Multicomponent hydrogel fertilizer technology for sustainable agriculture

Kliknij, aby edytować styl wzorca podtytułu

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Fertilizer crisis

Food security

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

PHOTOGRAPH BY PETER ESSI[...] AT GEO IMAGE COLLECTION

ENVIRONMENT

Global food crisis looms as fertilizer supplies dwindle

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

BY JOEL K. BOURNE, JR.

Ocena z zaliczenia

Hanna Grzeleńska <258653@student.pwr.edu.pl>

10:50

Do: katarzyna.chojnacka@pwr.edu.pl

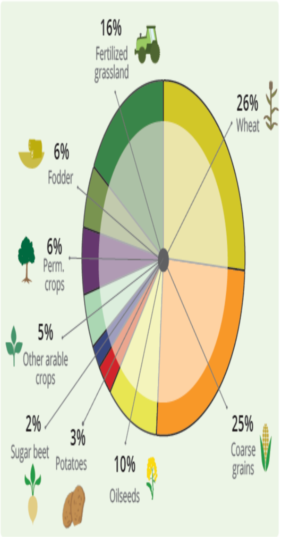
Szanowna Pani Profesor,

Chciałam zgłosić, że zaszła chyba pomyłka, ponieważ wiem, że pisała do Pani Profesor Pani Agata Guglas z zapytaniem, że nie ma wpisanej oceny z wykładu z Metod Biotechnologicznych w oc[...]
środowiska, a zaliczyła na ocenę 3.0. Za to ja sprawdziłam w swoim indeksie, że mam wpisaną ocenę 3.0 właśnie z wczorajszego zaliczenia, kiedy to ja nie zaliczyłam wczoraj i poinformowała n[...]
przyszła na drugi termin. Przypuszczam, że ocena w moim indeksie jest oceną Pani Agaty Guglas, byłyśmy w tej samej grupie. Dodatkowym problemem jest to iż, omyłkowo zaakceptowałam [...]
po zaakceptowaniu zobaczyłam jaki to jest przedmiot. Za co bardzo przepraszam była to po prostu pomyłka z mojej strony i niedopatrzenie.

Z poważaniem

Hanna Grzeleńska

Fertilizer consumption by crop in the European Union



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

Source: Fertilizers Europe

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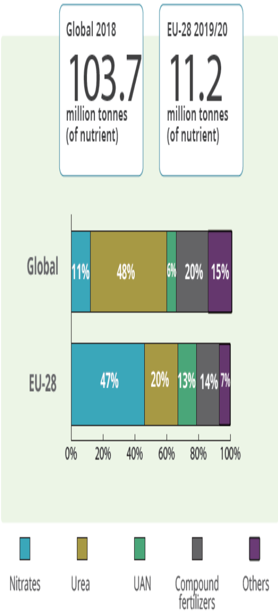
Nitrogen fertilizer consumption by product



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

Source: Fertilizers Europe/ IFA

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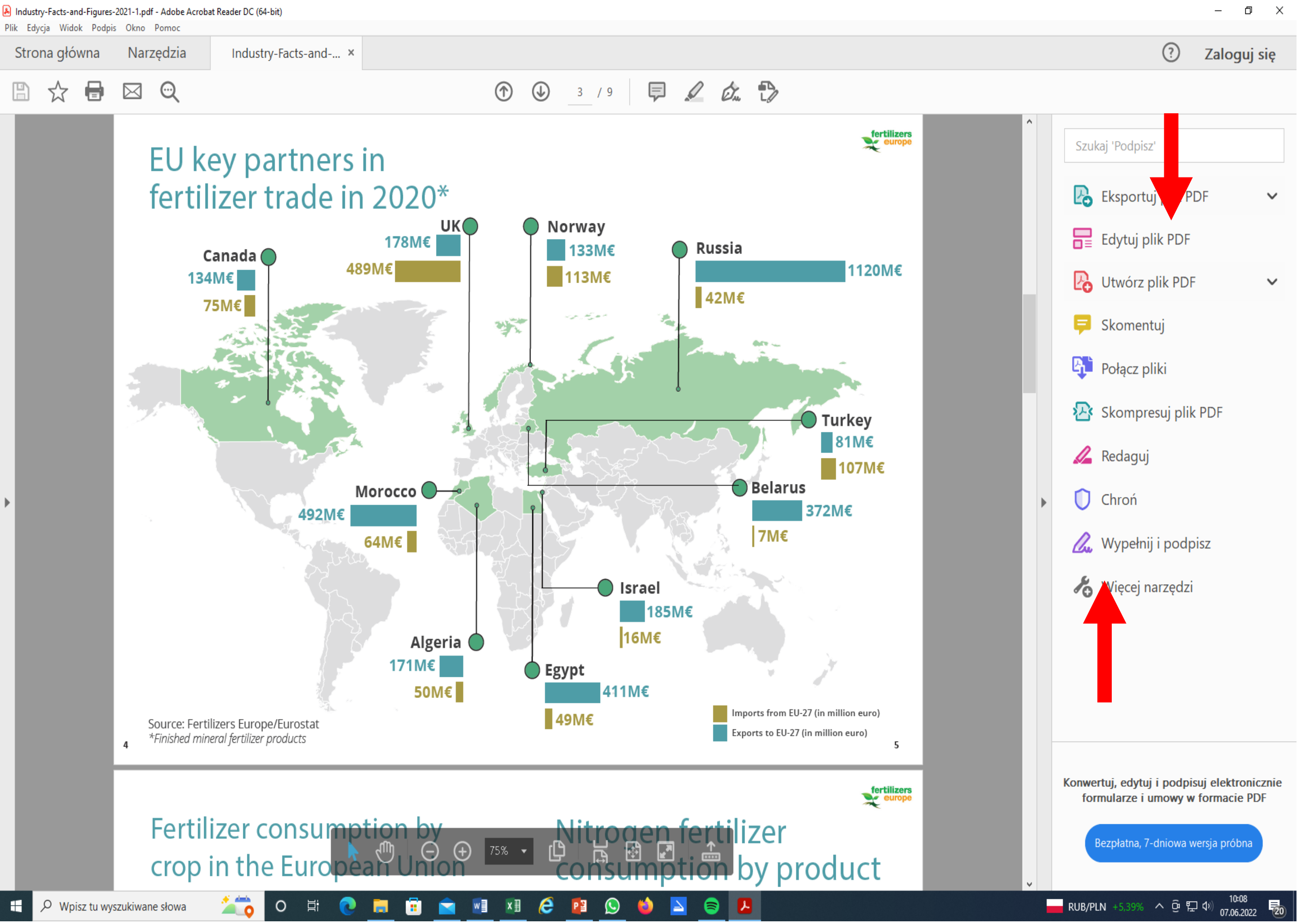
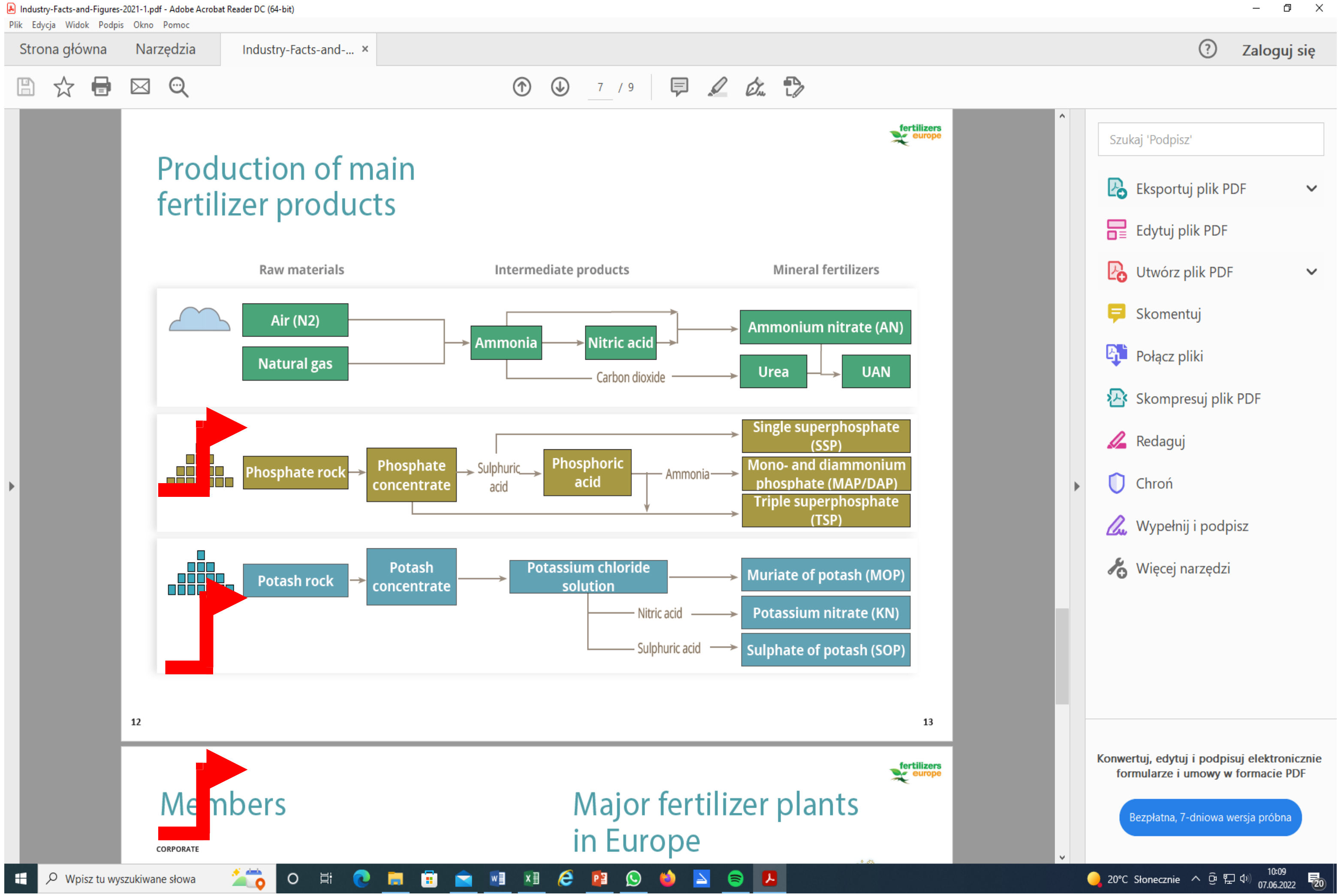
Fertilizer cons[...] in the European Union

Agricultural land use in the European Union



- 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.



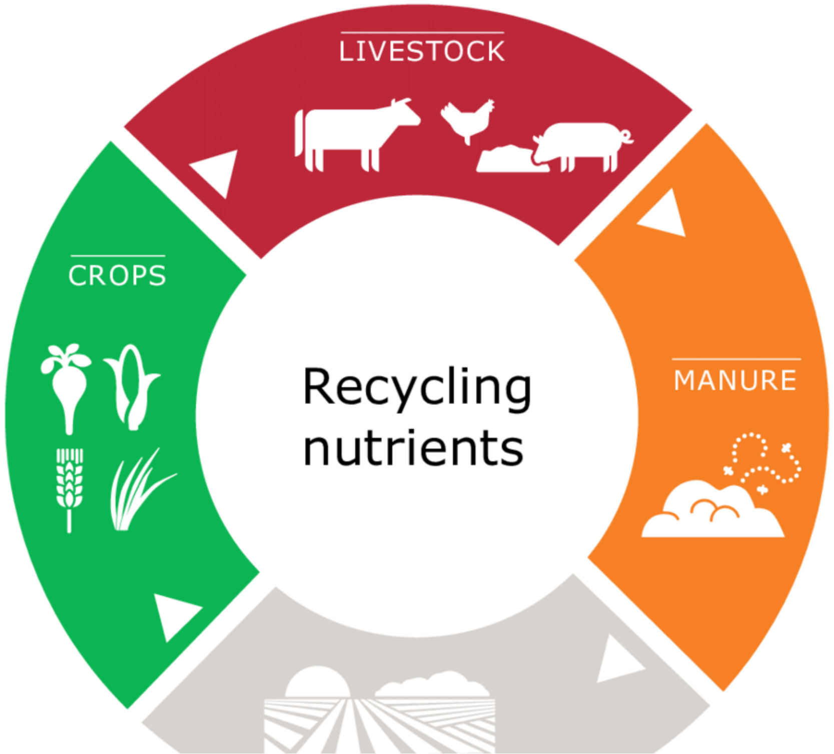
Russia and Belarus have supplied:

- natural gas
- 35% of phosphates
- 60% of potash and

to the EU market.

Solution:

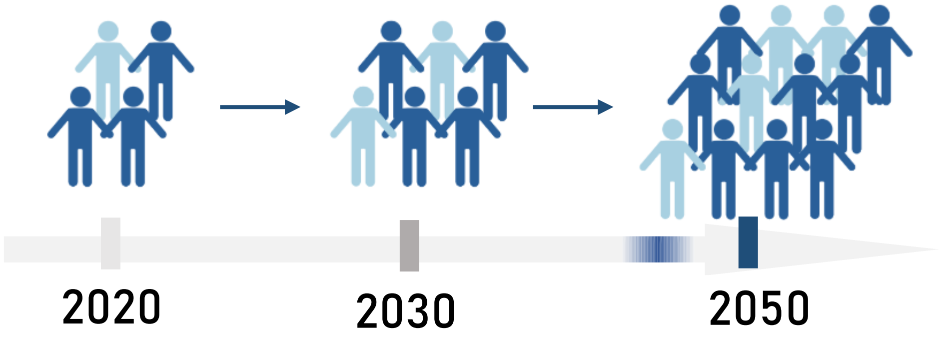
- Sustainable agriculture
- Locally available feedstock
- Circular economy – waste as a resource
- Integrated crop-livestock system
- Precision agriculture



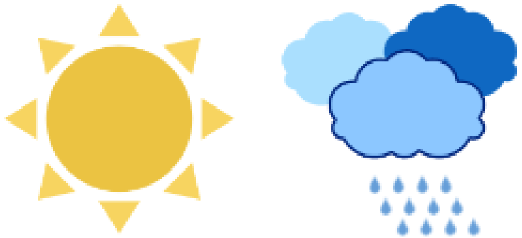
https://www.researchgate.net/figure/Circular-agriculture-Source-ASG-Livestock-Manure-brochure-WUR_fig1_336085866

Challenges and problems in agriculture

population growth

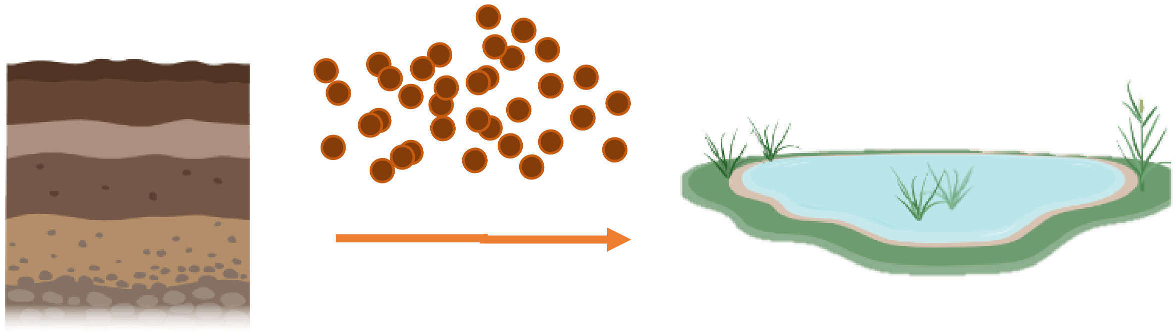


climate change

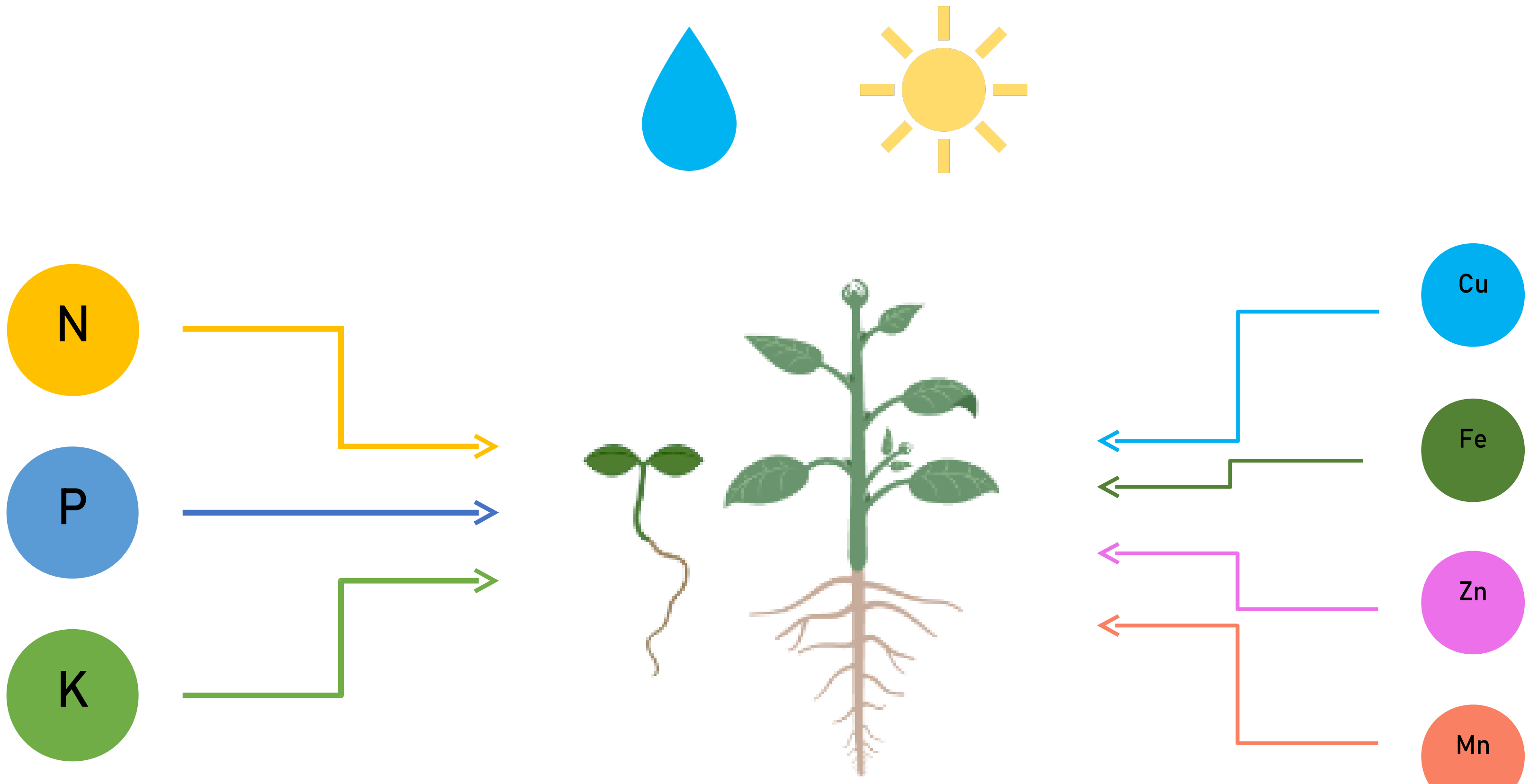


overfertilization

nutrients leaching to groundwater

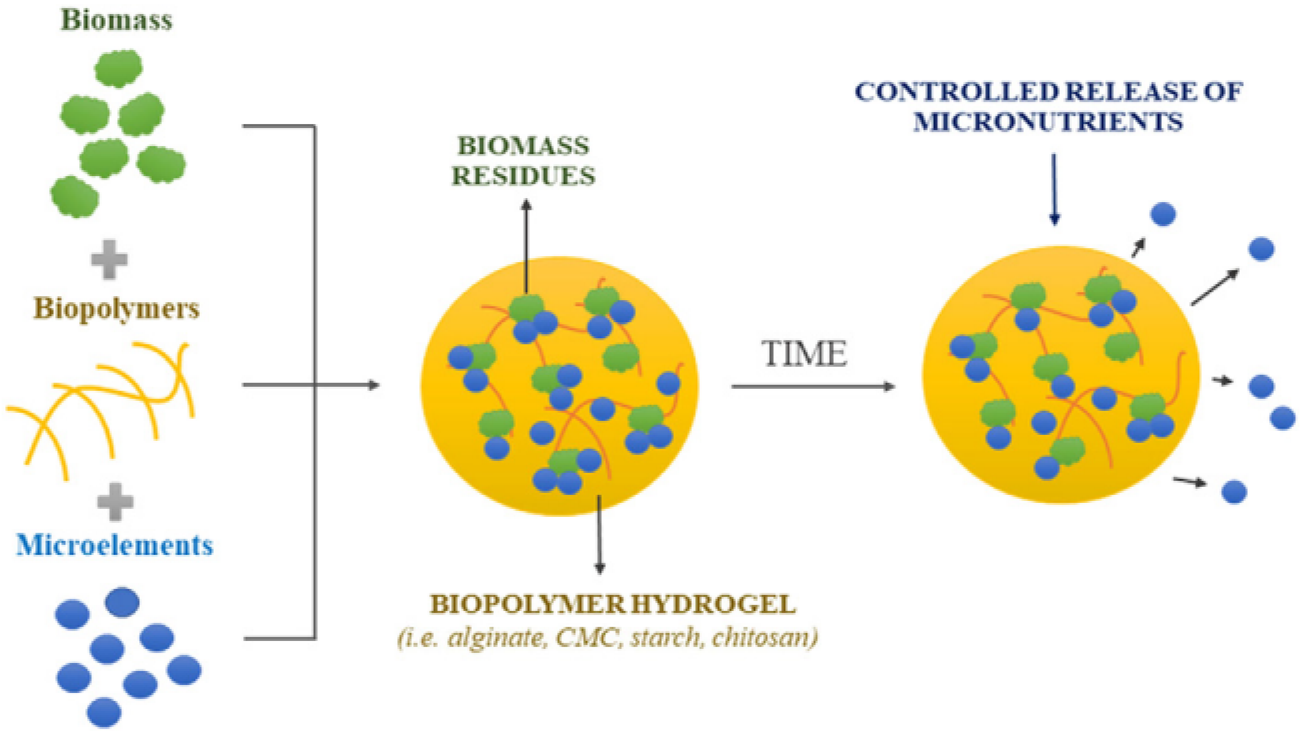


Nutrients for healthy plant growth



Hydrogel fertilizers – key to sustainable agriculture

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



Matrix based hydrogels

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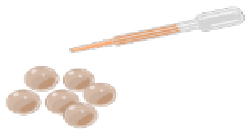
components

ALG	ALG CMC	ALG CMC PEAT	ALG CMC PEAT STARCH



crosslinking in CaCl2

crosslinking in CaCl2 + NPK

sorption of copper ions

coating that slows down the release

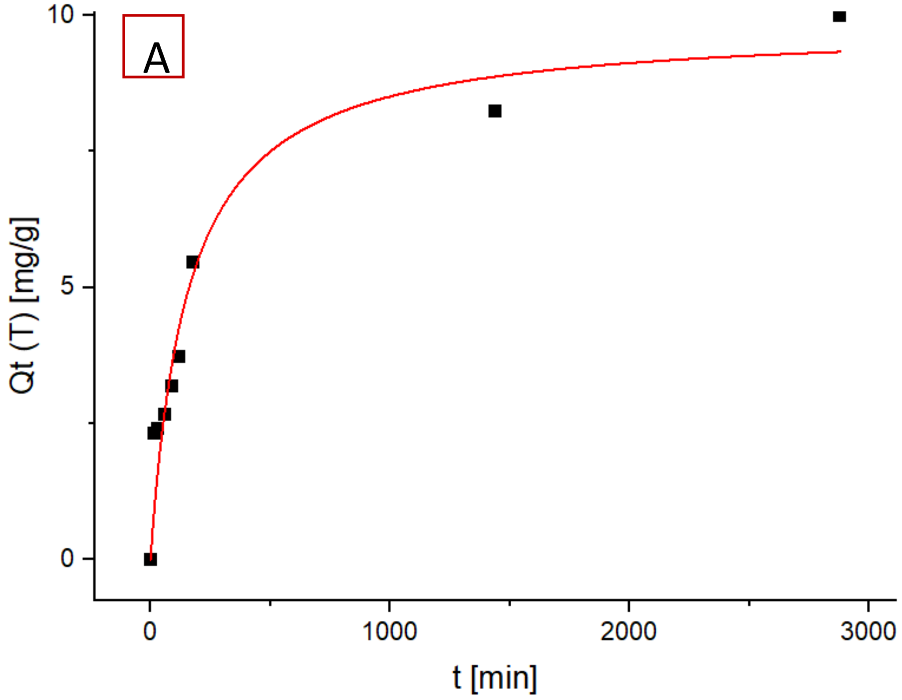
N: ammonium nitrate NH4NO3
P: monoammonium phosphate (NH4)H2PO4
K: potassium chloride KCl

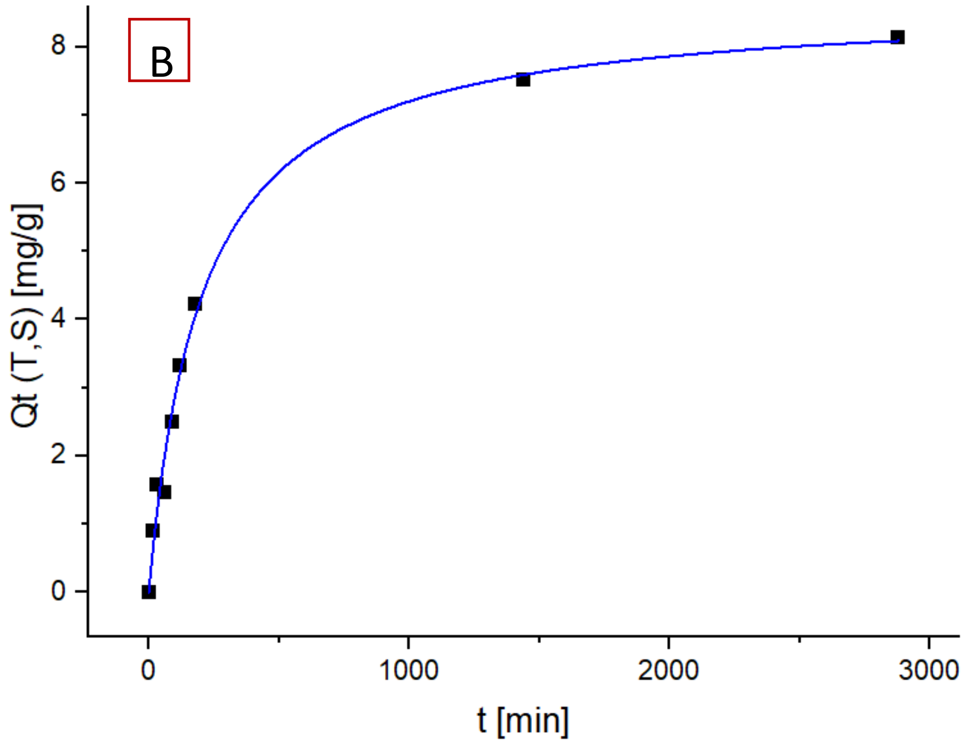
Matrix based hydrogels

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

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





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

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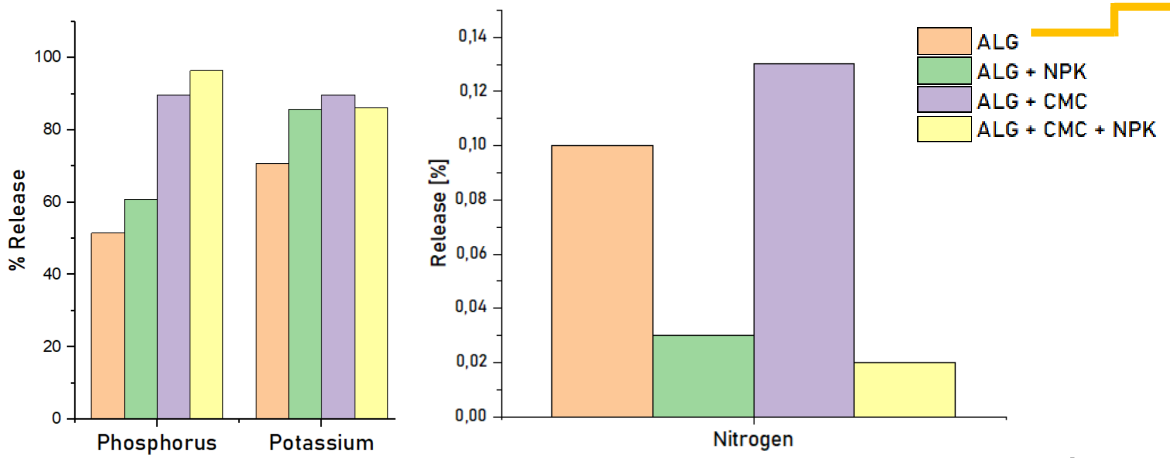
NPK release

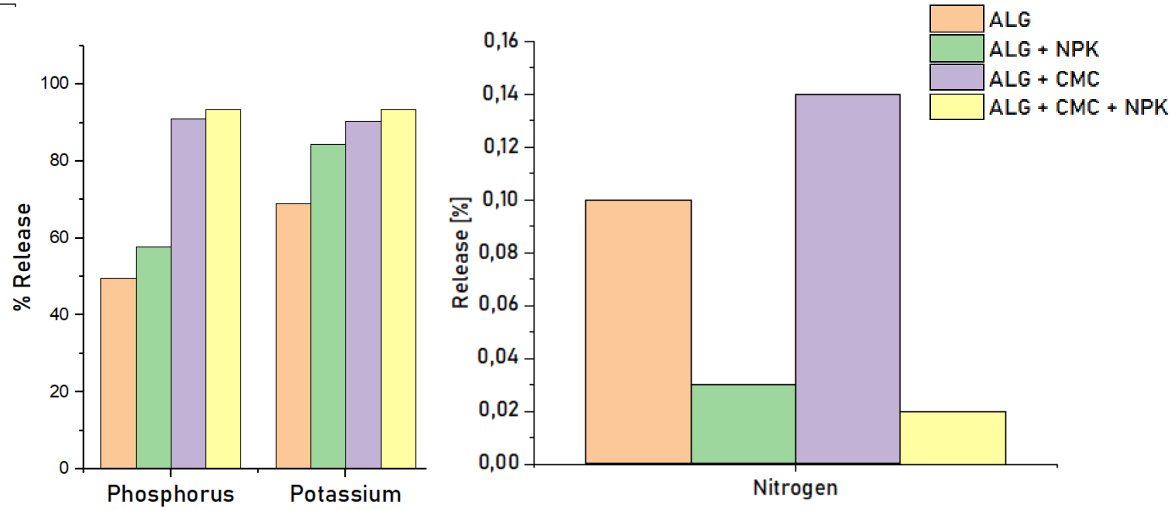


NPK release in water after 24h

slow release of nitrogen

through electrostatic interactions, nitrogen binds to the matrix

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



NPK release in sodium citrate after 24h

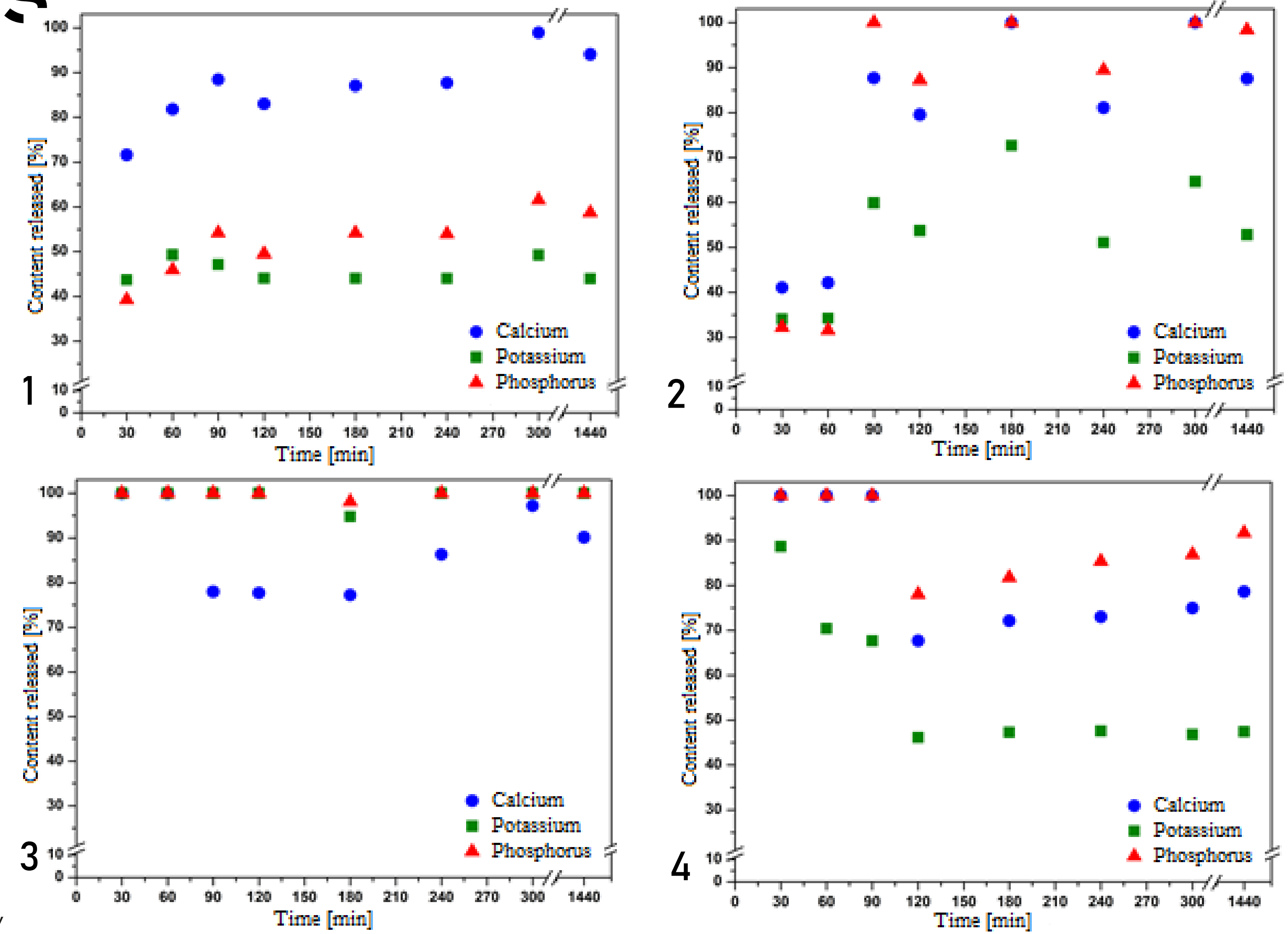
Release kinetics from coated composites

1 – ALG coated

2 – ALG + NPK coated

3 – CS coated

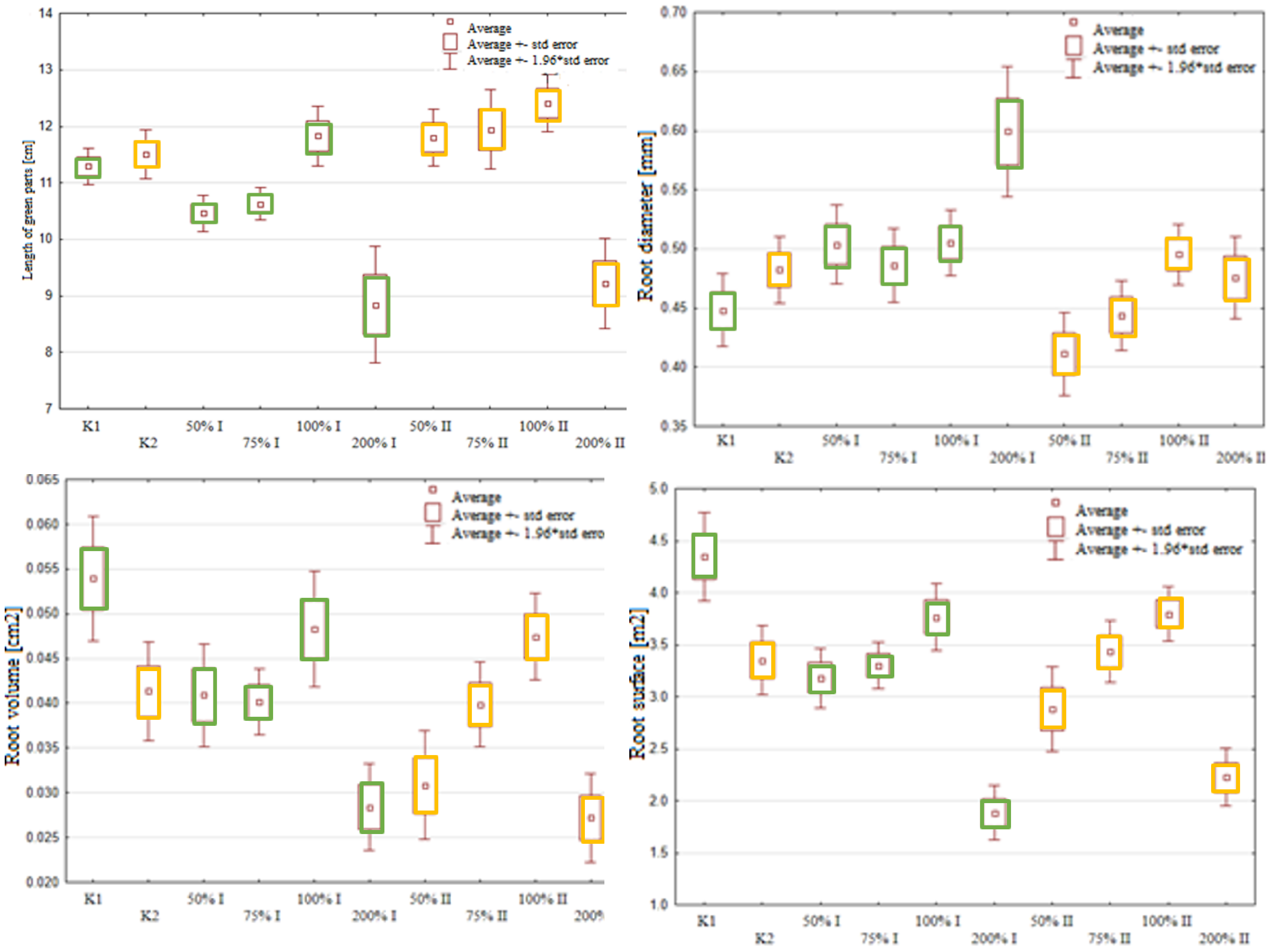
4 – hybrid coated



Germinatio n 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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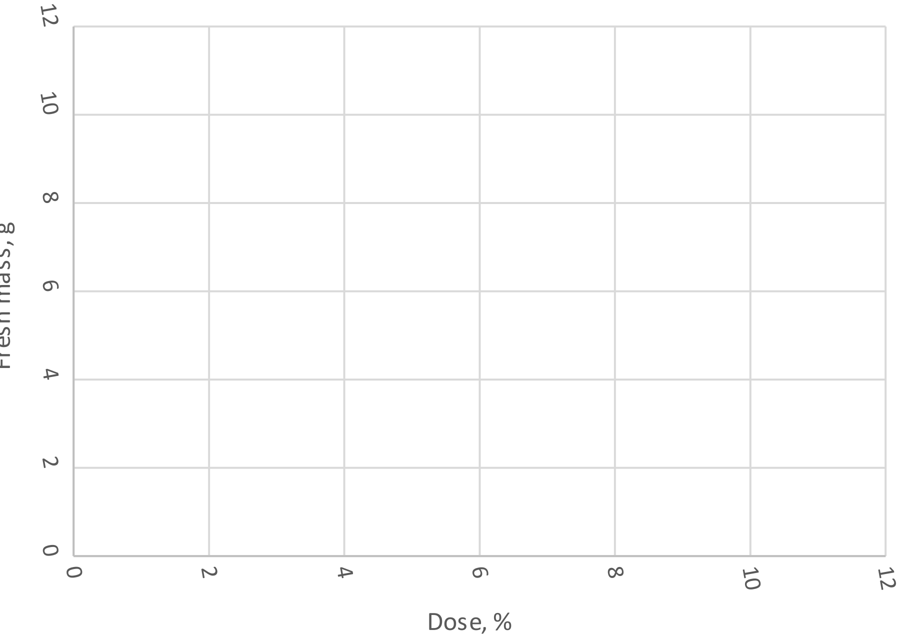
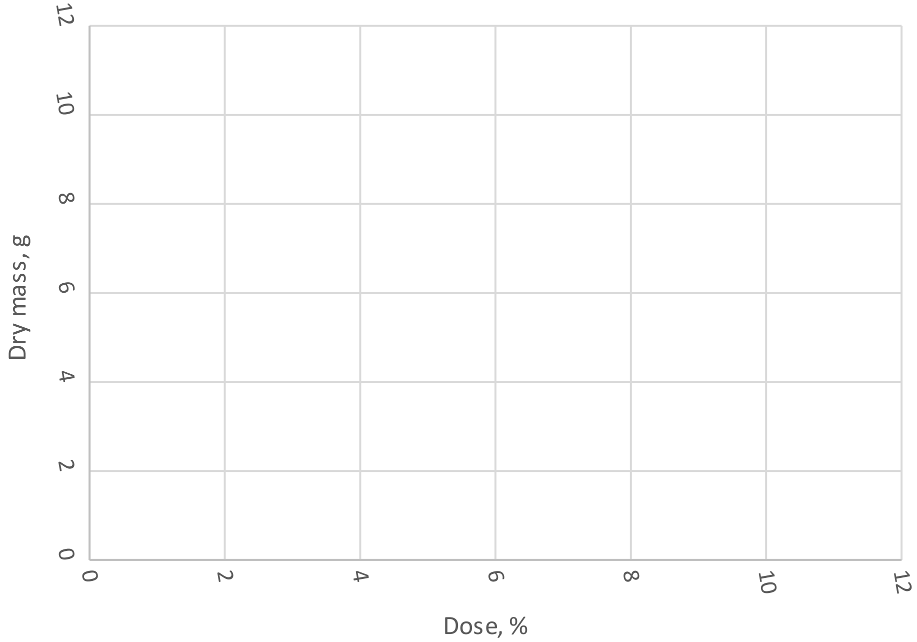
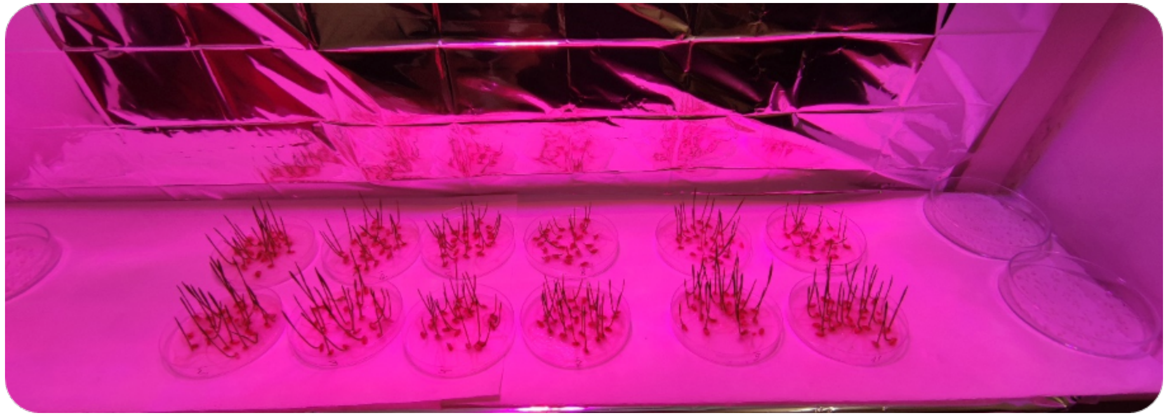
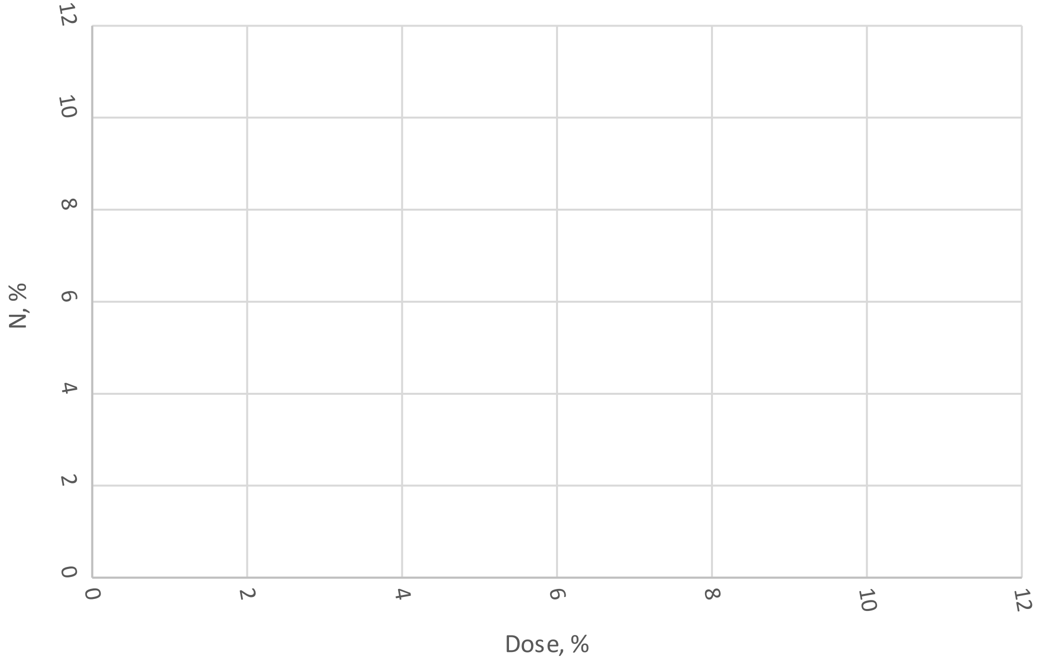
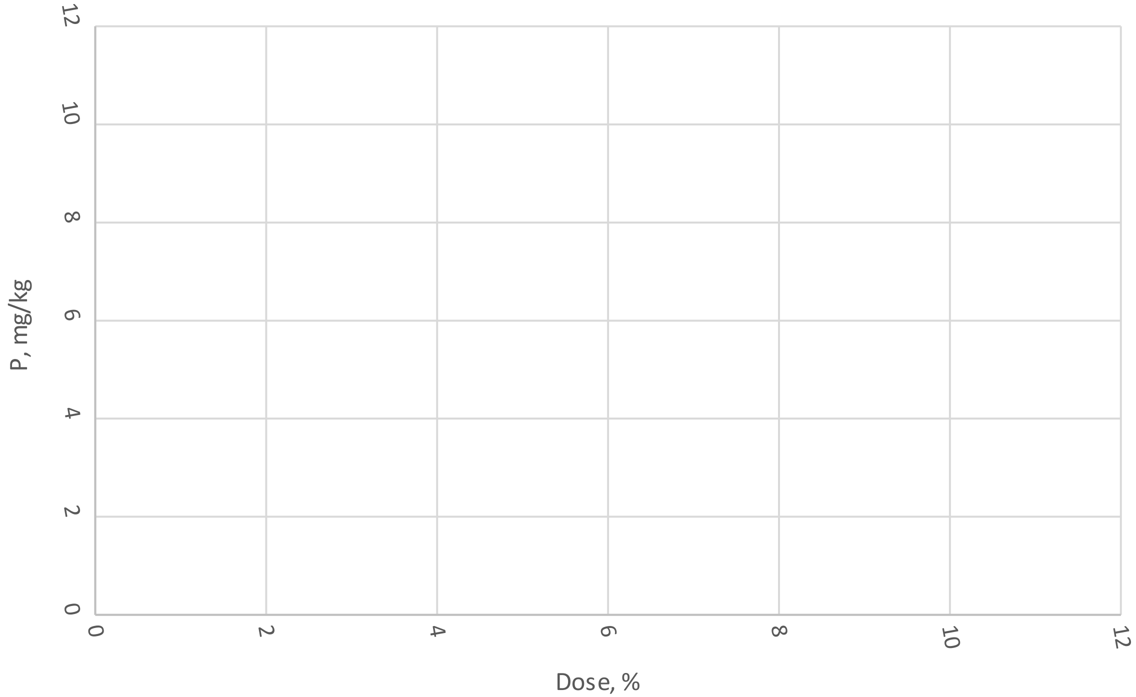
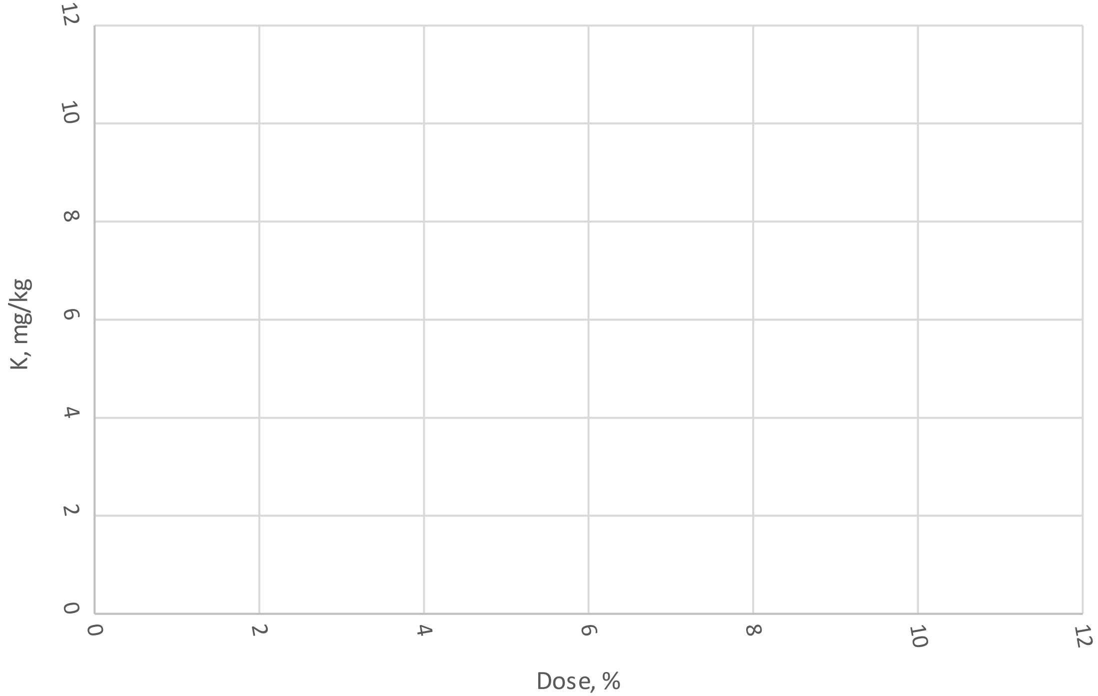

Dose, %
0 2 4 6 8 10 12

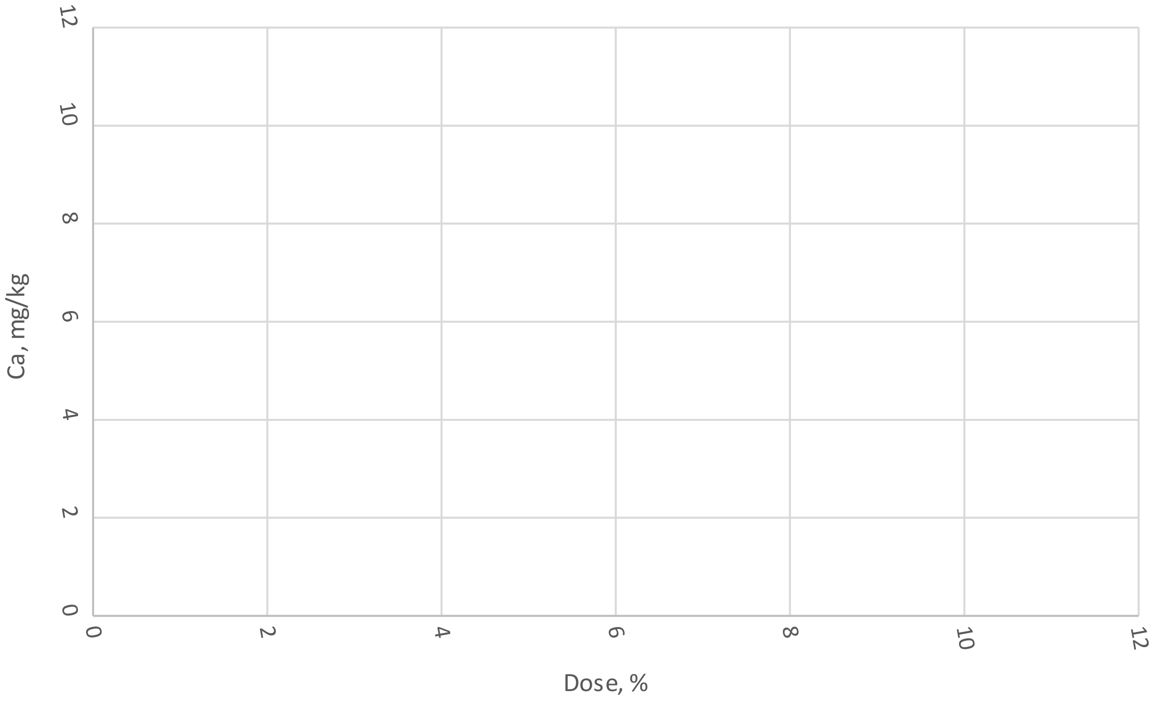

Dry mass, g
Dose, %
0 2 4 6 8 10 12



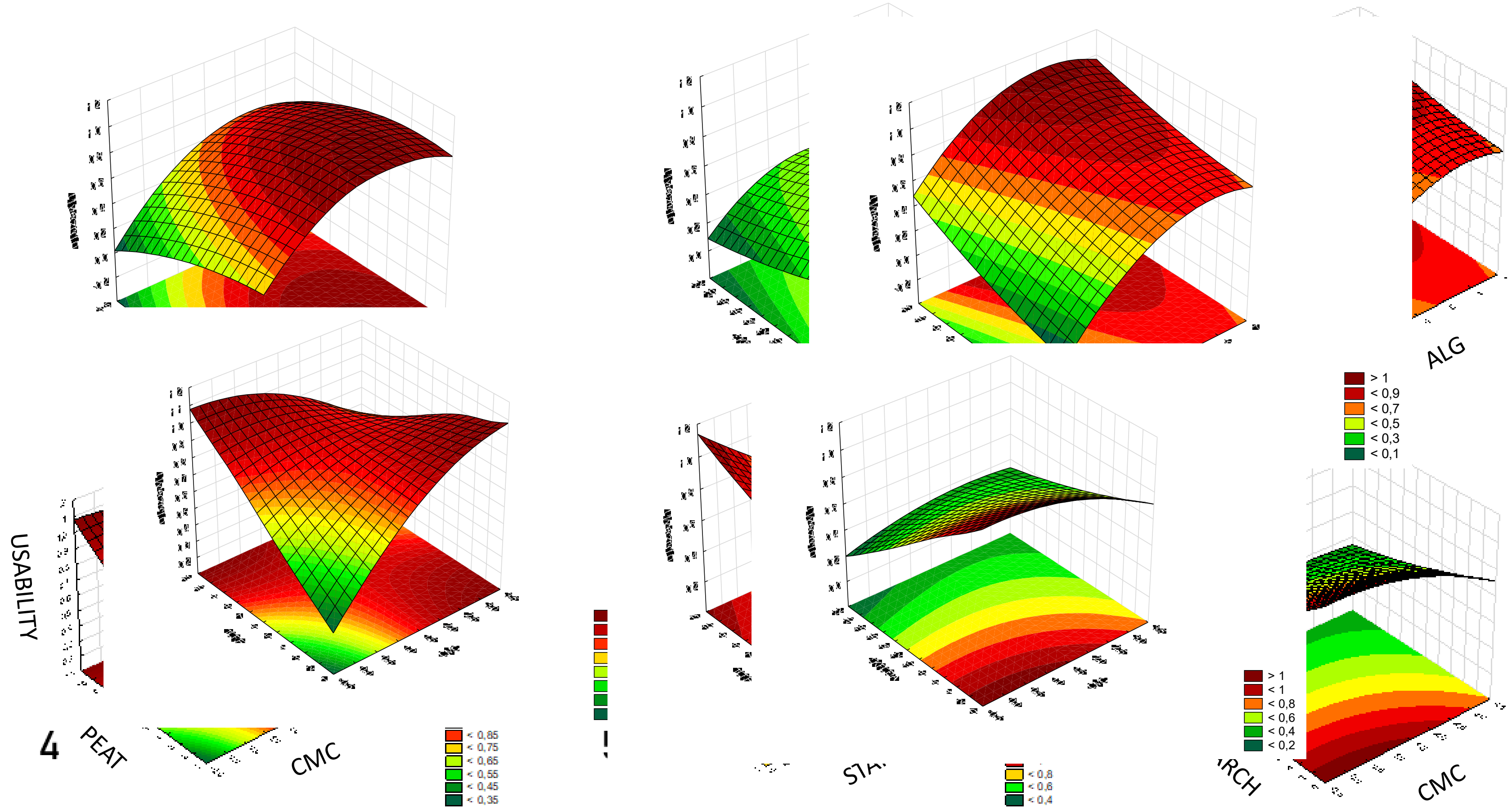

N, %
Dose, %


P, mg/kg
Dose, %


K, mg/kg
Dose, %


Ca, mg/kg
Dose, %

Concentration optimization by RSM



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

System response: content of adsorbed copper ions

Raw material cost to produce 1 kg of fertilizer

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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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