Soil-plant interactions governing phosphorus availability to rice

S. Martinengo, M. Schiavon, V. Santoro, D. Said Pullicino, L. Celi, M. Martin
sara.martinengo@unito.it

XL SICA Congress
Conciliating Sustainability, Resilience, and Food Quality.
New challenges for a 2030 agriculture
Pisa, Italy · 5-7 September 2022

Funding: P-rice Fosforo in risaia: equilibrio tra produttività e ambiente nell'ottica delle nuove pratiche agronomiche
PSR Lombardia 2014-2020

P cycle and plant responses under reducing conditions

Fe
OXIDES

dissolution
precipitation

Plant uptake

SOIL
SOLUTION

organication
mineralization

SOIL
ORGANIC
MATTER

desorption
adsorption

SECONDARY
MINERALS

P cycle and plant responses under reducing conditions

Fe
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REDUCTIVE
DISSOLUTION

$Fe^{3+} \rightarrow Fe^{2+}$

dissolution
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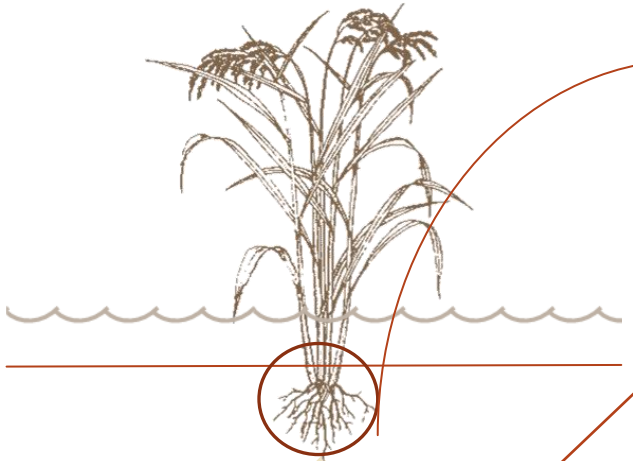


Plant uptake

SOIL
SOLUTION

desorption
adsorption

SECONDARY
MINERALS

organication
mineralization

SOIL
ORGANIC
MATTER

formation of root
aerenchymatic tissues

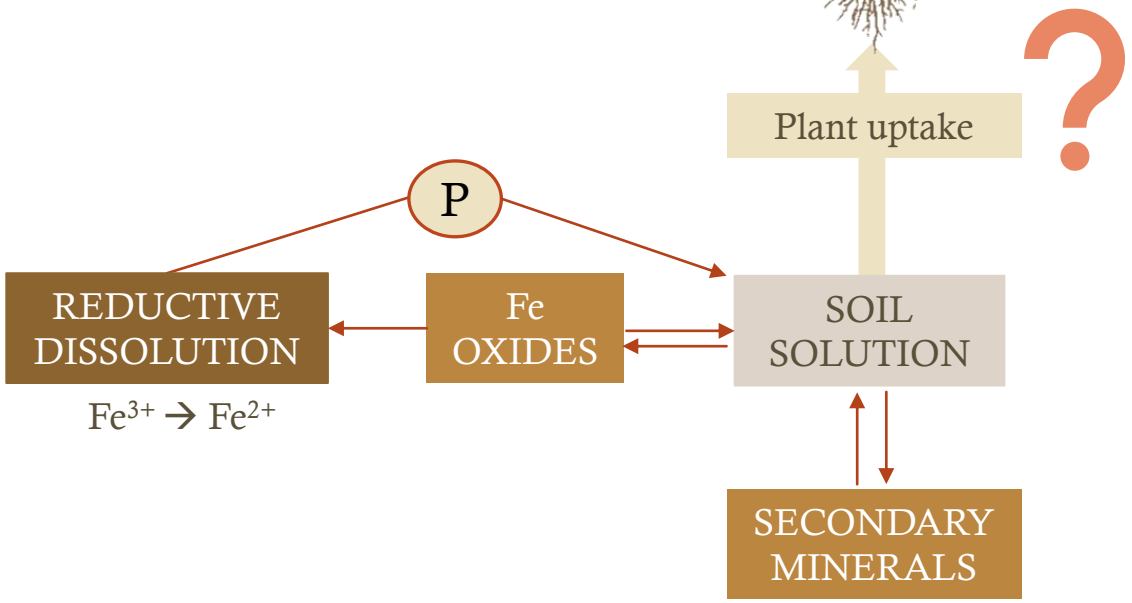
RADIAL OXYGEN LOSSES

$Fe^{2+} \rightarrow Fe^{3+}$

Chemical evaluation of P availability

- To be predictive of **plant availability** a soil test must estimate the **pool that plants can access** under specific soil conditions

- Each method estimates a **P release mechanism** in soil solution



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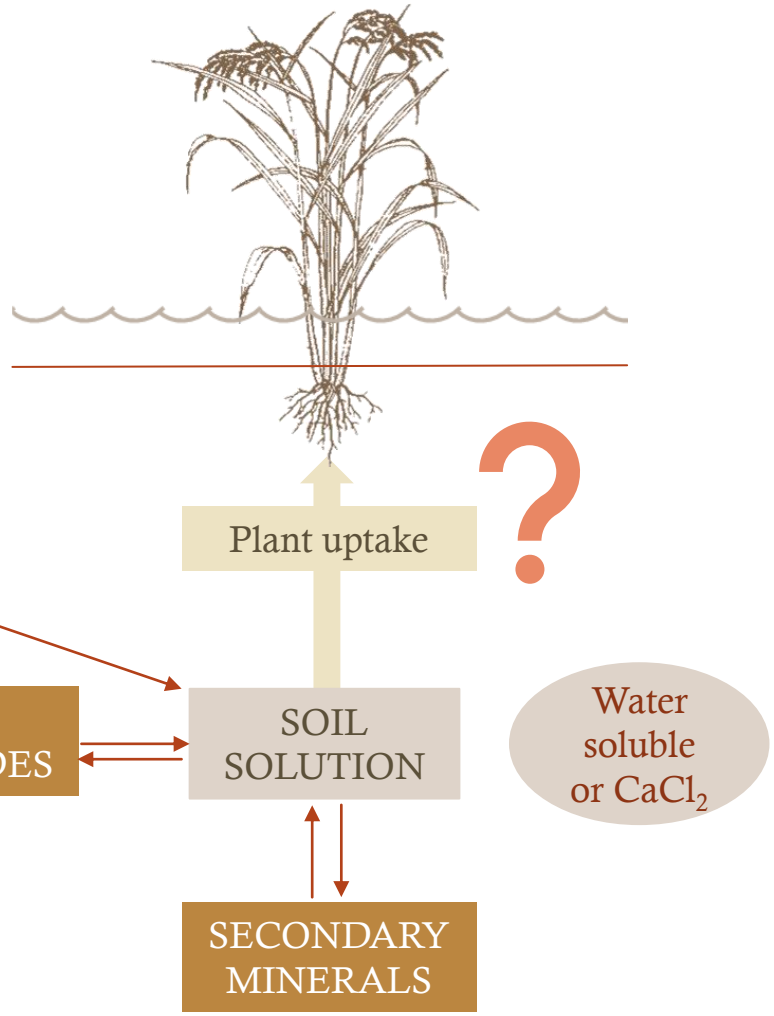

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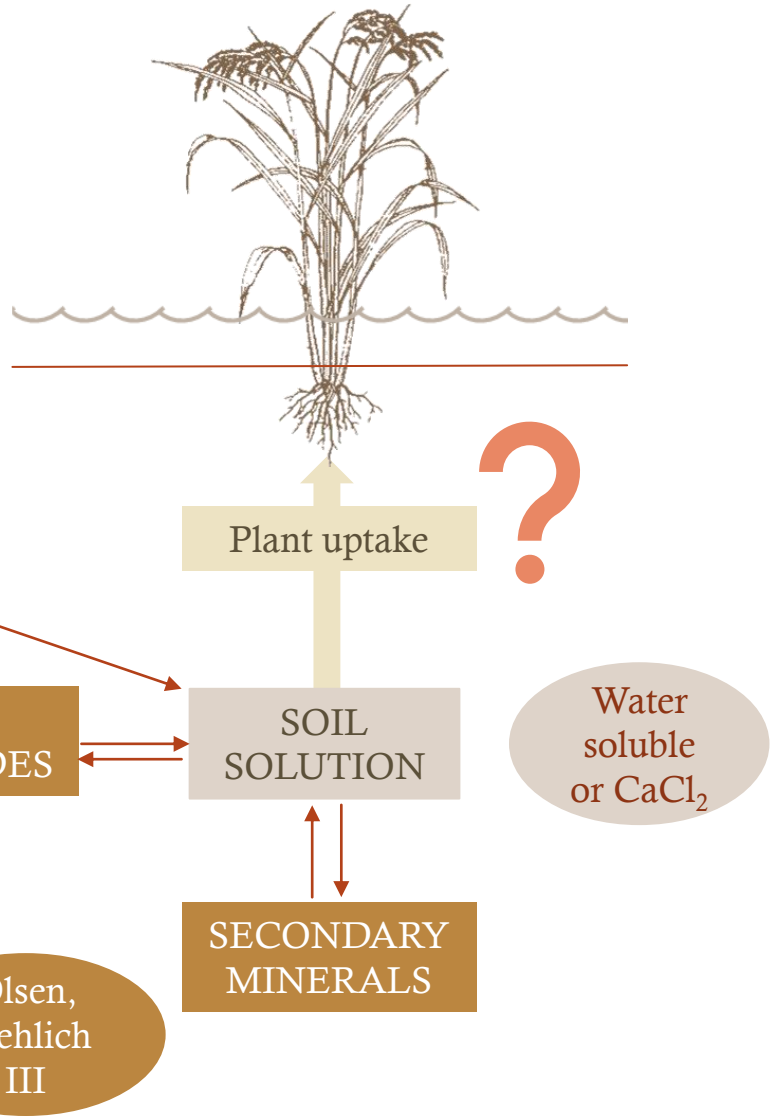

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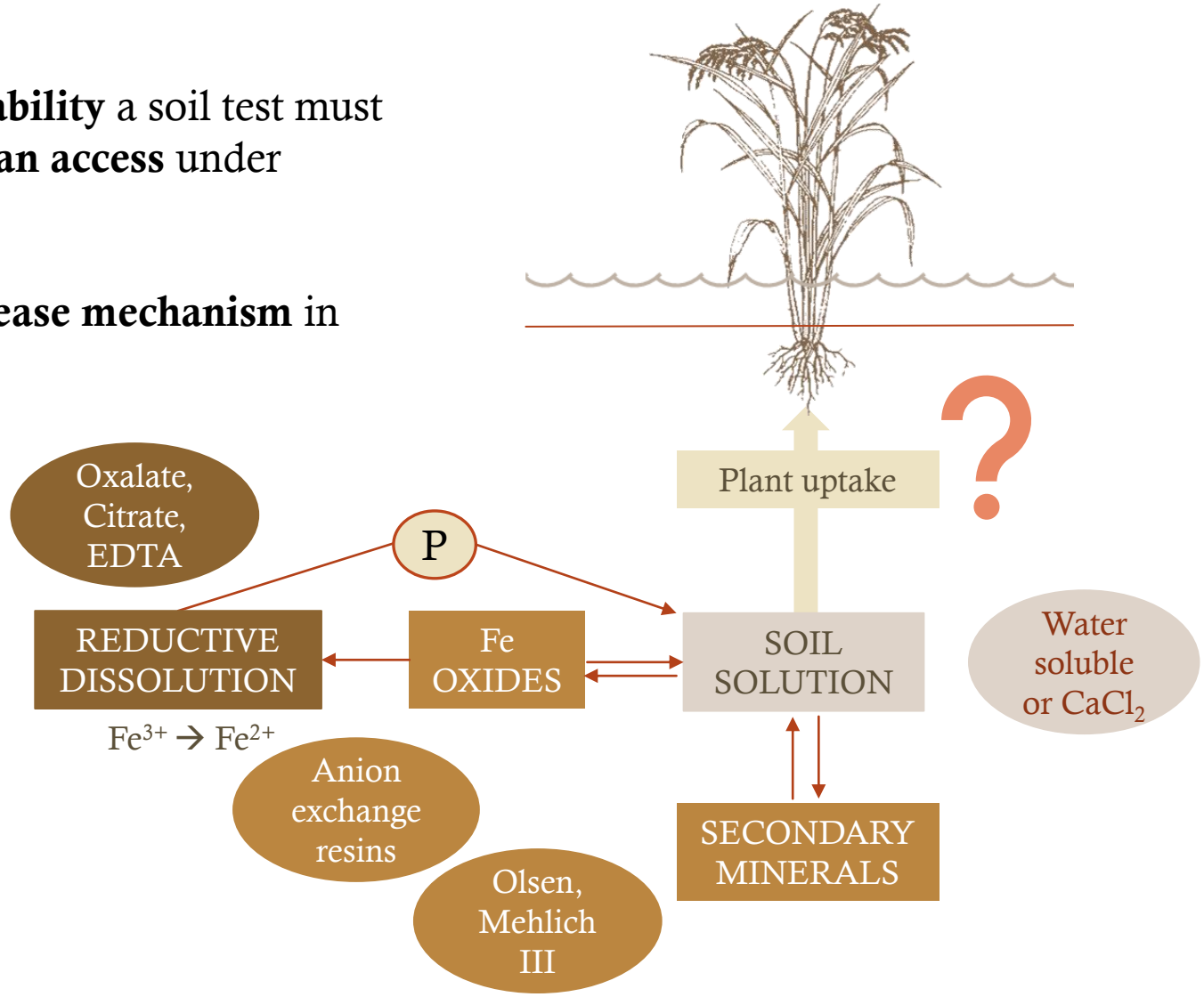


Rice plant responses to P availability

Root development

Plant uptake

Fe OXIDES

SOIL SOLUTION

mineralization

organication

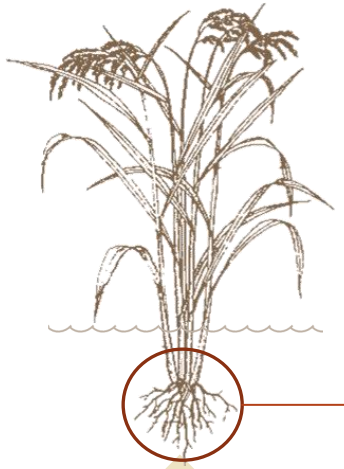
SOIL ORGANIC MATTER

P root transporters

Enzymatic activity

Research questions

which **extraction method** best represents P availability under **reducing conditions**?



Plant responses to reducing conditions

Plant responses to different P availability

how does **plant affect** P availability?

Fe OXIDES

REDUCTIVE DISSOLUTION

$Fe^{3+} \rightarrow Fe^{2+}$

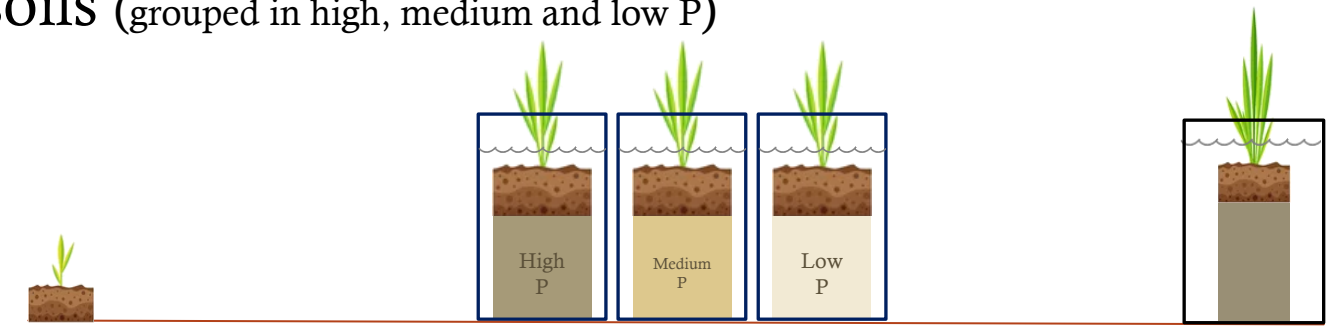
P

Plant uptake

SOIL SOLUTION

Methods

12 paddy soils (grouped in high, medium and low P)



60 days rice growth **under continuos flooding**

SOIL SAMPLES

soil P supply quantification

P extractants

- calcium chloride (soil solution P)
- Olsen – Mehlich III (losely bound P)
- anion exchange resins (desorbable P)
- EDTA (Fe complexant)
- Citrate-ascorbate (P competitor; Fe reducer)
- Oxalate (P competitor; Fe complexant)

SOIL SOLUTION SAMPLES

Release kinetics of:

Fe(II)
Molibdate reactive phosphate

PLANT HARVESTING

PLANT SAMPLES

Plant P uptake

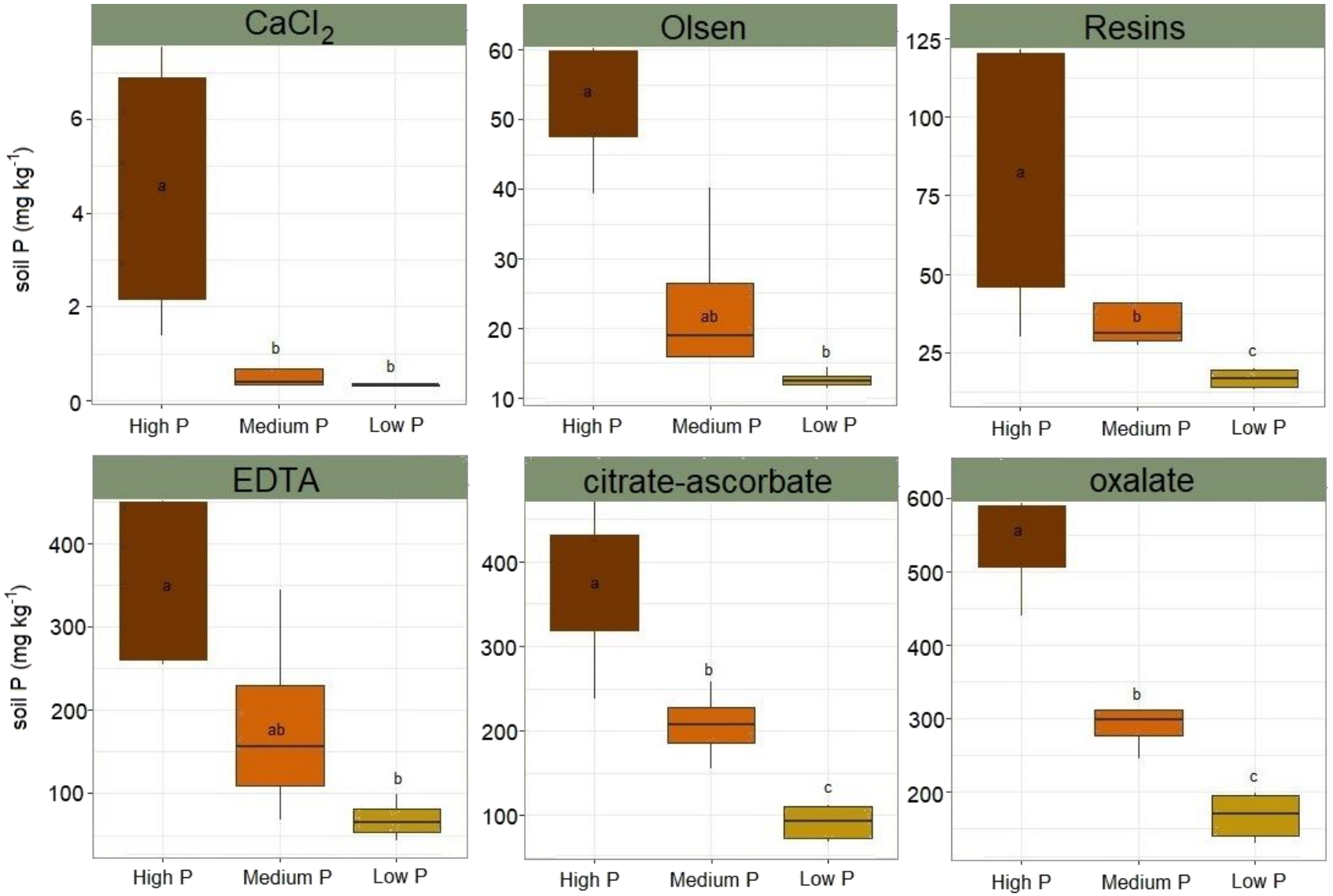
Total P concentration in plant tissues

Responces to P availability

Root biomass;
Enzymatic activity;
P transporters gene expression

Results and Discussion

Methods to assess available P in soil



Is the P extracted really available to plant uptake?

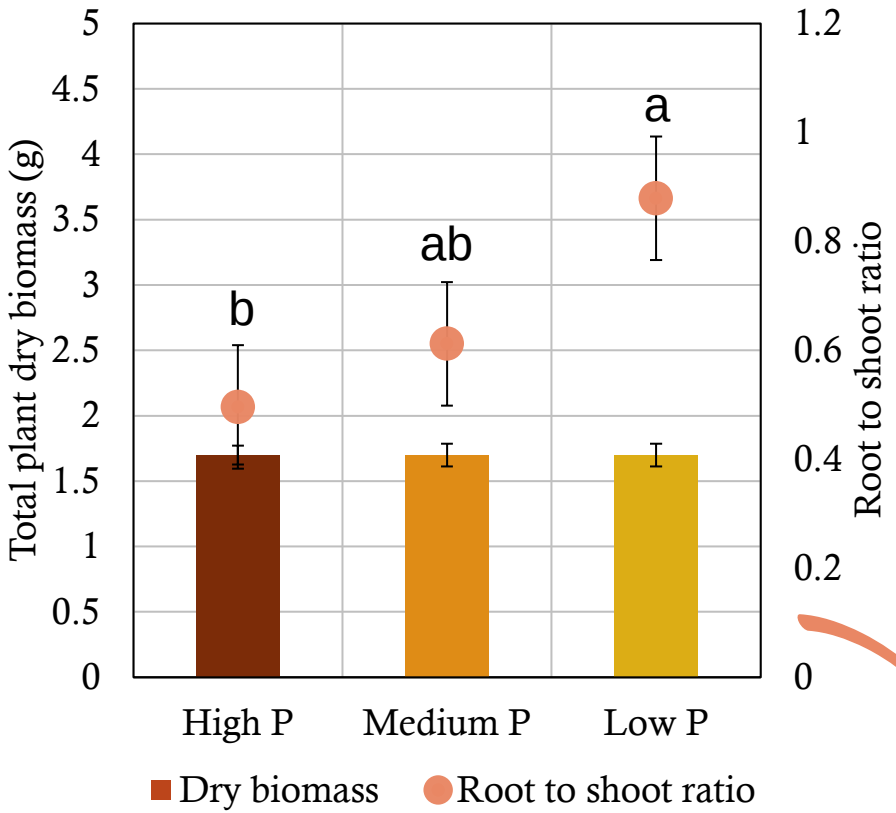
?

Plant uptake

SOIL P

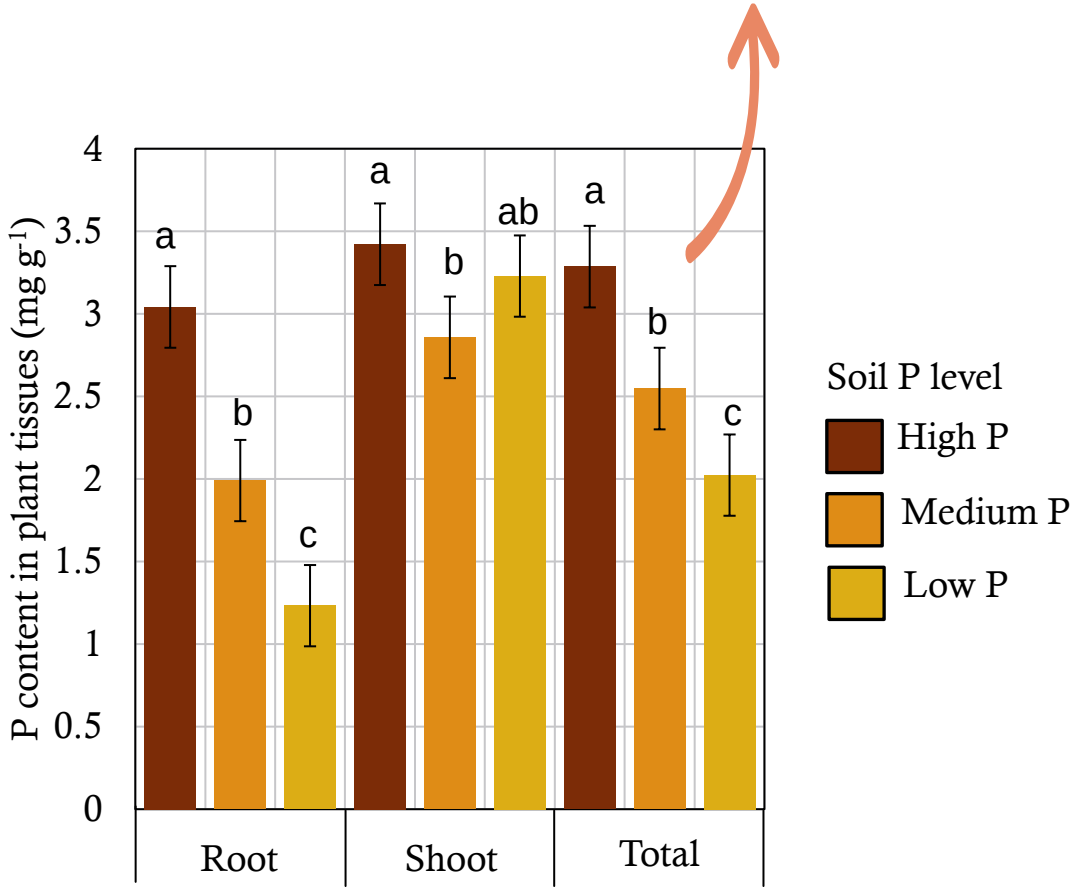
Results and Discussion

Plant development and P concentration



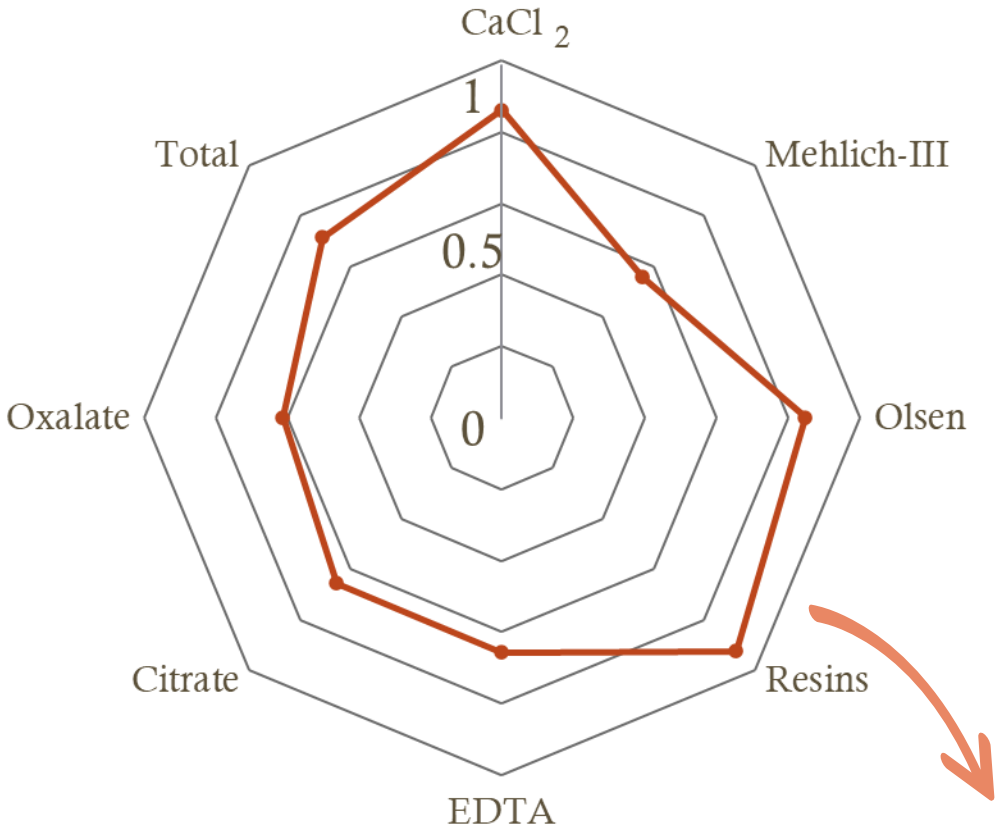
Increasing of root to shoot ratio

Significant differences in P content in plant tissues based on soil P supply

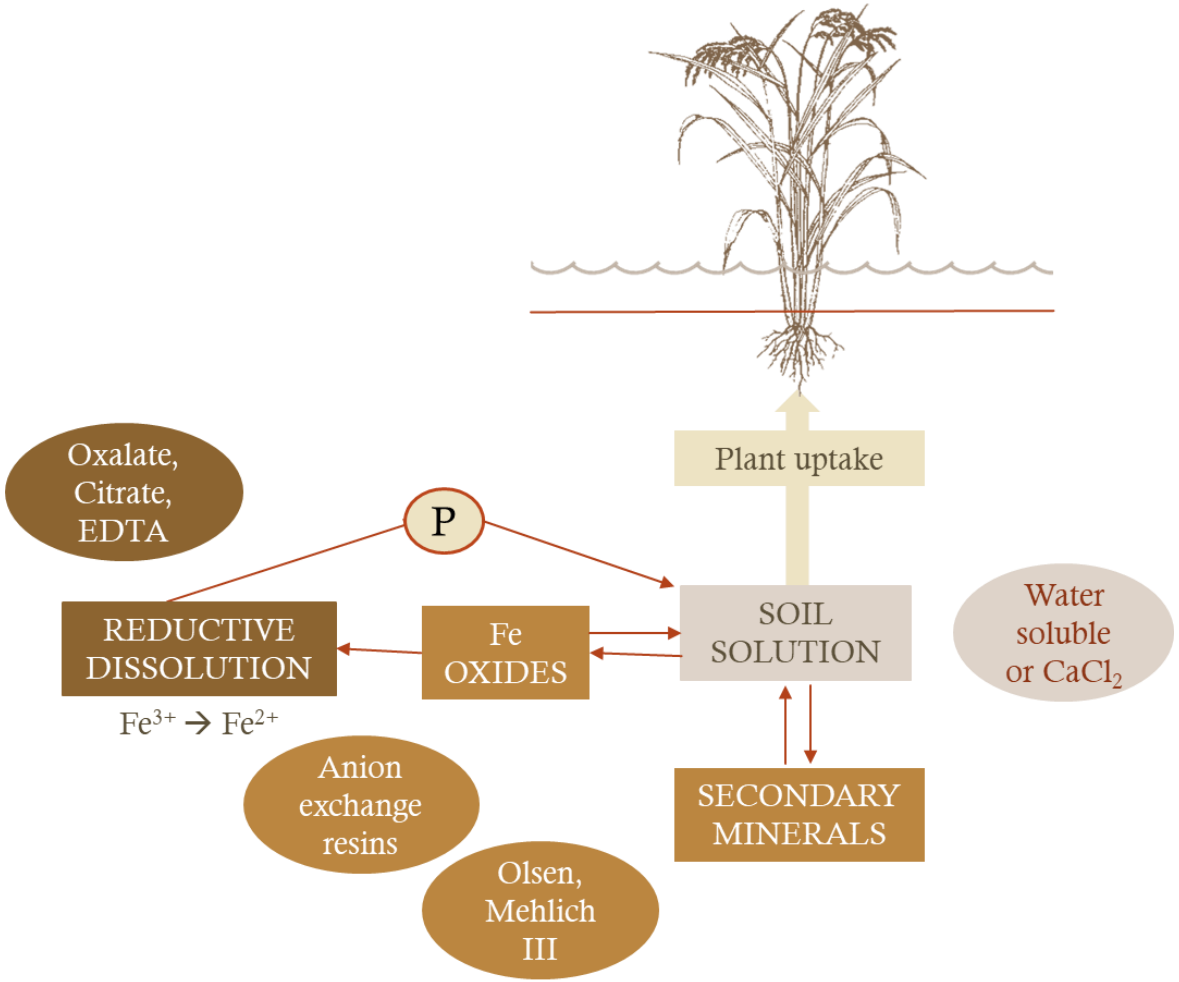


Results and Discussion

P availability in soil and plant uptake



Anion exchanging resins give the best correlation with P in plant tissues, followed by $CaCl_2$ and Olsen.



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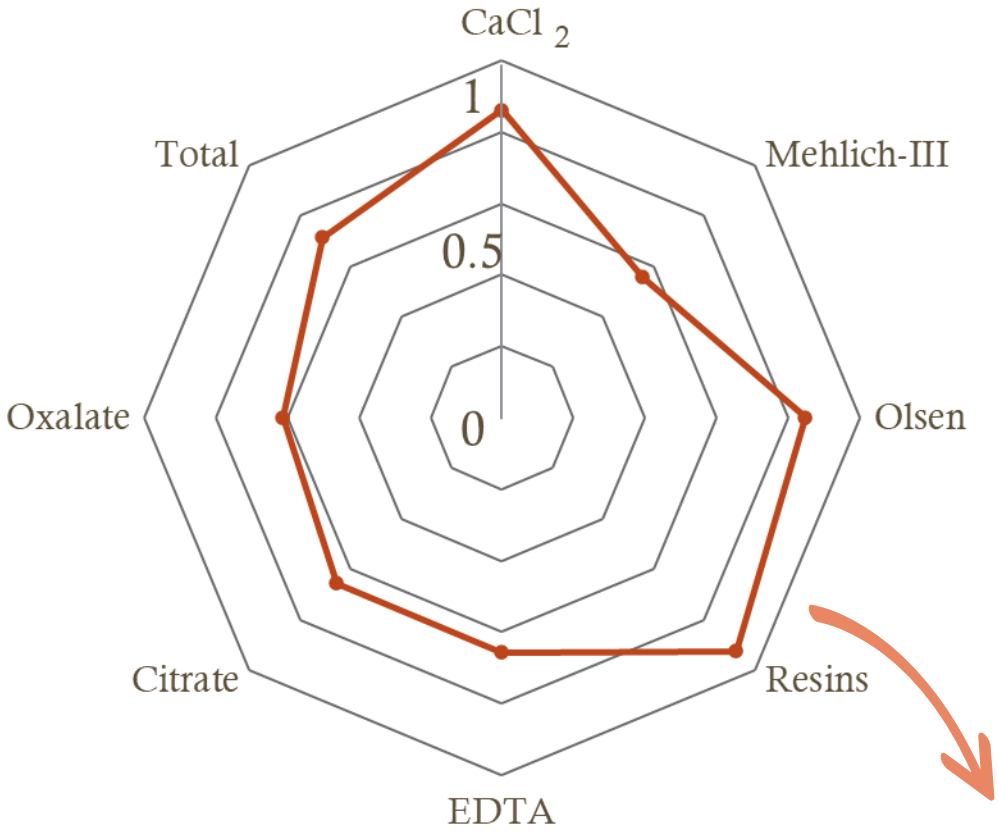

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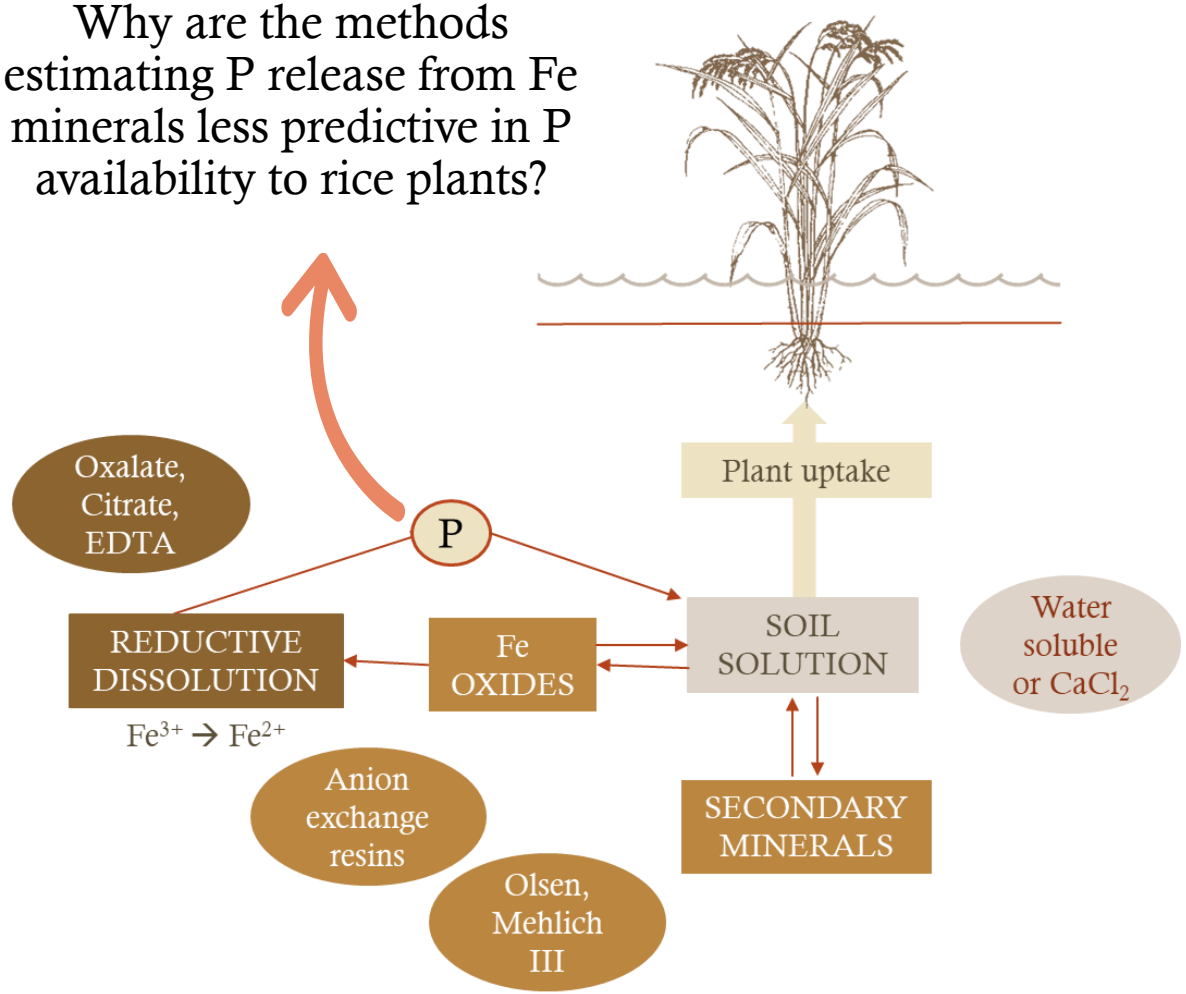
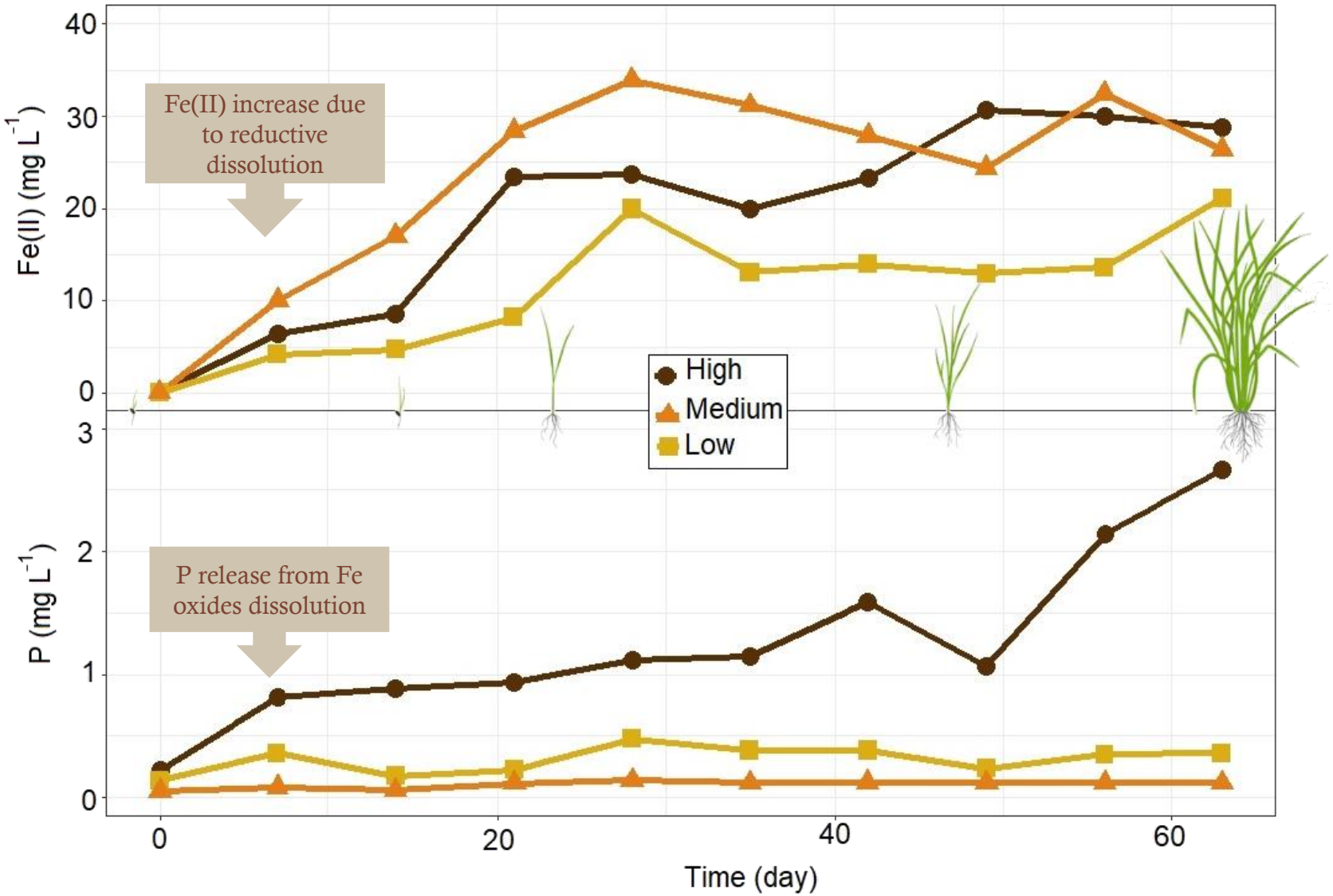
Why are the methods estimating P release from Fe minerals less predictive in P availability to rice plants?



Results and Discussion

Kinetics of P and Fe(II) in the soil solution



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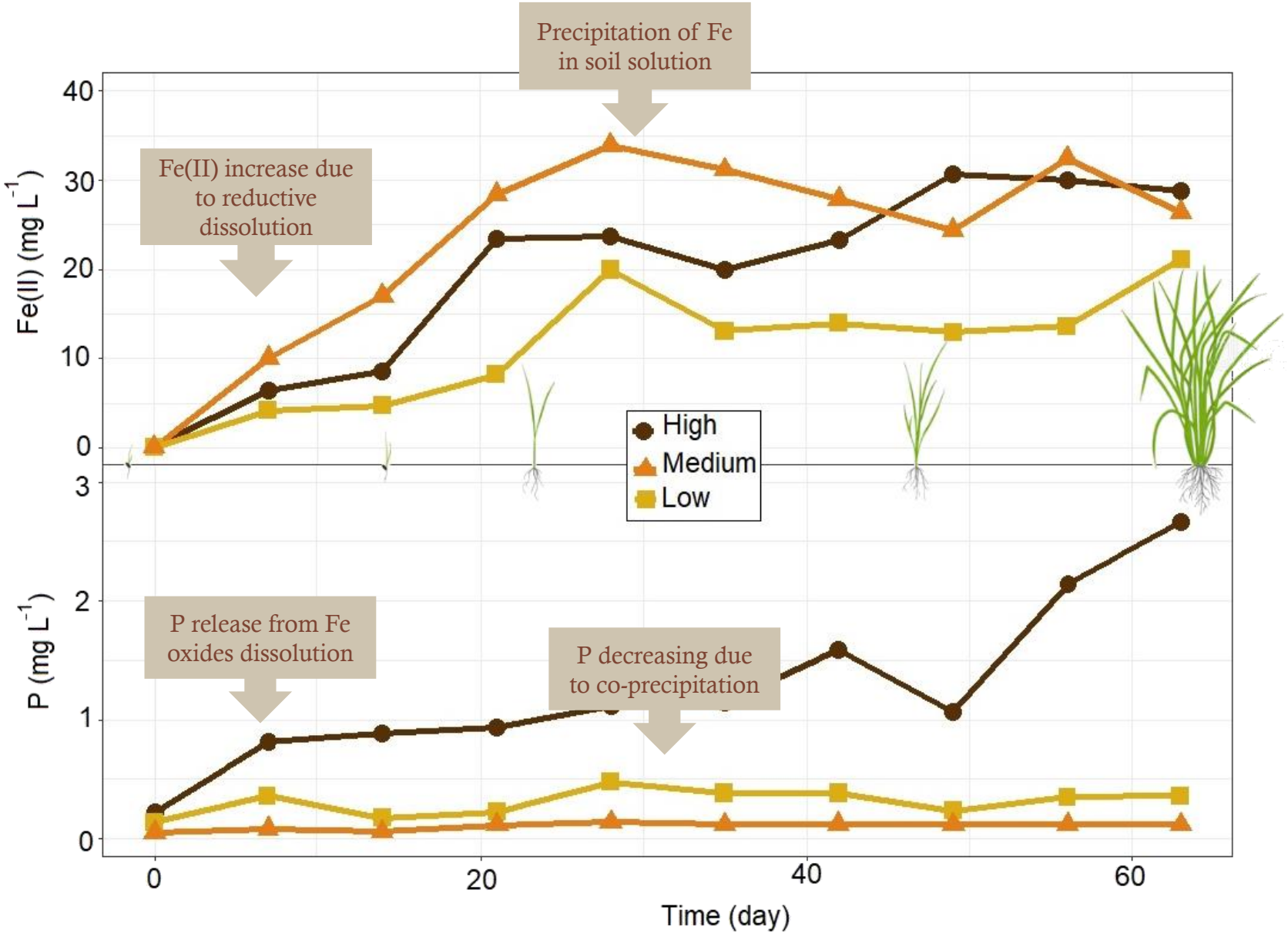

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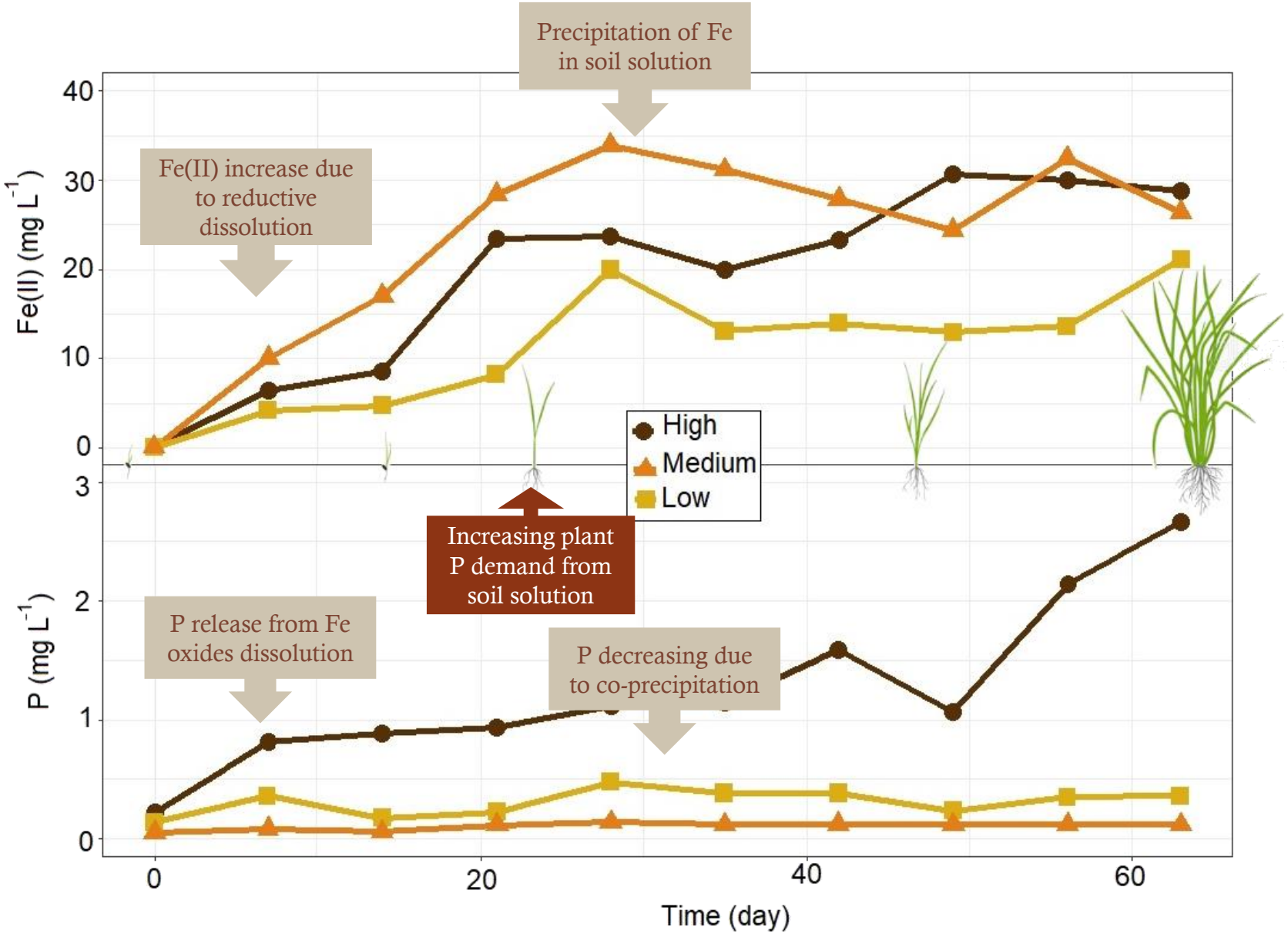
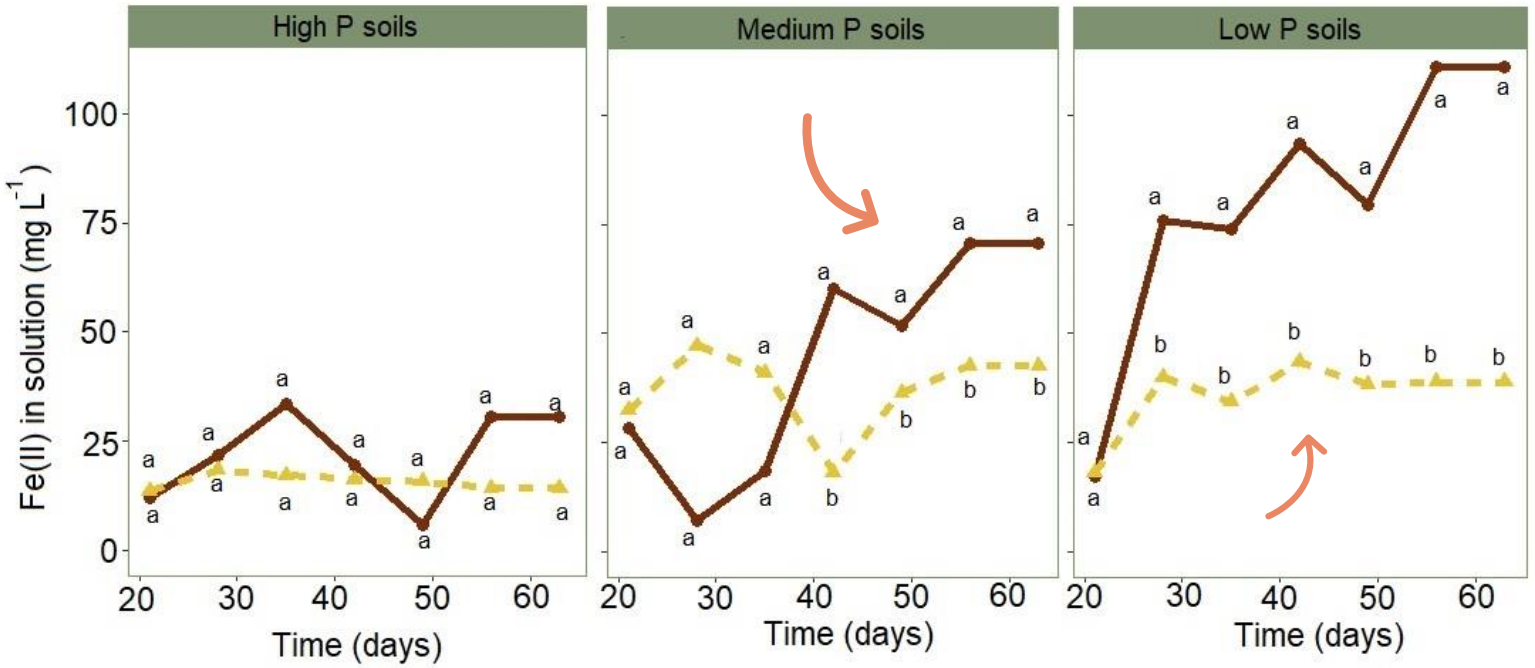


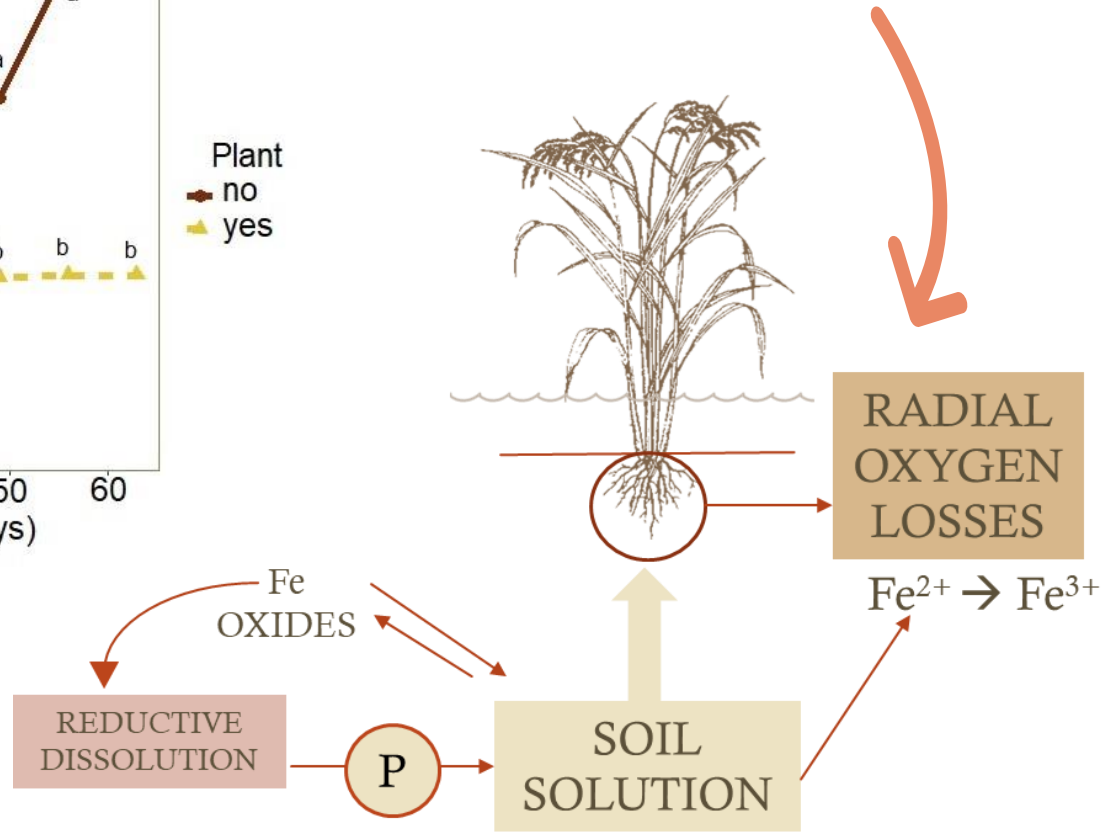
- Temporal shift between P relase from Fe minerals and plant uptake from soil solution
- The subsequent increase in P concentration could be caused by other mechanisms than reductive dissolution

Results and Discussion

Plant responses to P availability - 1

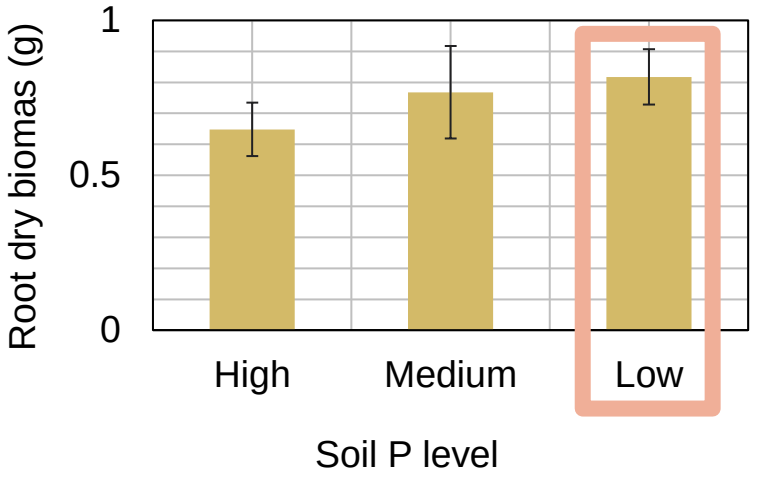


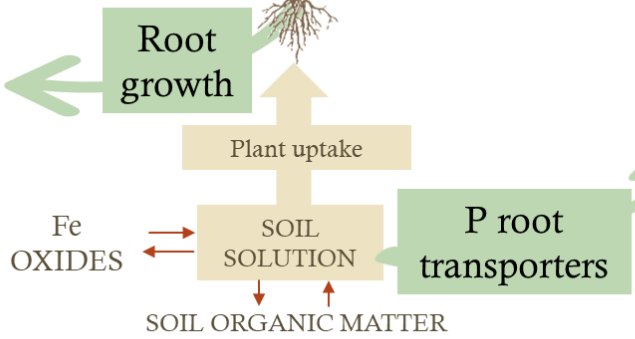
The **lower concentration of Fe(II)** with plant development could be related to **higher radial oxygen loss** due to higher root development

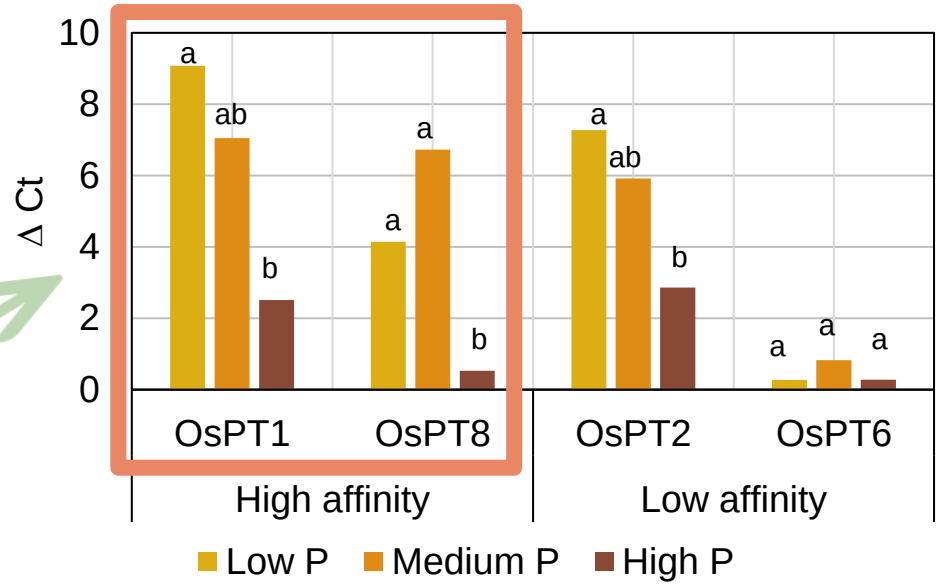


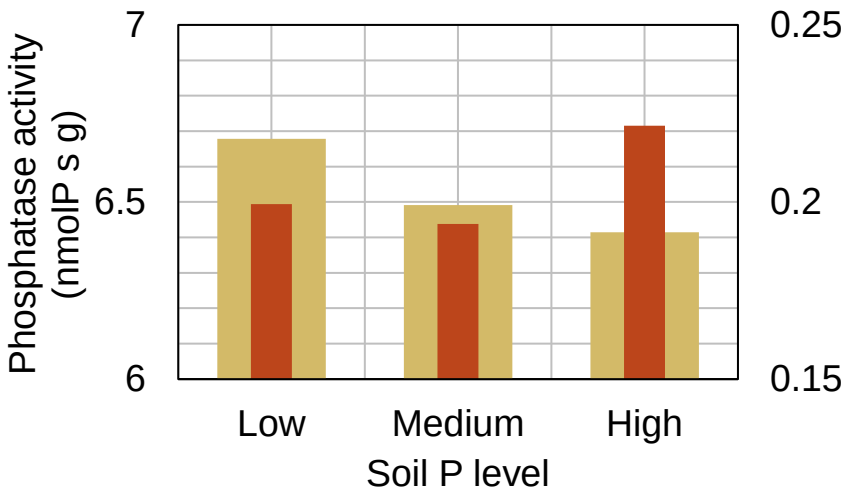
Results and Discussion

Plant responses to P availability - 2



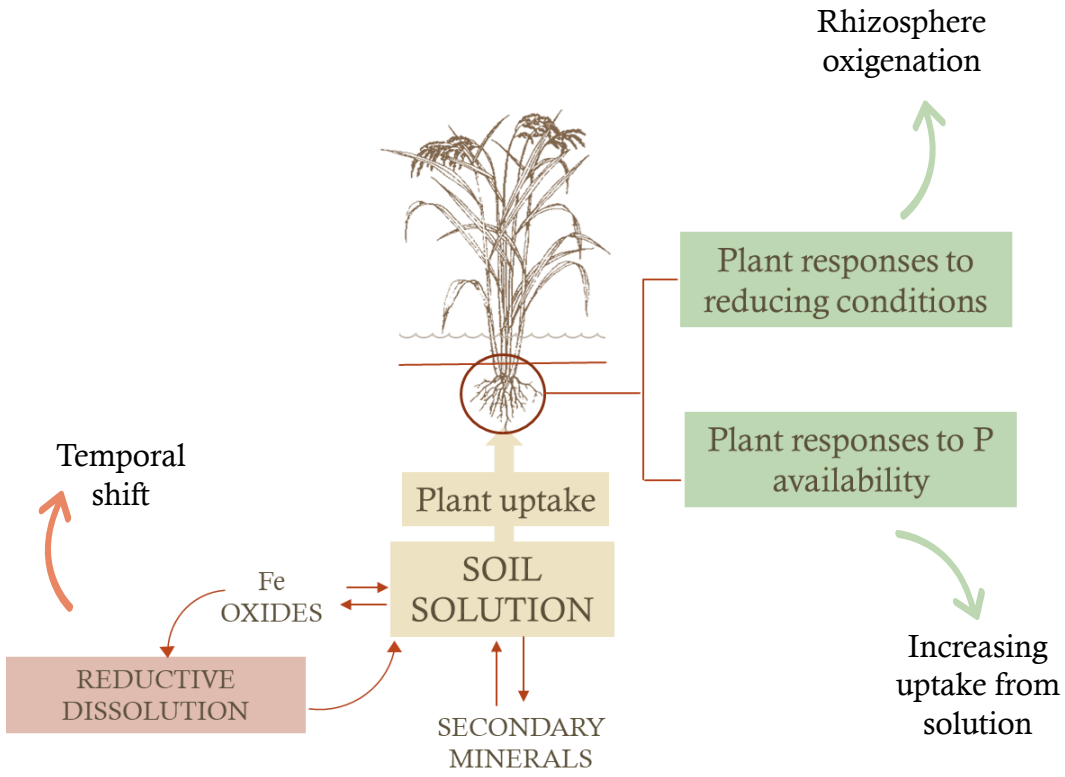






Conclusions

- **Anion exchange resins represent the best estimation of P availability to rice plants**
- The **chemical methods** related to **Fe reduction** not only overestimate the amount of P release but also do not correlate with P uptake
- **Asincrony** between P release from Fe oxides **reductive dissolution** and P demand by plants
- **Plants responses** to soil P availability shape the **rhizosphere redox** conditions that lead to alternating dissolution/sorption processes during plant growth



Thank you for the attention!

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sara.martinengo@unito.it

Sara Martinengo – DISAFA UniTO

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