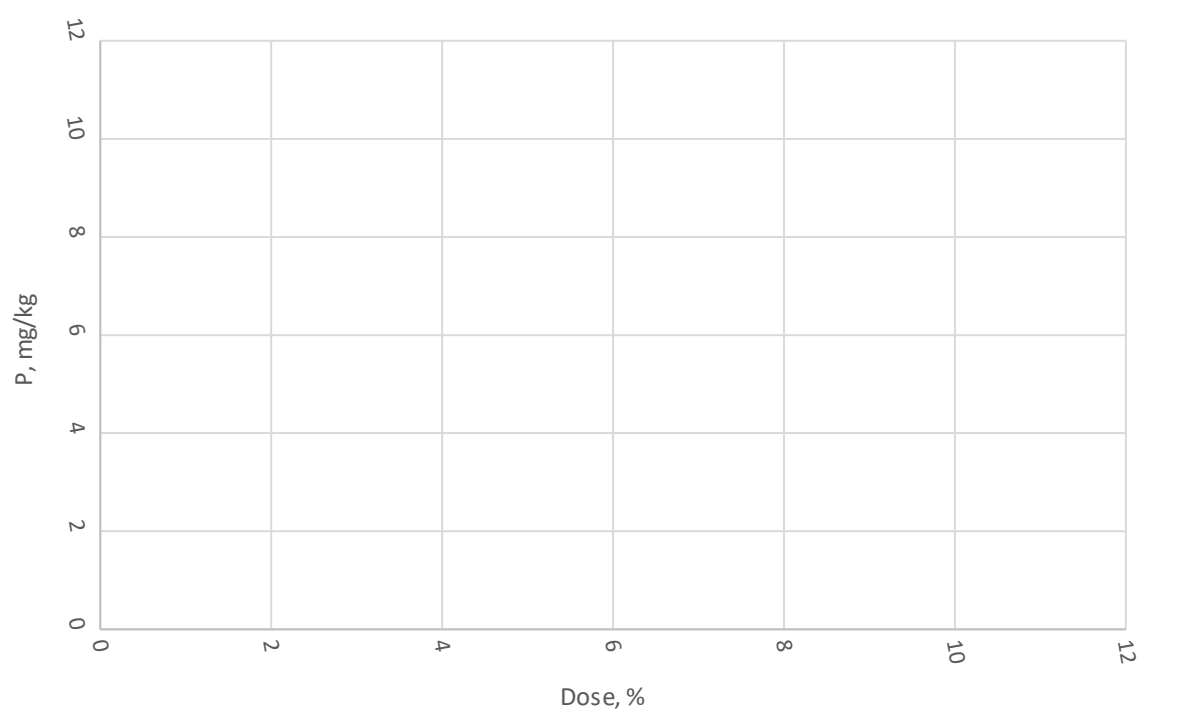
I - ALG-based fertilizer

II - fertilizer based on ALG+CMC

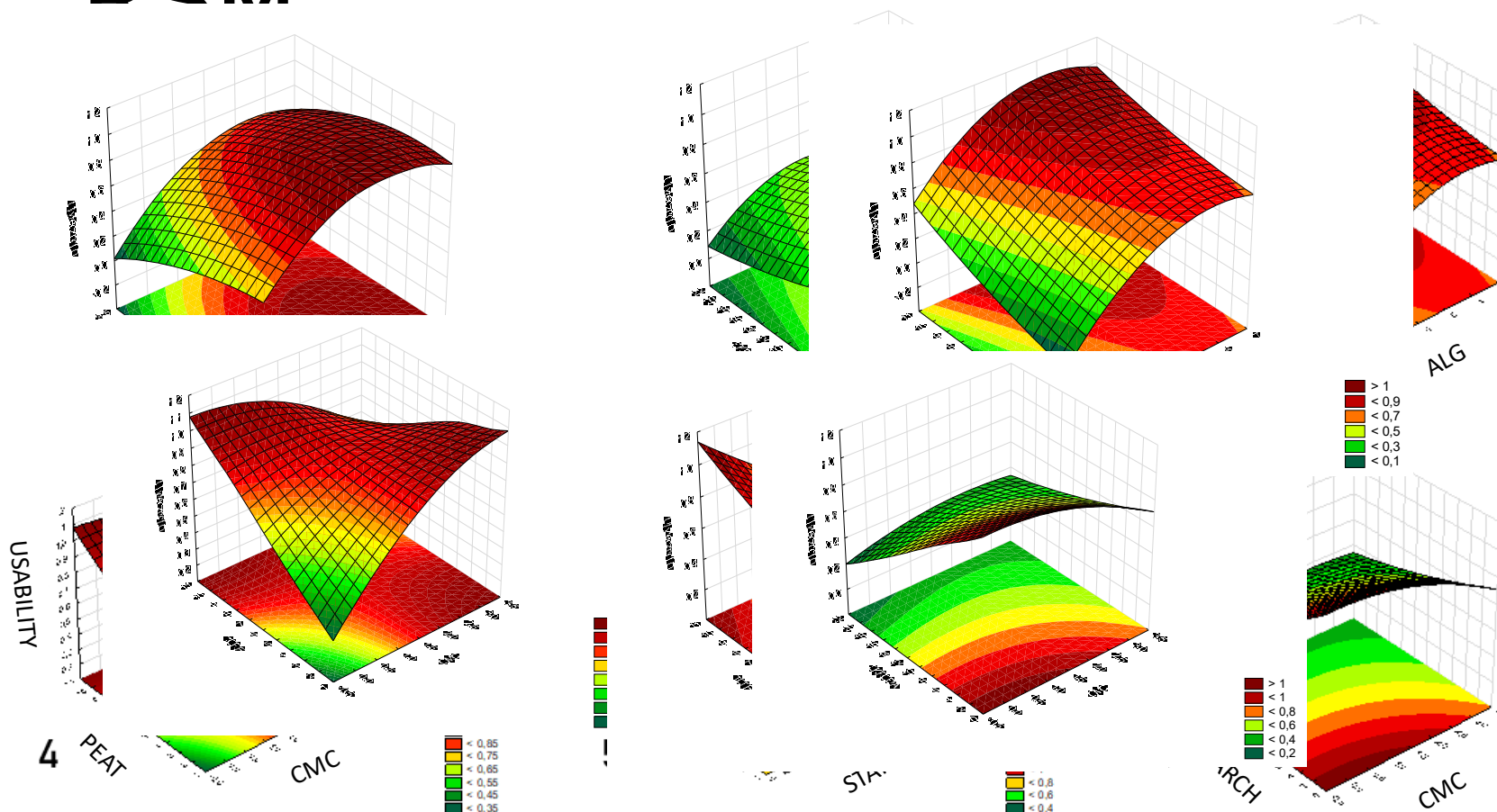


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Concentration optimization by DCM



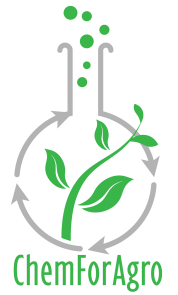
COMPONENT	MIN [%]	MAX [%]
ALG	1,5	6
CMC	0,1	3
STARCH	2	20
PEAT	2	10

System response:
content of adsorbed
copper ions



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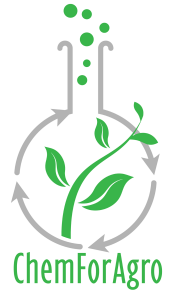
Raw material cost to produce 1 kg of fertilizer



components	Cost [€]
alginate sodium	5.88
carboxymethylcellulose sodium	2.47
peat	1.08
starch	1.10
ammonium nitrate	0.61
monoammonium phosphate	6.37
potassium chloride	6,66
calcium chloride	3.98
summary	28.15

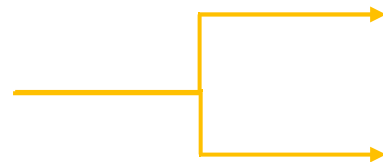


To sum up



- 1) The designed matrices based on biopolymers, carboxymethylcellulose and alginate, demonstrated the ability to encapsulate fertilizer nutrients NPK.
- 2) The effectiveness of slow-release coatings has been demonstrated. They reduced the release of calcium and potassium by 35% and phosphorus by 45% per day.
- 3) Biosorbents such as peat enable the sorption of significant amounts of copper ions, making it possible to design fertilizers with extended micronutrient release times

WHAT'S NEXT?



Complete analysis of peat- and starch-supplemented hydrogels produced (e.g., release kinetics, bioavailability, germination and pot trials)

Use of other additives, e.g. bentonite, and coatings for more complex materials



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