CropBooster-P Workshop of WP4

Nitrogen Use Efficiency.

Anne Krapp & Céline Masclaux-Daubresse

Experts:

Jean-Pierre Cohan (ARVALIS),

Alia Dellagi (INRAE Versailles)

Christine Foyer (University of Birmingham)

Alain Gojon (INRAE Montpellier)

Anne Krapp (INRAE Versailles)

Céline Masclaux-Daubresse (INRAE Versailles)

Philippe Nacry (INRAE Montpellier)

Pascal Ratet (IPS2, CNRS-University Paris-Saclay)

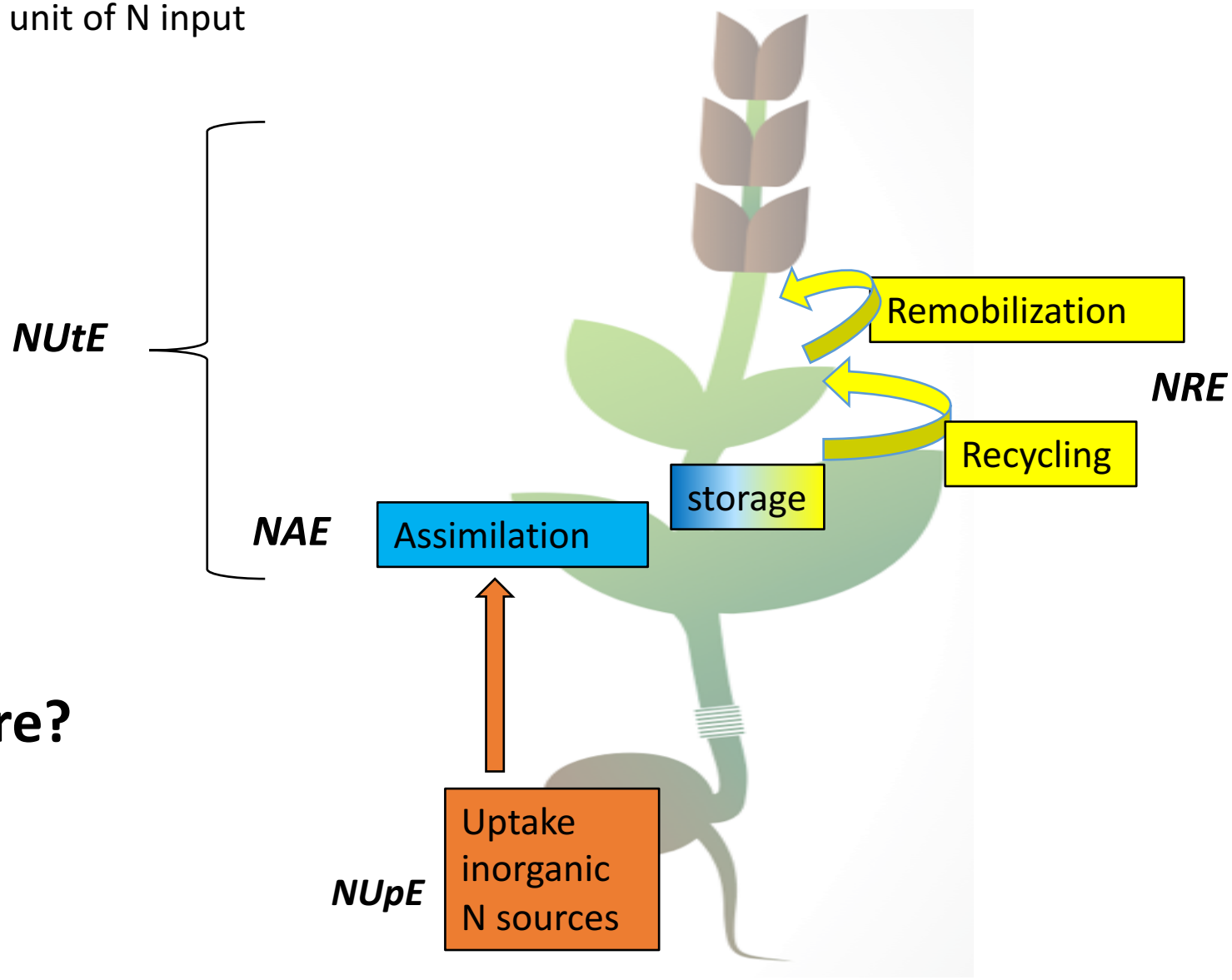
François Taulemesse (ARVALIS)

Andreas Weber (University of Duesseldorf)

Nicolaus von Wirén (IPK Gatersleben)

Nitrogen enzymes and transporters in root, shoot, reproductive organs.

NUE = Yield/biomass per unit of N input



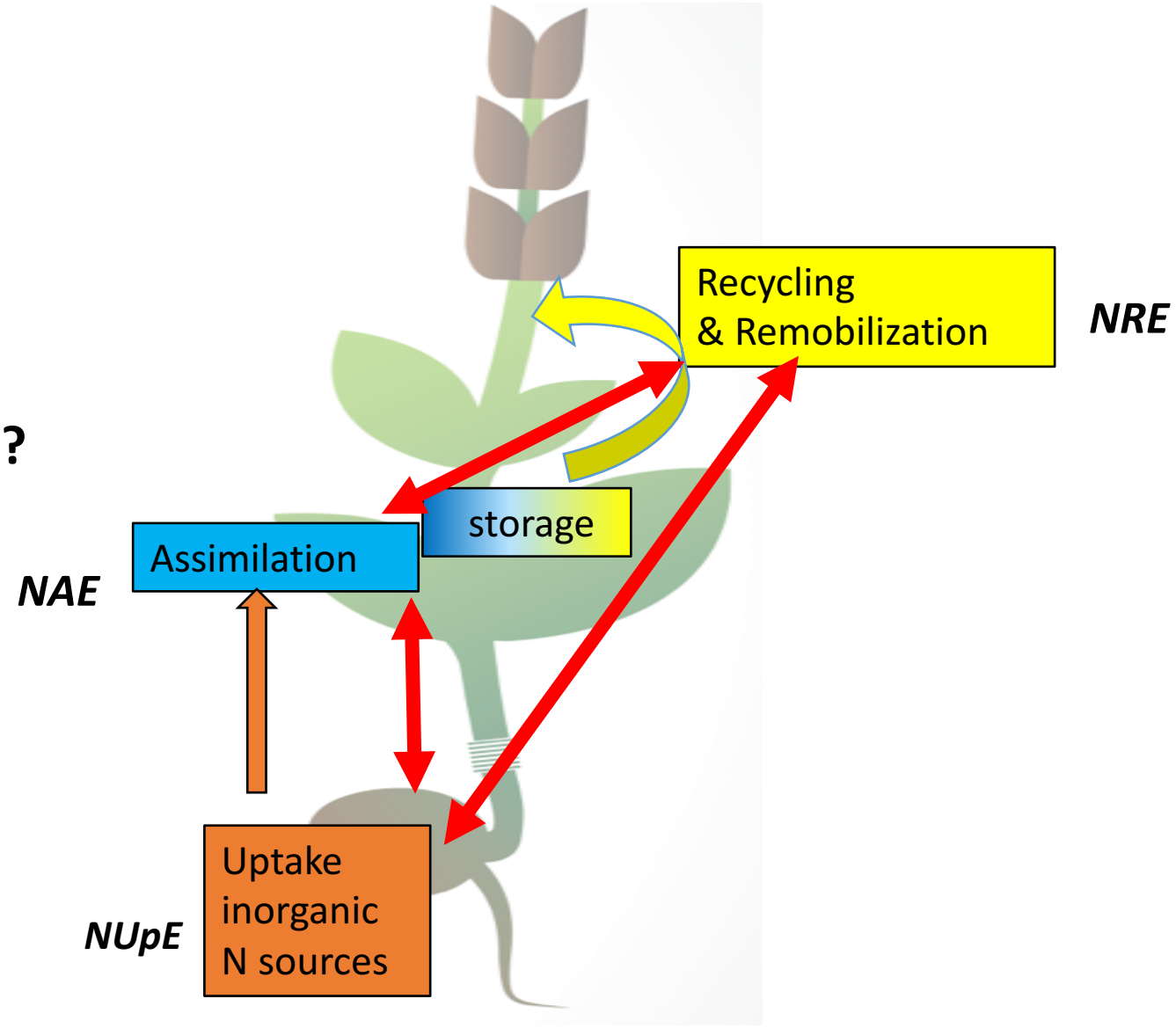
?

When and where?

Whole-plant level.

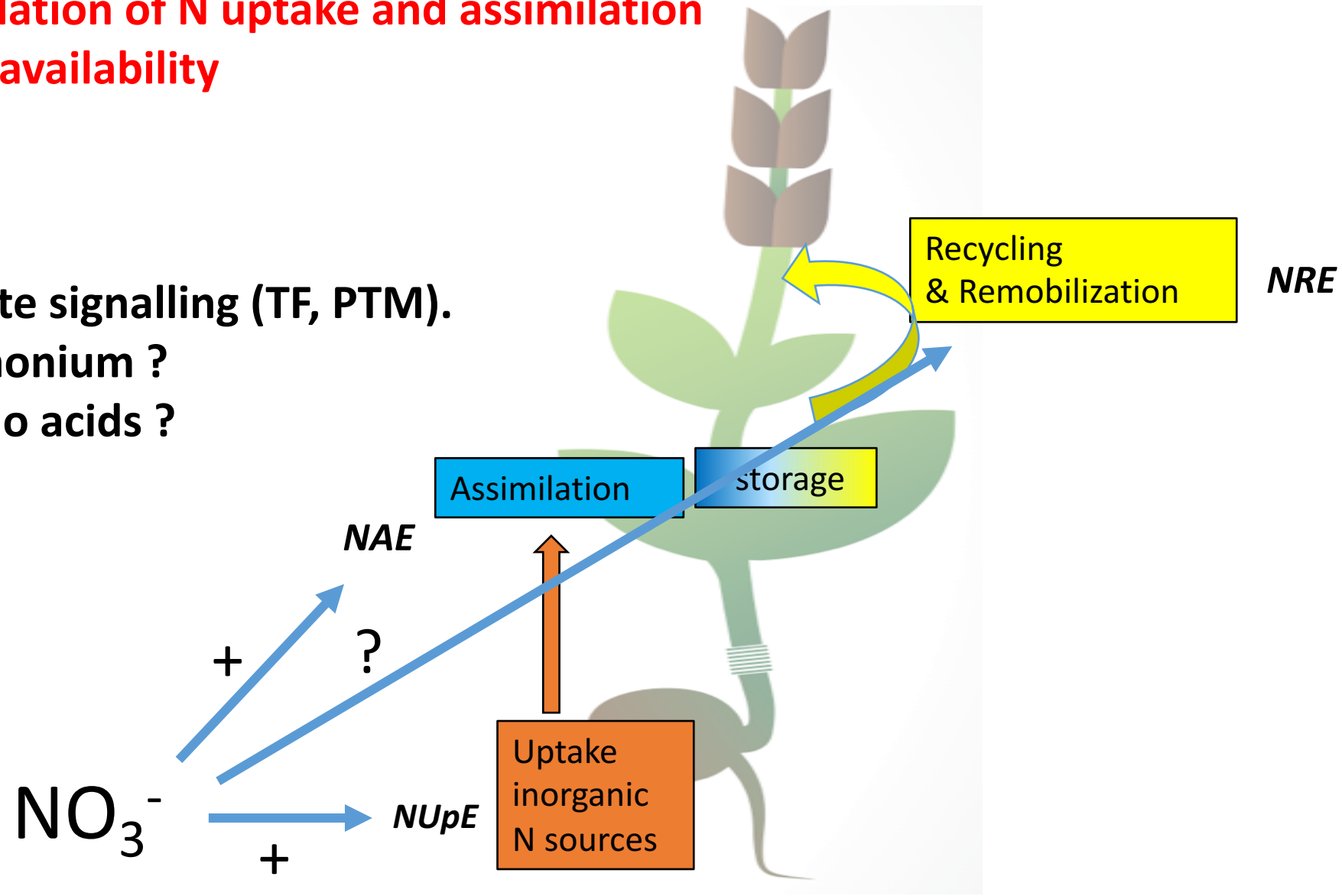
Coordination?
Cross-talk sink/source?
Long distance signalling?

?



Regulation of N uptake and assimilation by N availability

Nitrate signalling (TF, PTM).
Ammonium ?
Amino acids ?



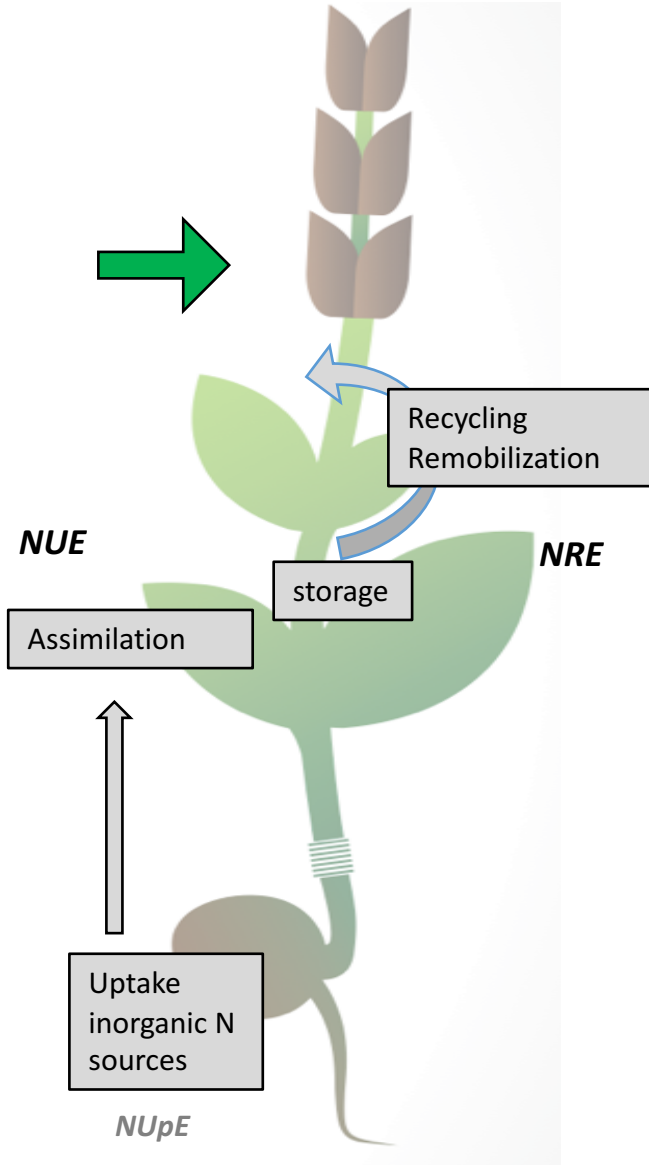
Endogenous factors and connection to other metabolisms

PHOTORESPIRATION

PHOTOSYNTHESIS

Signals:

Sugars, energy, inorganic-N, organic-N



Cross-talk with photosynthesis and photorespiration

Redox status/cofactors
Organelle to organelle communication

Regulatory levels

Transcription factors
Regulatory networks (time/space)
Epigenetics
PTM (post-translational modifications)

Regulations by exogenous factors

HIGH CO_2
Temperature
Water

?

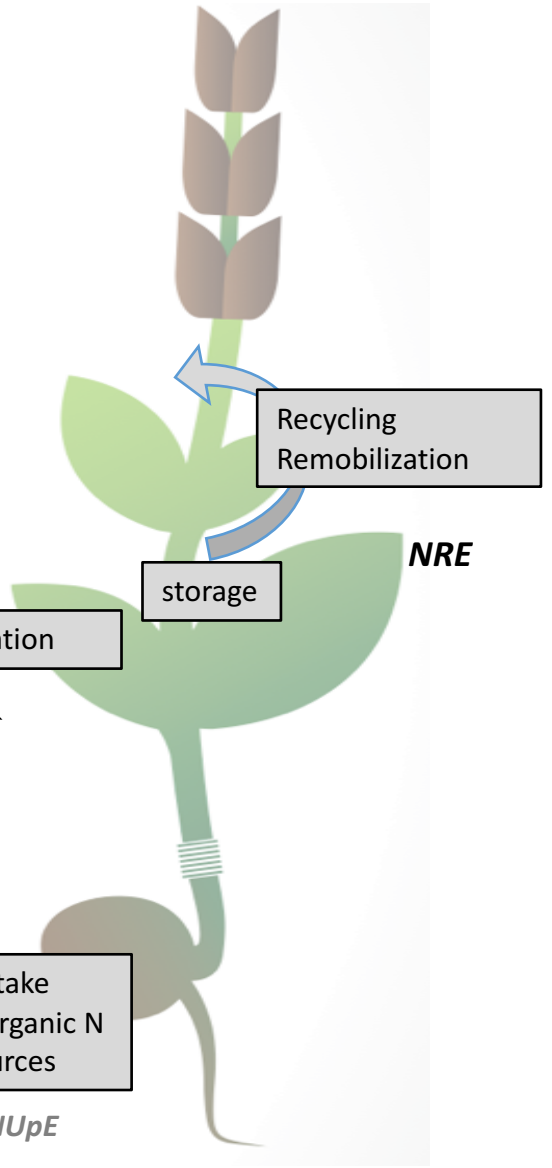
PHOTOSYNTHESIS

Signals:
sugars, energy,
inorganic-N, organic-N

PHOTORESPIRATION

NUE

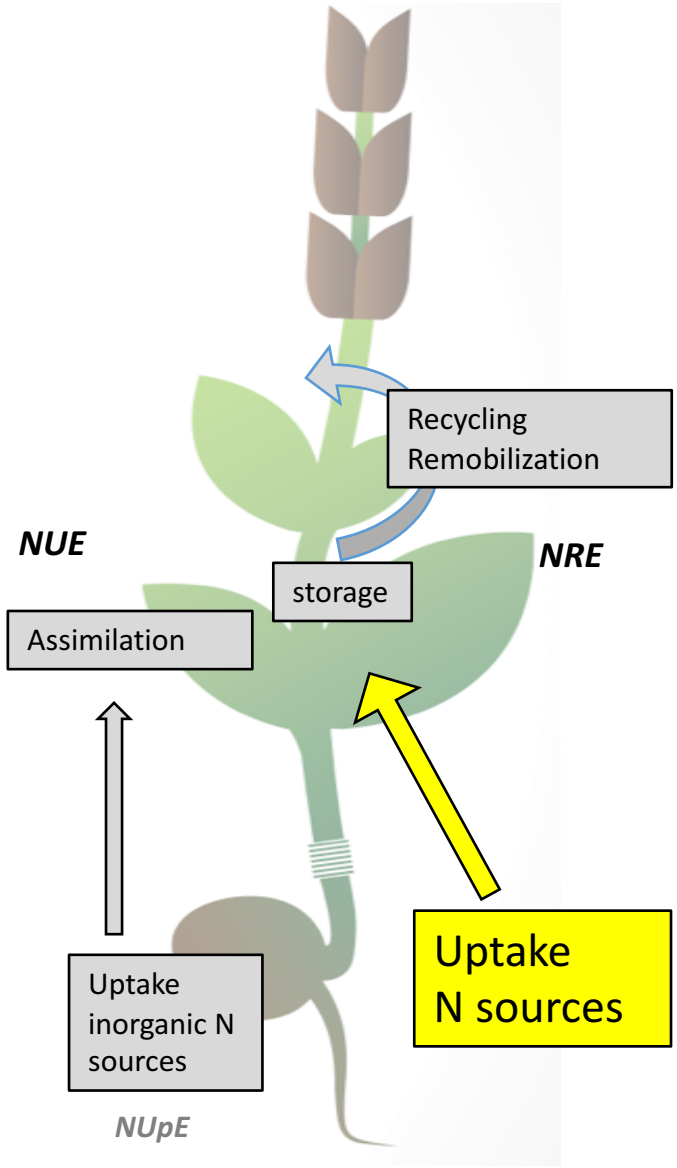
NRE



Availability other minerals (P, S, Fe, ...)

Availability of different N sources (Organic N sources)

Influence of plant neighbouring.



Contribution of microbes and helper plants?
Indirect effects *via* plant partners?

?

HIGH CO_2
Temperature
Water

Microbes

Uptake
N sources

Helper plant

Availability
other minerals (P, S, Fe, ...)

What is relevant for the future

Enforce the basic knowledge on N metabolism, on model, cereals, legume and vegetable species

Coordination of N uptake, assimilation, storage and remobilization during plant life.
Dynamic spacio-temporal analyses of molecular mechanisms and N flux during development and in different organs -> identify cross-talks/ limiting points (in different species).

Analyse N regulatory networks in different organs and developmental stages.
Identify master regulators: TF, PTMs, enzyme activities, cofactors, organelle cross-talks.

Identify limiting steps considering N regimes and sources of N fertilizers in different species.
Modelling/comparing multiomics data (fluxomic, transcriptomic, proteomics) with plant growth and plant physiology indicators along development.

Determine the effects of photorespiration and of photosynthesis modes on NUE and N metabolism by comparing dicot/monocots, C3/C4, legume/non legumes.

From recent advances on model plants, smooth transfer knowledge from to crops: develop molecular tools to facilitate analyses on crops.

Transfer of results from lab to field

Confirm key actors in crops/in field: Use of NBT? Meta-analyses? Quantitative genetics?

Confirm bottlenecks in the field quantifying N fluxes and contribution of NupE, NutE, NRE on appropriate genotypes/crop species, under different N fertilizer regimes.

Evaluate impact of climate change on N metabolism (high temperature, water availability and high [CO2] in priority) considering all N fertilizer regimes and comparing different crop species. Monitoring N markers/ fluxes in different plant species and growth conditions. `

Estimate interrelated effects of climate change on WUE, NUE, PUE, FeUE...

Holistic approach: pay attention to plant/soil/microbe interactions in NUE and effects of climate change: plant genotype effects /dependences to soil and microbes / dependence to climate/environment.

Develop approaches to reach farmer's demands

Demand of farmers is to consider erratic climate changes and propose solutions that offer robustness and resilience of agriculture systems and stability of crop production under unpredictable extreme climate situations.

Need of tools/knowledge to match N-supply to crop-demand taking into account the technical limits of agricultural practices.

Determine the best strategies for 4R management, for each crop:
Right N source, Right rate, Right time, Right place.

Suggestions of action plan:

For our investigations, we may agree on common protocols and "tool boxes" to

-> Identify the generic and specific NUE bottlenecks in the different crop species.

-> Consider NUE for different N sources (organic, inorganic, atmospheric).

-> Evaluate the impact of agricultural practices on the identified NUE bottlenecks.

-> Propose specific solutions/strategies adapted to each crop.

-> Predict the impacts of climate change on the proposed strategies, test robustness.

-> Evaluate the impact of proposed strategies on WUE, PUE....

-> Consider the most efficient and reasonable strategies (research effort, low cost, feasibility, adaptability, profitability, acceptability by consumers /citizens) according to plant biologists, breeders, farmers, socio-economic researchers, consumers.