Oregon State University Oregon Wine Research Institute

Oregon State University

# Influence of scions and rootstocks on vine vigor in response to high nitrogen availability

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Oregon Grape Day 04-03-2019

# Introduction

**Grapevine vigor = shoot growth potential**

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**Grapevine vigor = shoot growth potential**

↑

**Genotype X Environment**

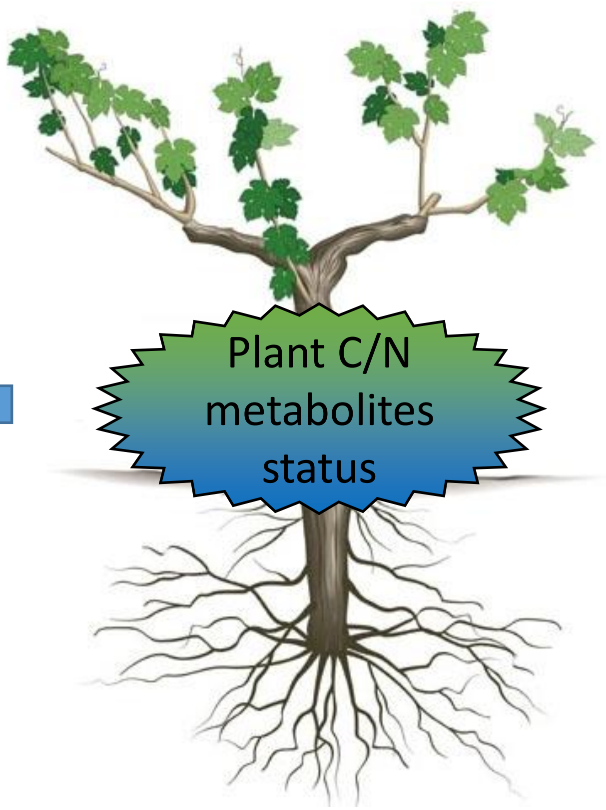
↗ ↖

**Scion X Rootstock** **X** **Nitrogen availability**

<u>Goal:</u> identify mechanisms involved in the scion-rootstock-nitrogen interaction

# Introduction

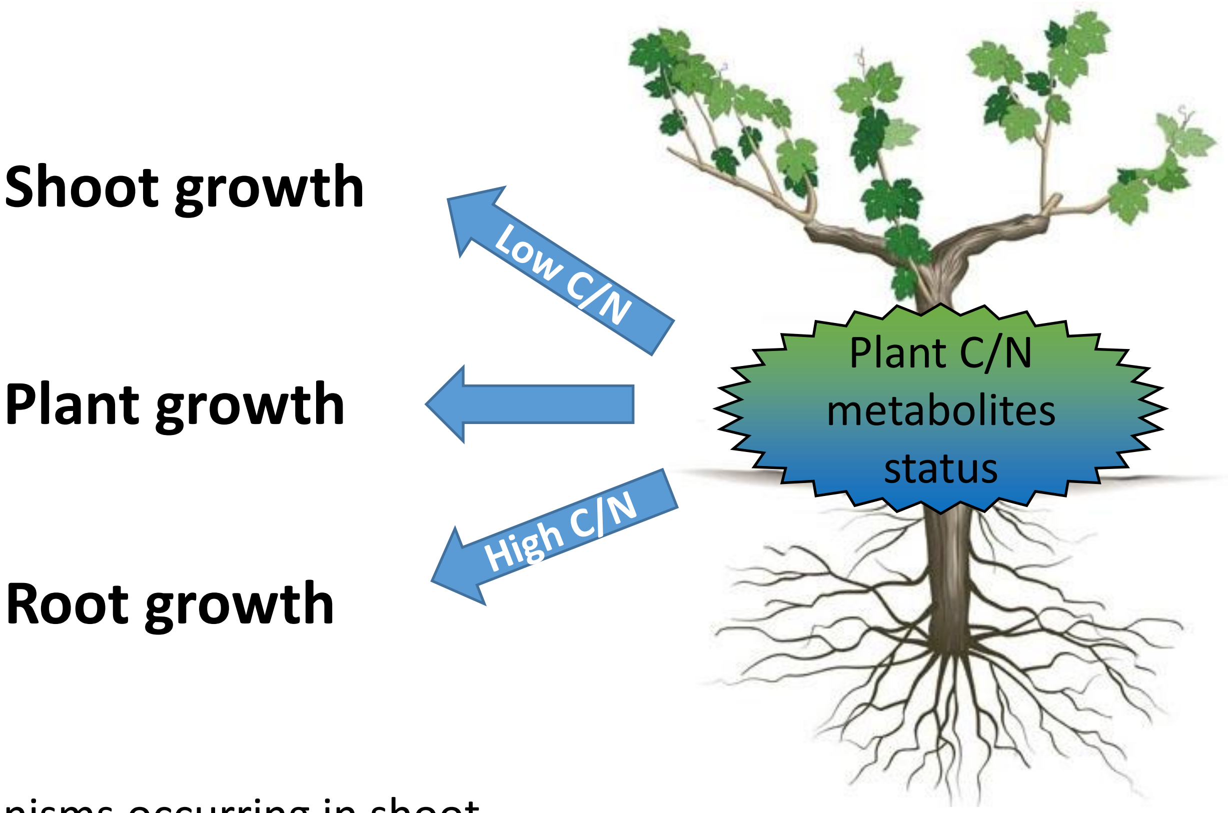
**Plant growth**




Mechanisms occurring in shoot

Mechanisms occurring in roots

# Introduction

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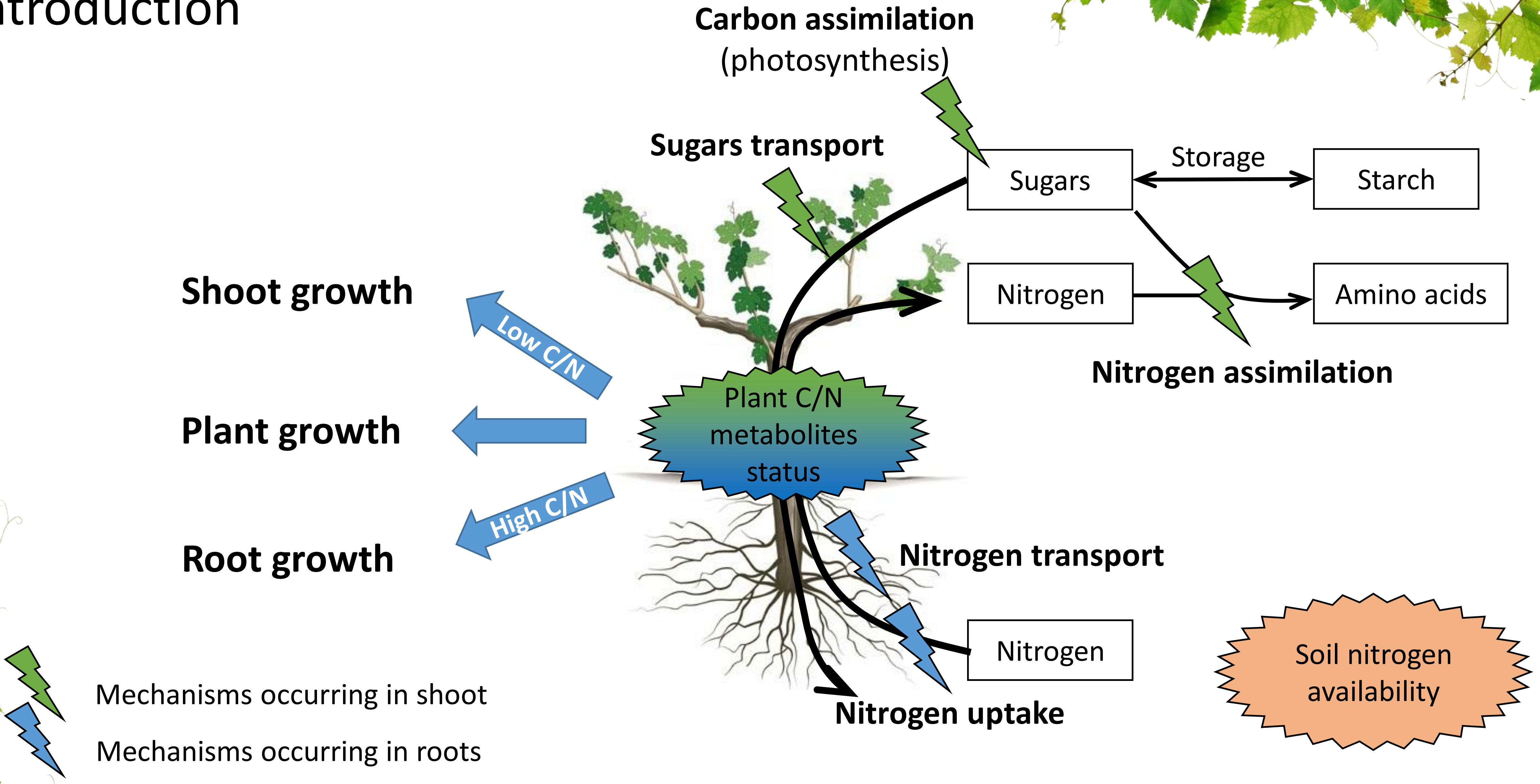
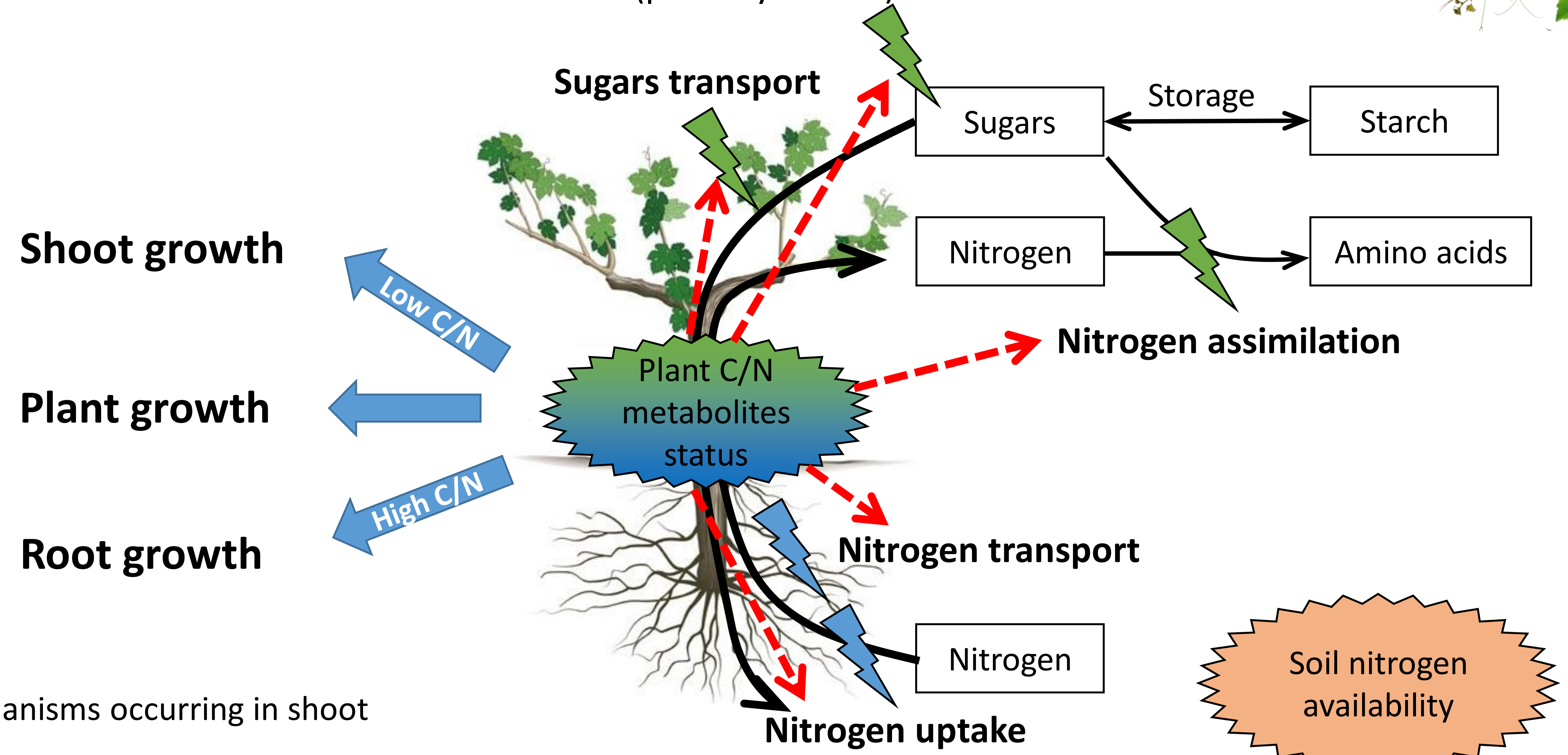


# Introduction




Mechanisms occurring in shoot

Mechanisms occurring in roots

**How scions and rootstocks regulate C and N metabolism at whole plant level?**

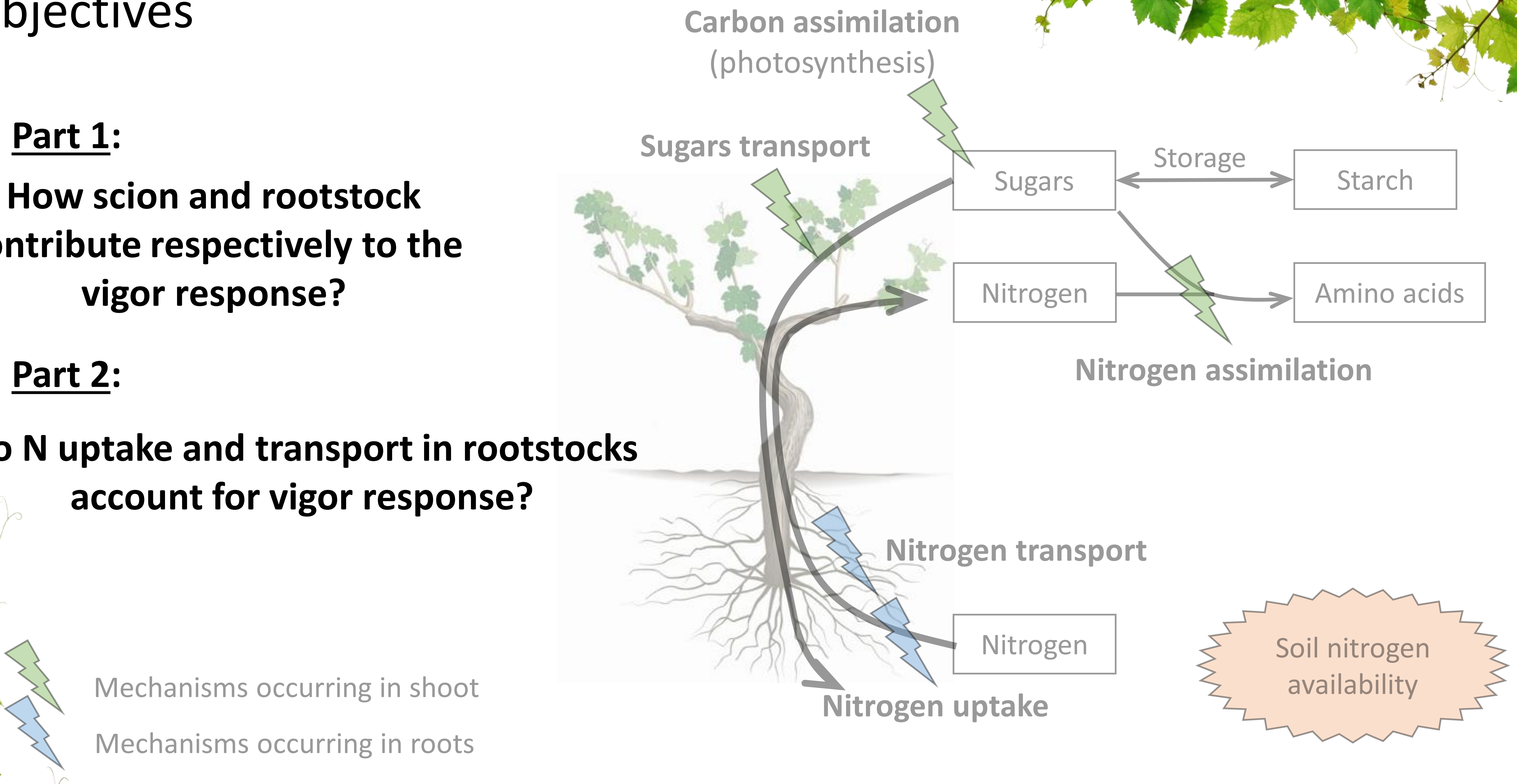
# Objectives

- **Part 1:**

**How scion and rootstock contribute respectively to the vigor response?**

- **Part 2:**

**Do N uptake and transport in rootstocks account for vigor response?**




**How scions and rootstocks regulate C and N metabolism at whole plant level?**

# Part 1: Experimental designs

**Pinot Noir clones**

Expected vigor →

Rootstocks (Expected vigor ↑)

| | Jackson | Dijon | Pommard |
|---|---|---|---|
| RG | X | X | X |
| 3309C | | | X |
| 101-14 | | | X |
| 1103P | | | X |

## Scions and rootstocks variability trial:

- **2017**: **N availability response**
  - Moderate Nitrogen (MN: 4mM)
  - High Nitrogen (HN: 8mM)
- **2018**: **N reserve remobilization**
  - Low Nitrogen content
  - High Nitrogen content

**Evaluation of vigor and metabolites allocation:**

- Metrics: stem length, leaf area, gas exchange, biomass (leaves, stem, trunk, roots)
- Colorimetric assays: Soluble sugars, insoluble starch, free amino acids, nitrate

# Part 1: Experimental designs

**Pinot Noir clones**

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|---|---|---|---|
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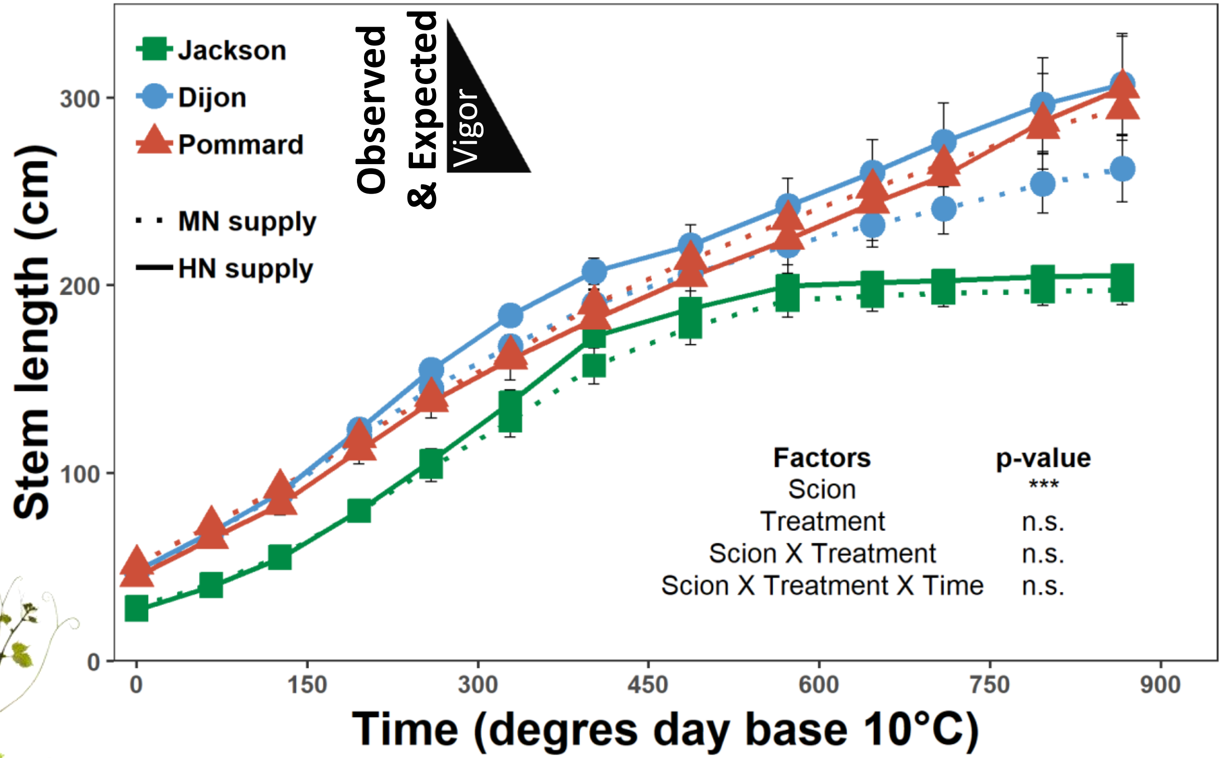
## Scions and rootstocks interaction trial:

- **2018 & 2019**: **N availability response across years**
  - Moderate Nitrogen
  - High Nitrogen

# Part 1: Vigor of Pinot noir clones grafted on RG

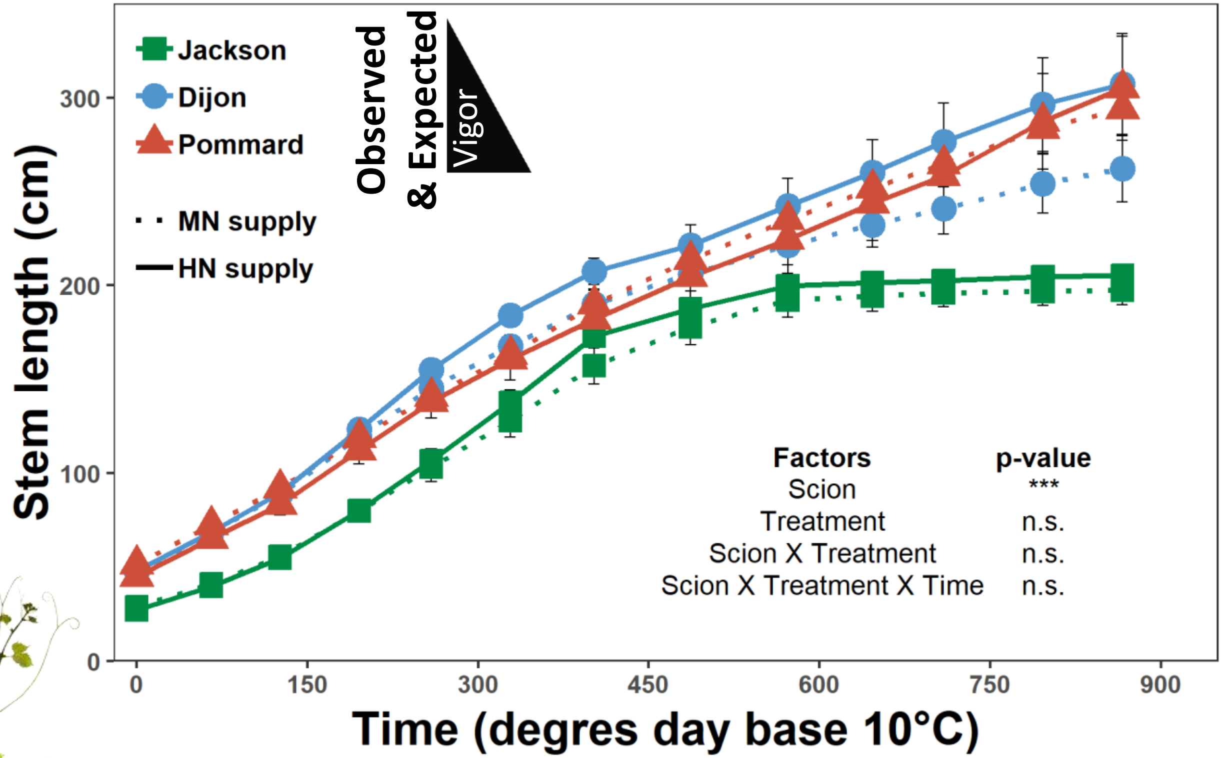
## 2017: N availability response



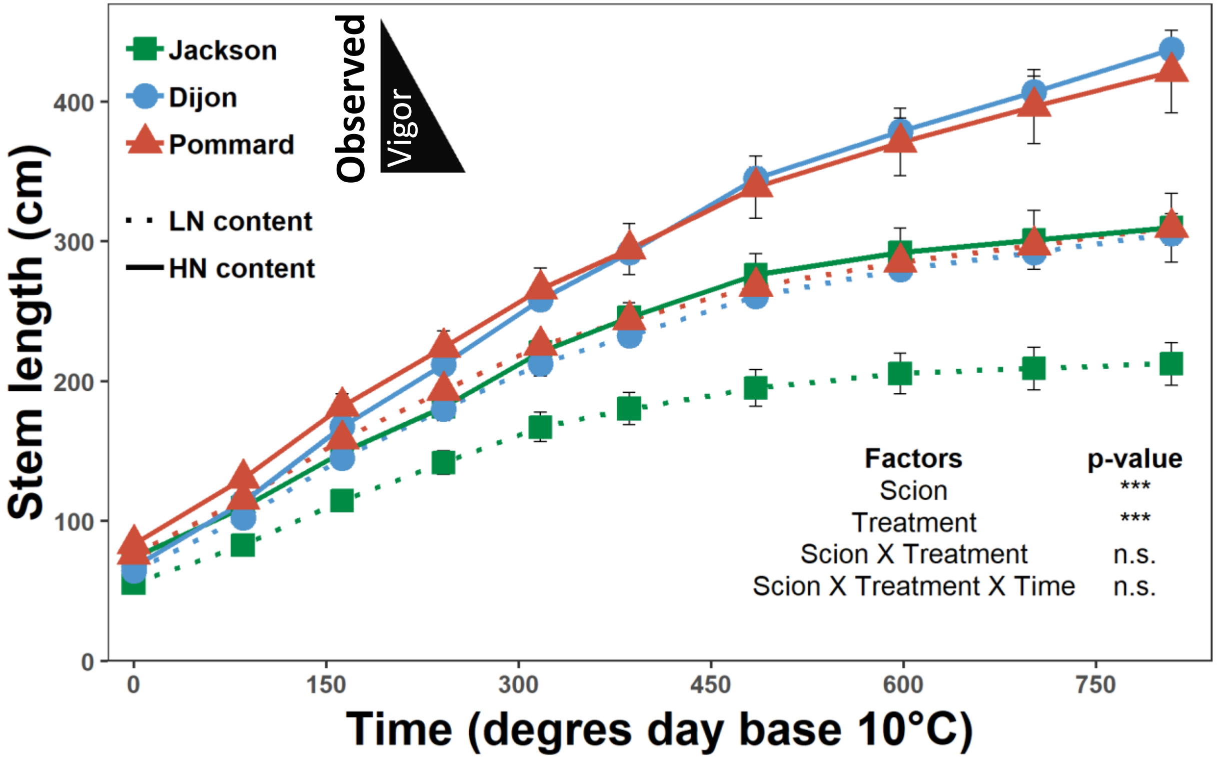

- **N supply did not affect stem length**
- **Expected scions vigor when grafted**

# Part 1: Vigor of Pinot noir clones grafted on RG

**2017: N availability response**




**2018: N reserve remobilization**



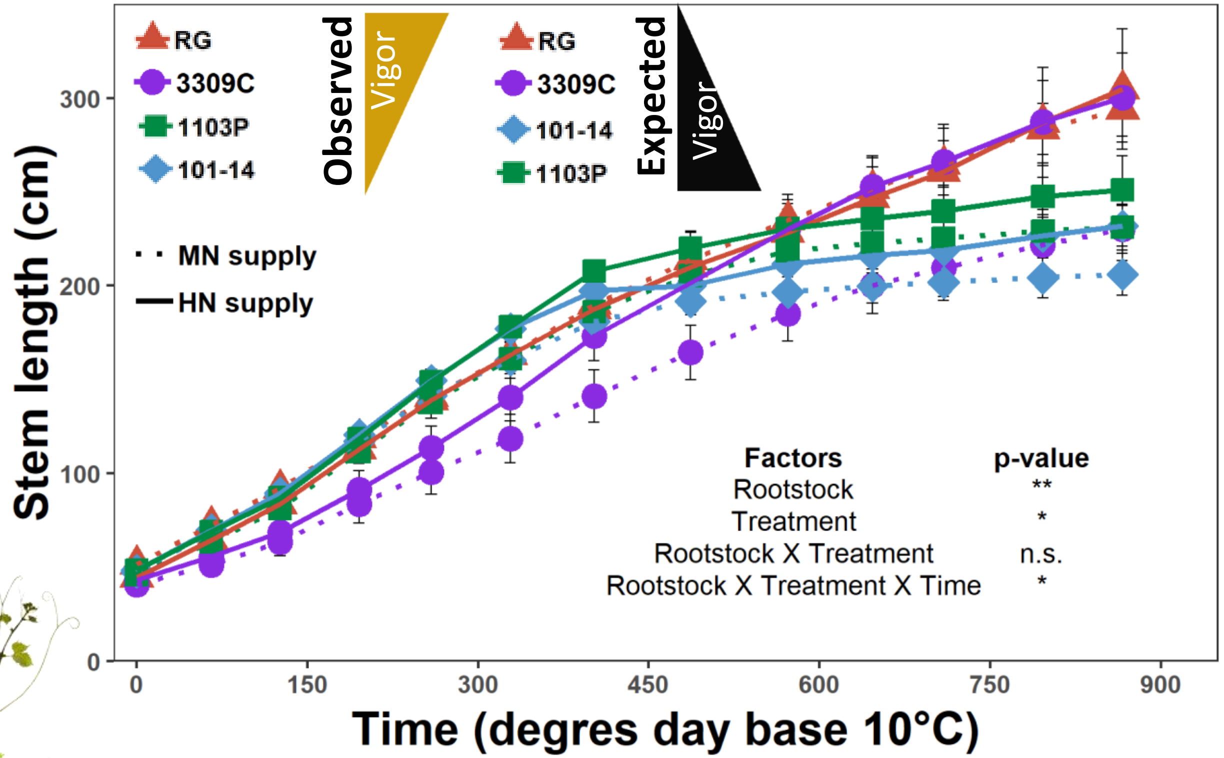

- **N supply did not affect stem length**
- **Expected scions vigor when grafted**

- **N reserve affects stem length**
- **Order of scions vigor is maintained**

**Differences in scions vigor is not affected by N supply but by C assimilation capacity** (data not shown)

# Part 1: Rootstocks influence on Pommard vigor

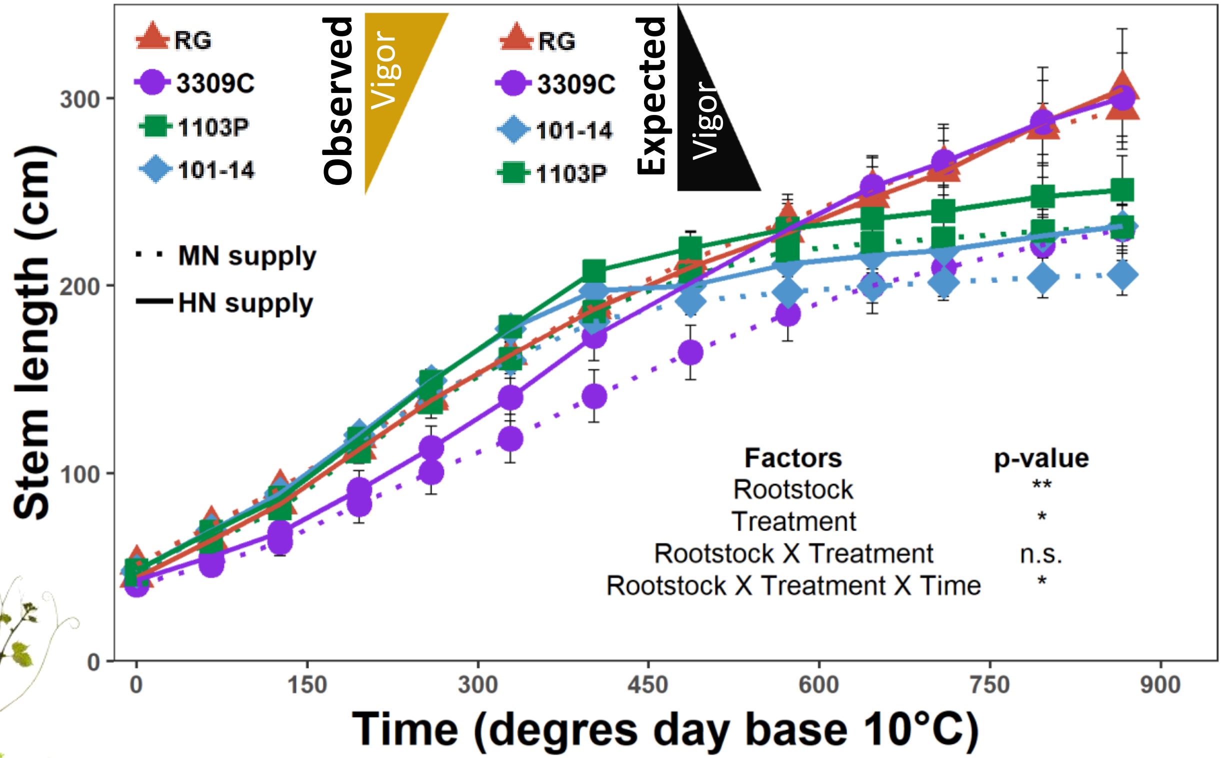
## **<u>2017:</u> N availability response**



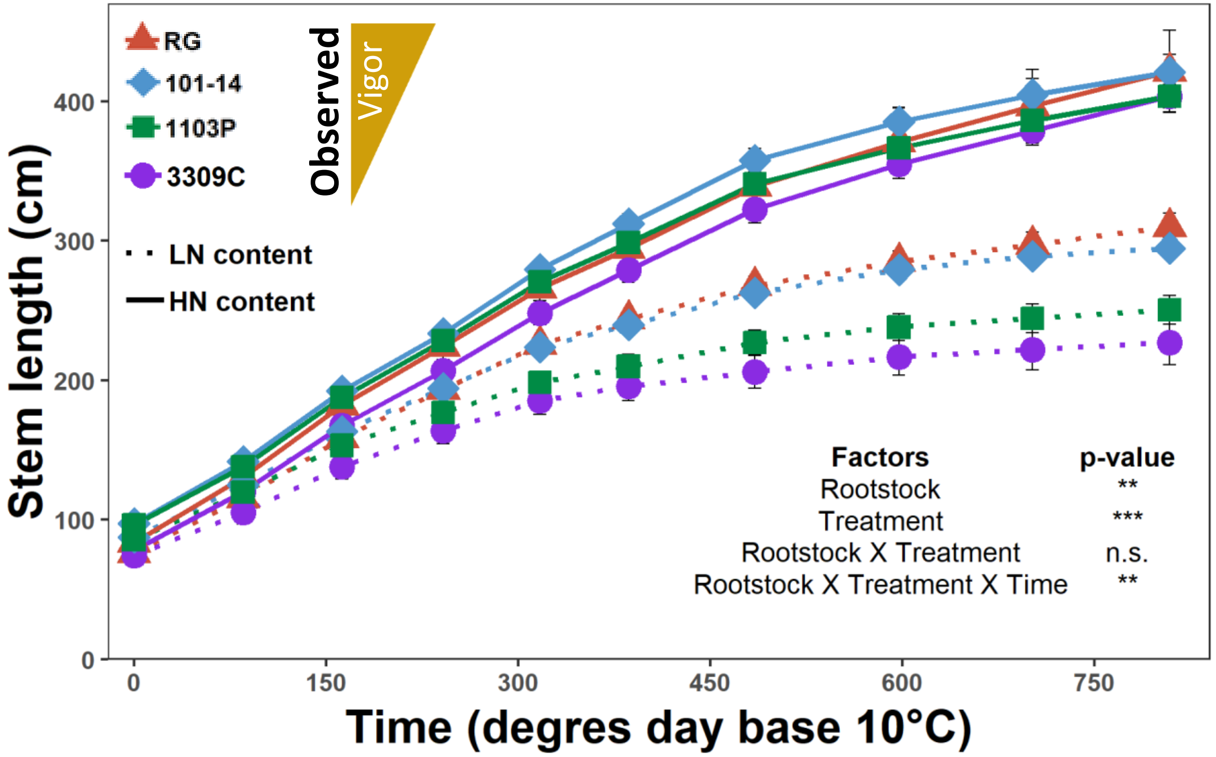

- **Differences in vigor responses to N supply that do not support common knowledge**

# Part 1: Rootstocks influence on Pommard vigor

## 2017: N availability response




## 2018: N reserve remobilization

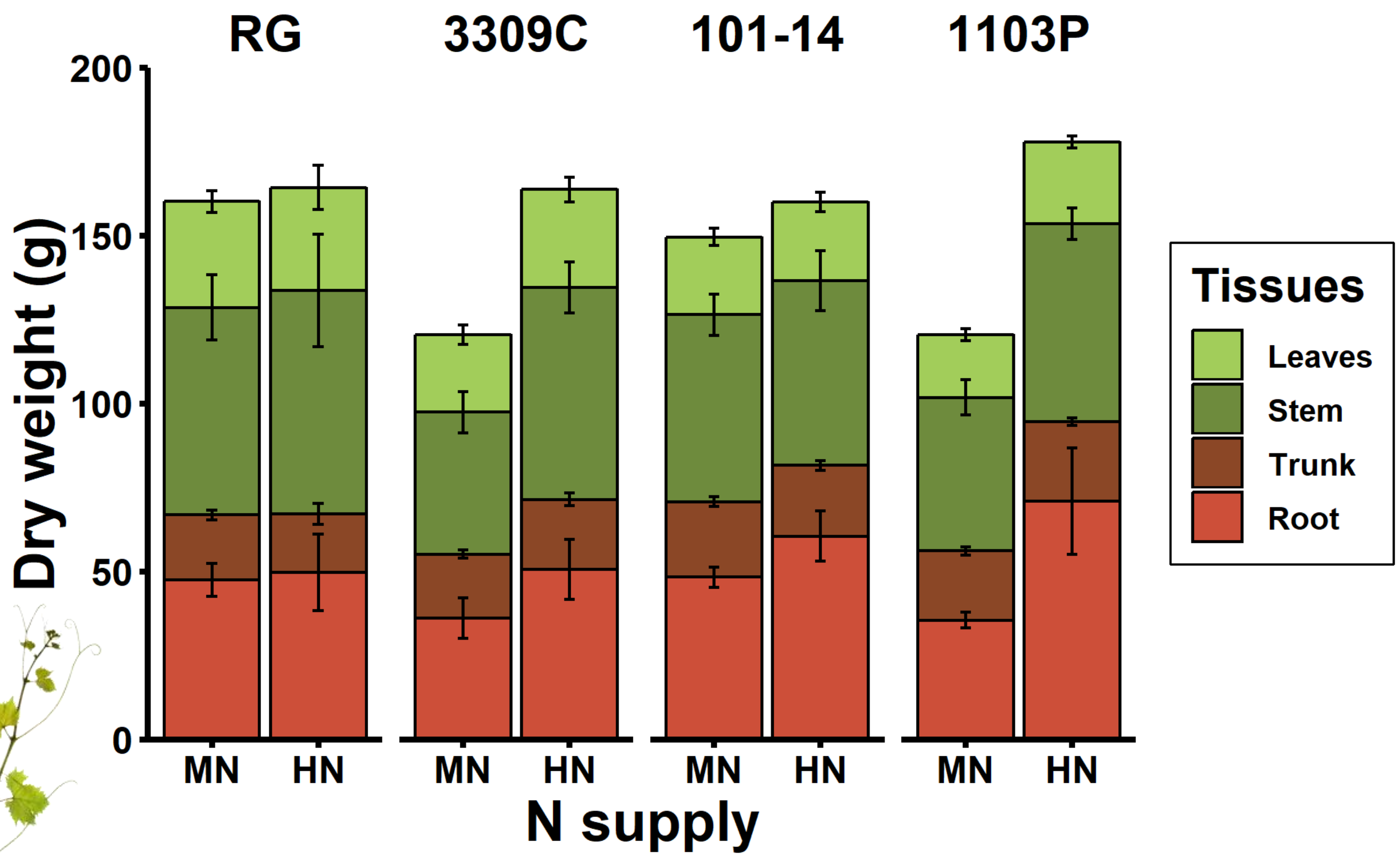



- **Differences in vigor responses to N supply that do not support common knowledge**

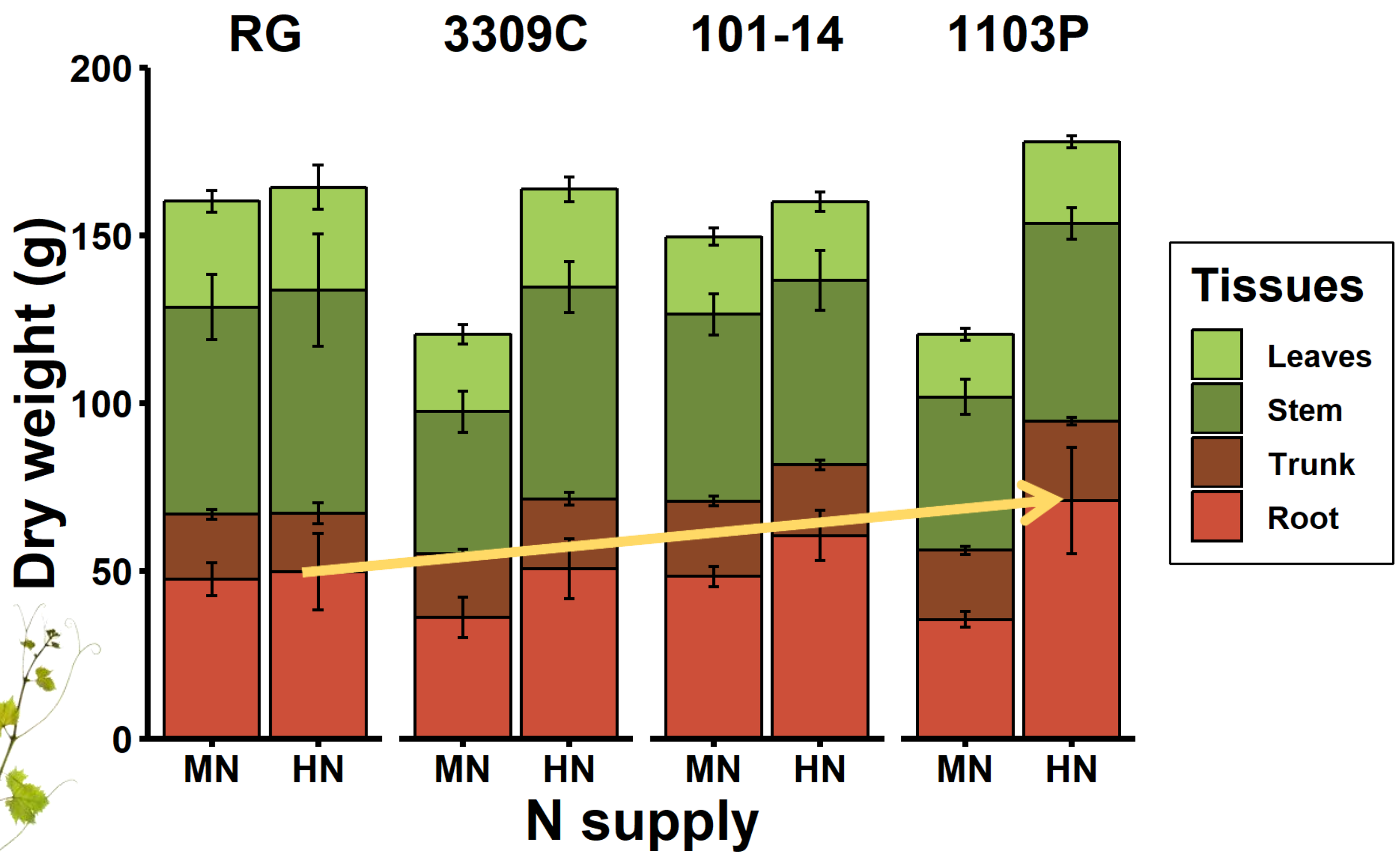
- **N reserve affects stem length**
- **Non-conserved behavior across years**

→ **Nitrogen metabolism may discriminate rootstocks behaviors**

# Part 1: Biomass allocation among rootstocks



# Part 1: Biomass allocation among rootstocks

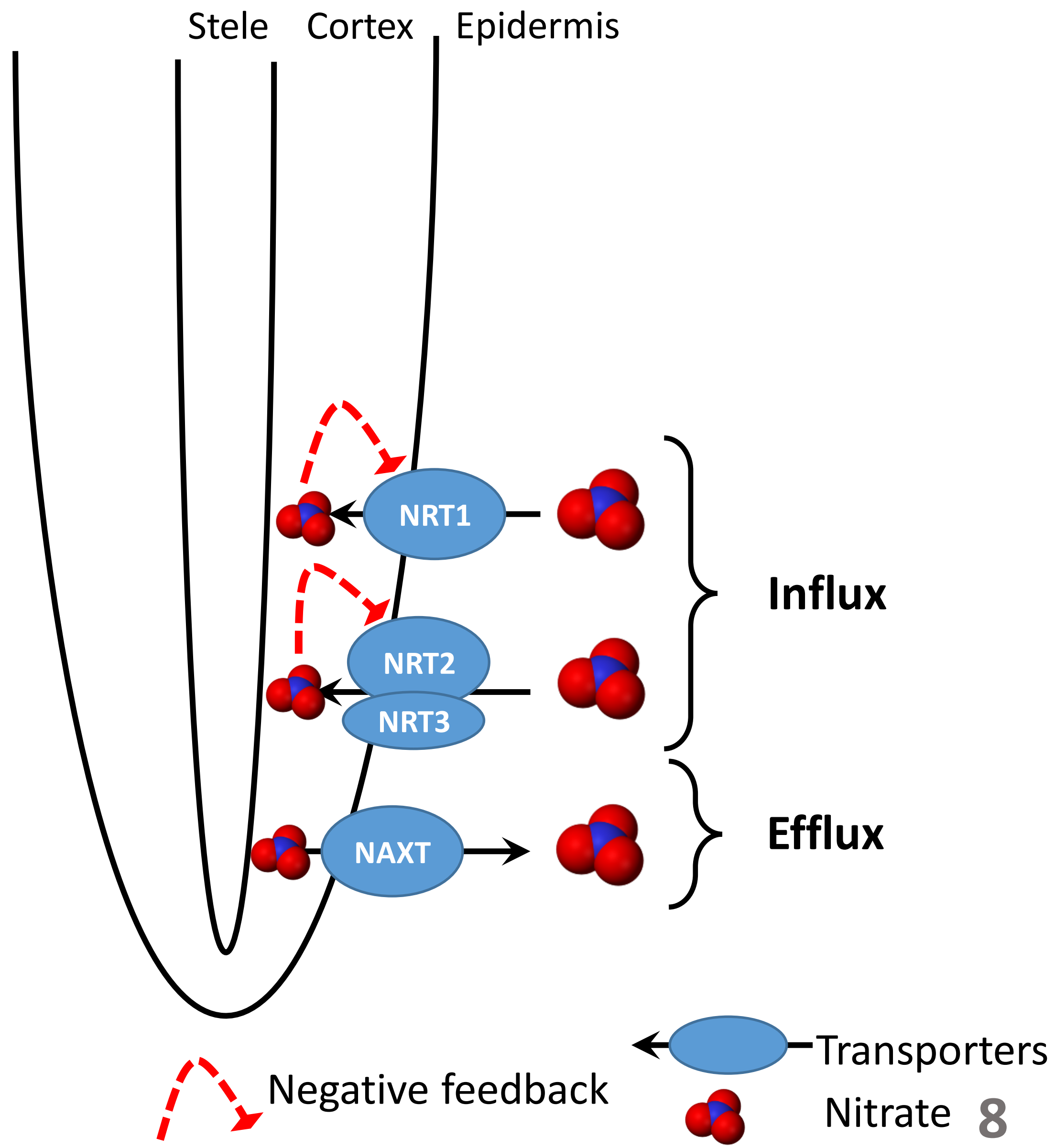



- **In response to nitrogen availability, biomass allocation differs between rootstocks.**
- **Higher N stored for 101-14 and 1103P** (data not shown)

**Biomass allocation response among rootstocks affects N storage capacity**

# Part 2: Nitrate uptake properties

**Plant material:** Riparia Gloire or 1103Paulsen grafted to Pommard



# Part 2: Nitrate uptake properties

**Plant material:** Riparia Gloire or 1103Paulsen grafted to Pommard

- **Capacity of N uptake (Not presented)**
- **Regulation of N uptake**

N re-supply

Hours after N re-supply

0 2 4 8 12 24

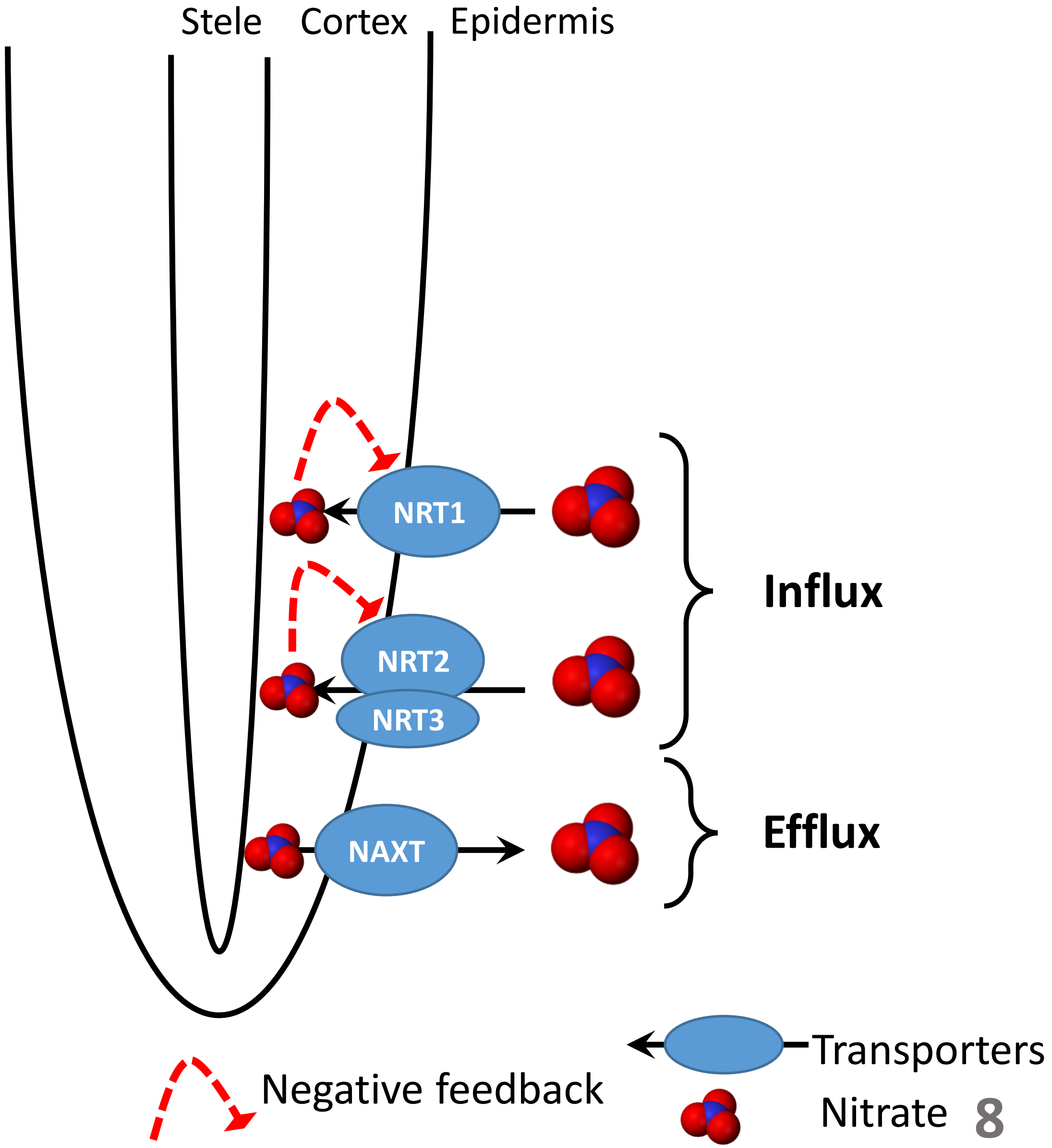
**N-starved plants**

**Root harvest**

➢ **Nitrate uptake measurement**

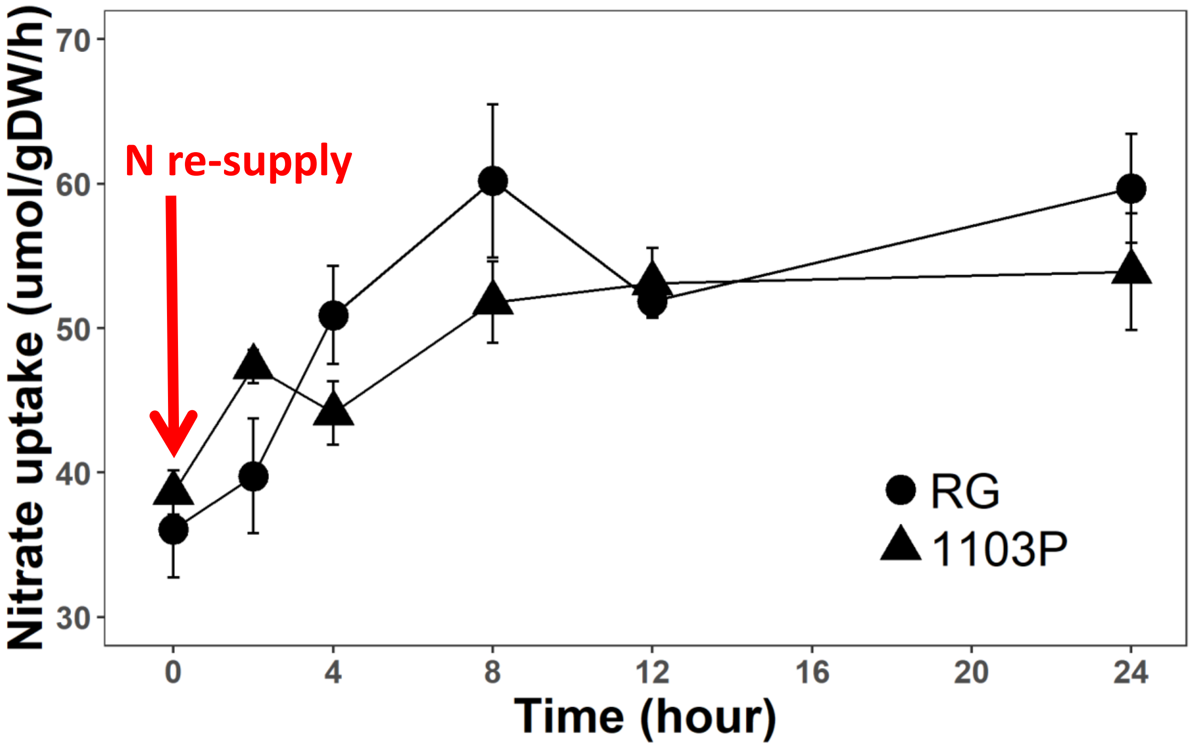
Root labeling with 1mM of $^{15}NO_3$

➢ **Gene expression analysis** (influx and efflux transporters)



# Part 2: Nitrate uptake properties

**Regulation of nitrate uptake**



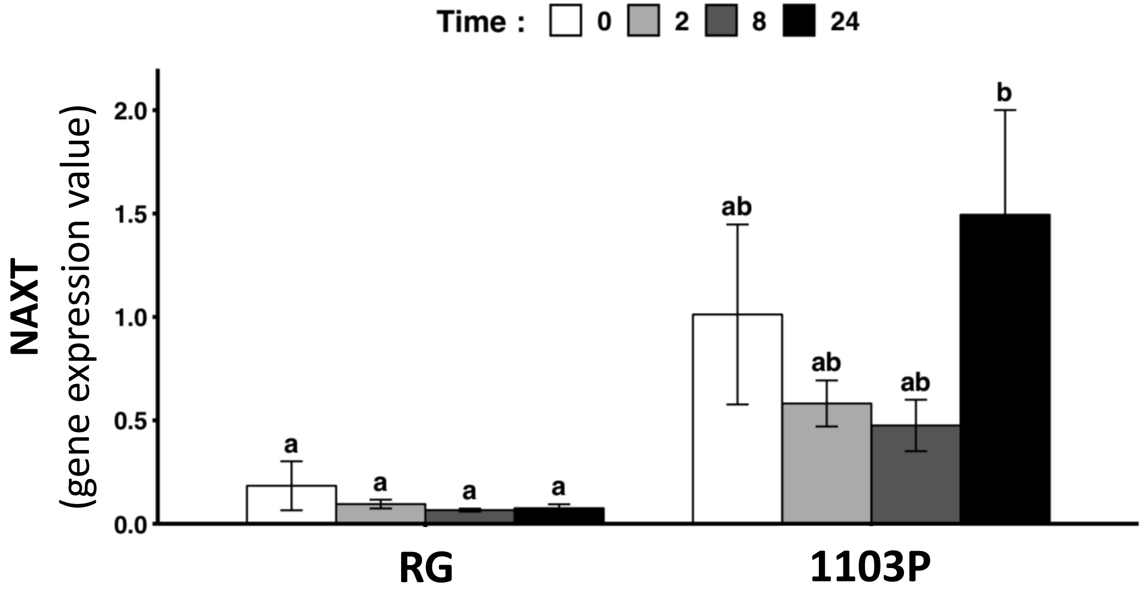

- **Maximum nitrate uptake observed after 8 hours**
- **Same capacity of nitrate uptake (data not shown)**
- **Same regulation of genes involved in nitrate influx (data not shown)**

**Nitrate uptake regulation and its capacity are not different between rootstocks**

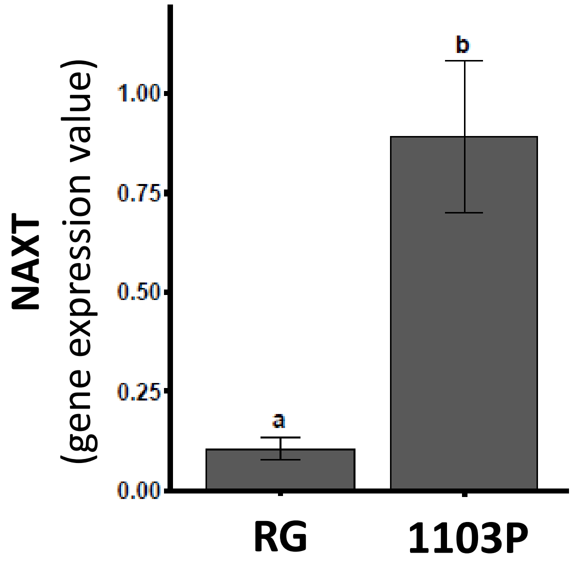
# Part 2: Nitrate uptake properties

## Gene expression of nitrate efflux transporter

❖ **Time X Genotype**




❖ **Main genotype effect**

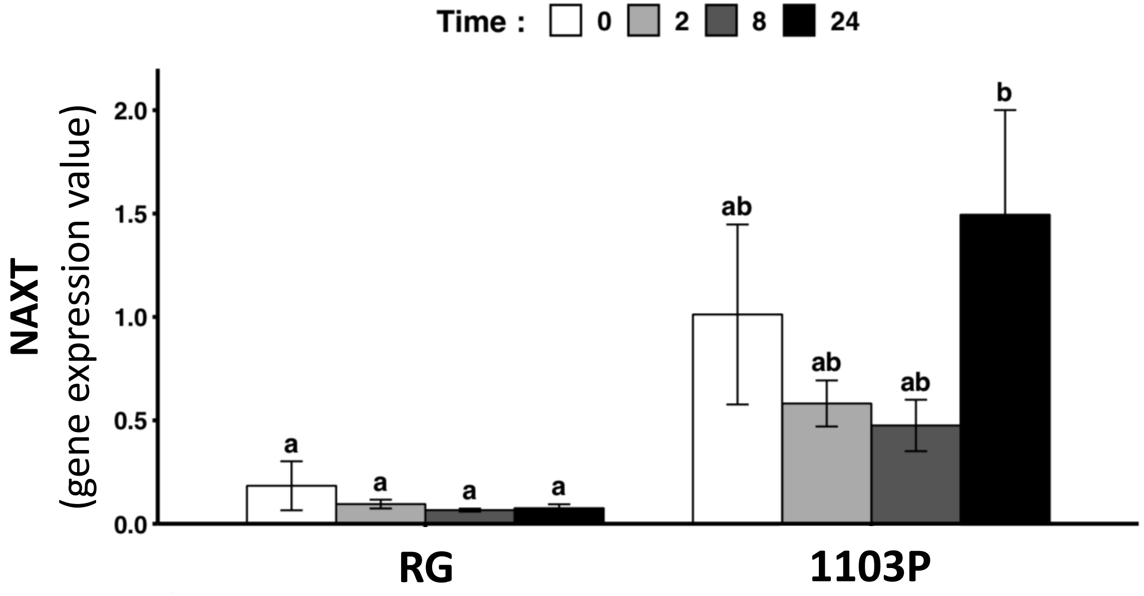



- **Gene expression is not affected by N re-supply**
- **Genotypic difference in gene expression for the nitrate efflux transporter**

# Part 2: Nitrate uptake properties

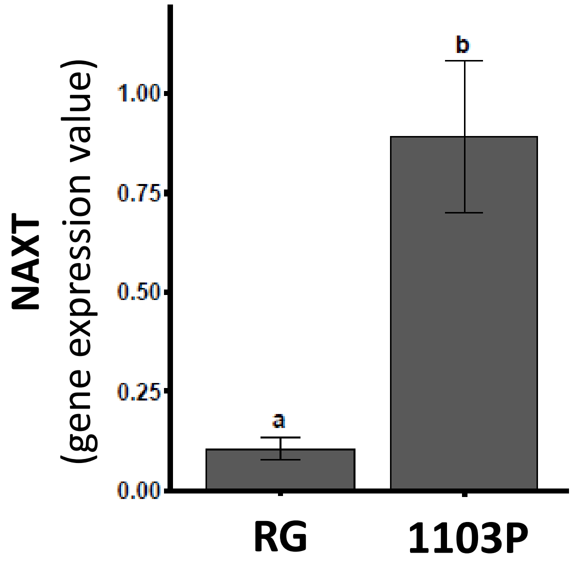
## Gene expression of nitrate efflux transporter

❖ **Time X Genotype**




- **Gene expression is not affected by N re-supply**

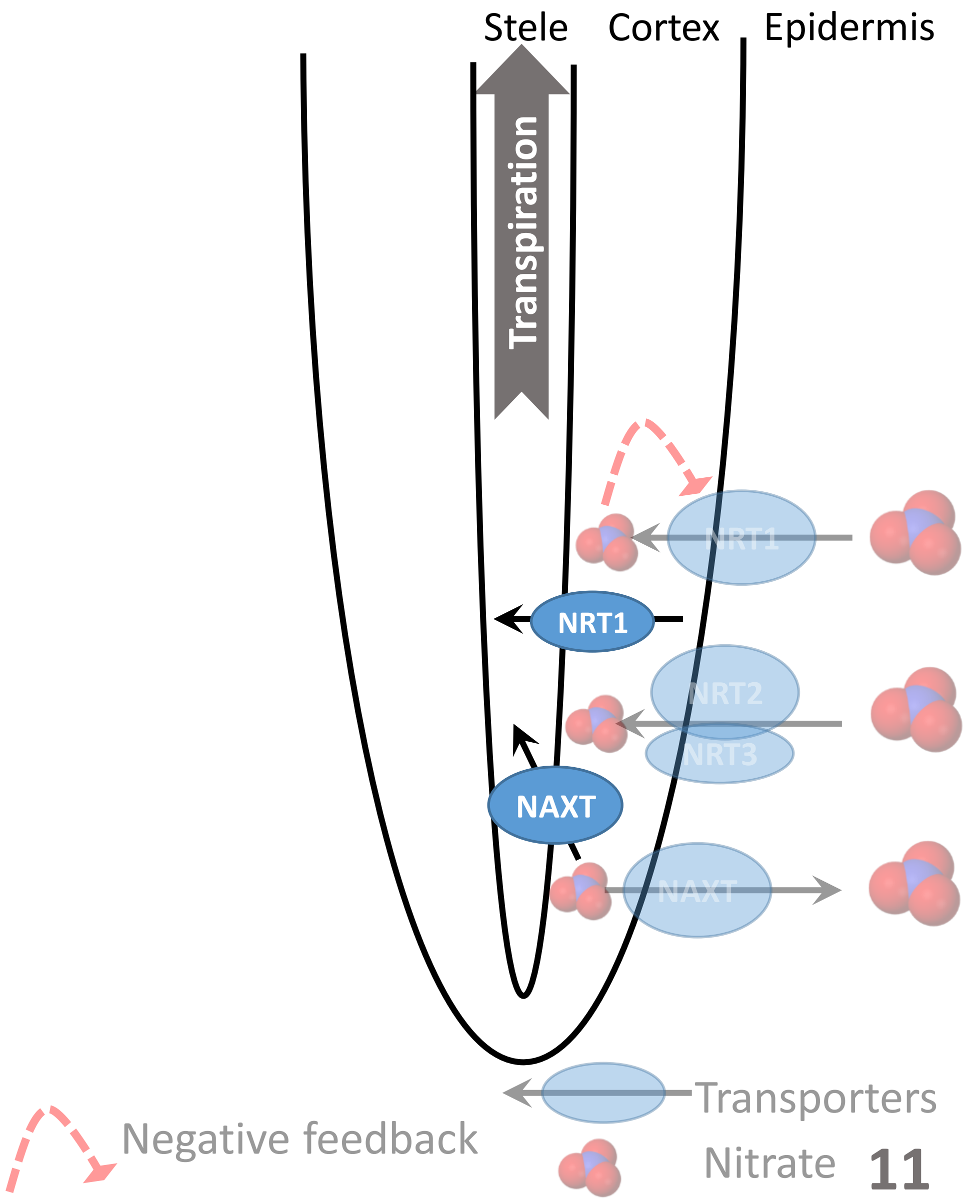
❖ **Main genotype effect**




- **Genotypic difference in gene expression for the nitrate efflux transporter**
- **Nitrate efflux transporter is also involved in N root-to-shoot transport (Taochy et al., 2015)**

# Part 2: Nitrate root-to-shoot transport

**Plant material:** Riparia Gloire or 1103 Paulsen grafted to Pommard



# Part 2: Nitrate root-to-shoot transport

**Plant material:** Riparia Gloire or 1103 Paulsen grafted to Pommard

**Steady state treatments:**

High N (2.4mM)

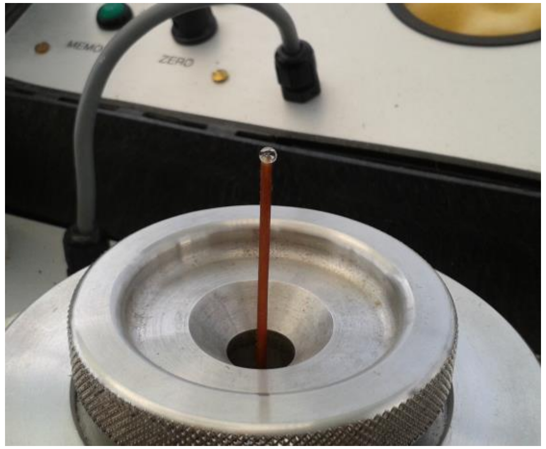
Low N (0.8mM)

Plant growth (12 weeks)

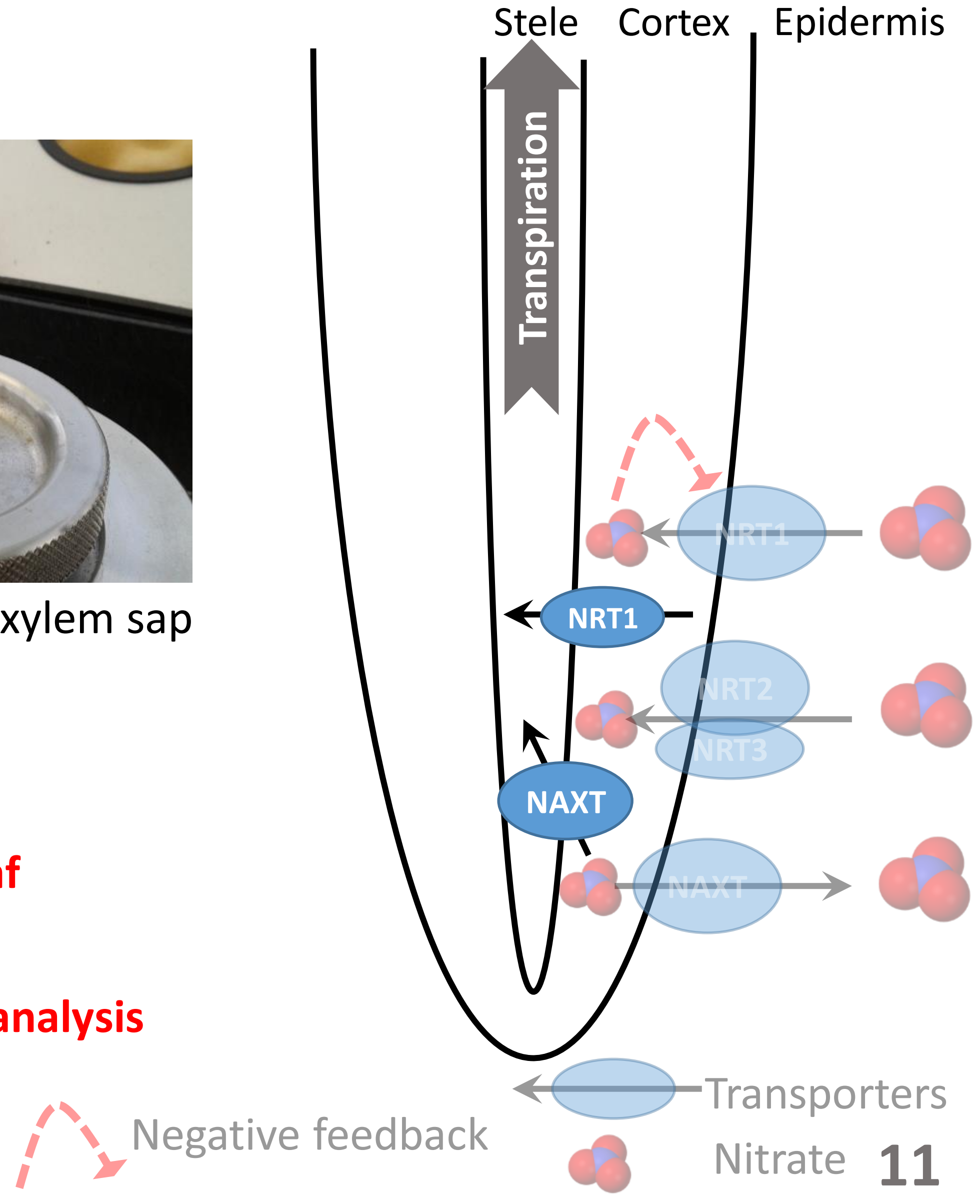
0 4 8 12 24

Hours after labelling

**Labelling solution ($^{15}NO_3$)**



Collection of leaf xylem sap



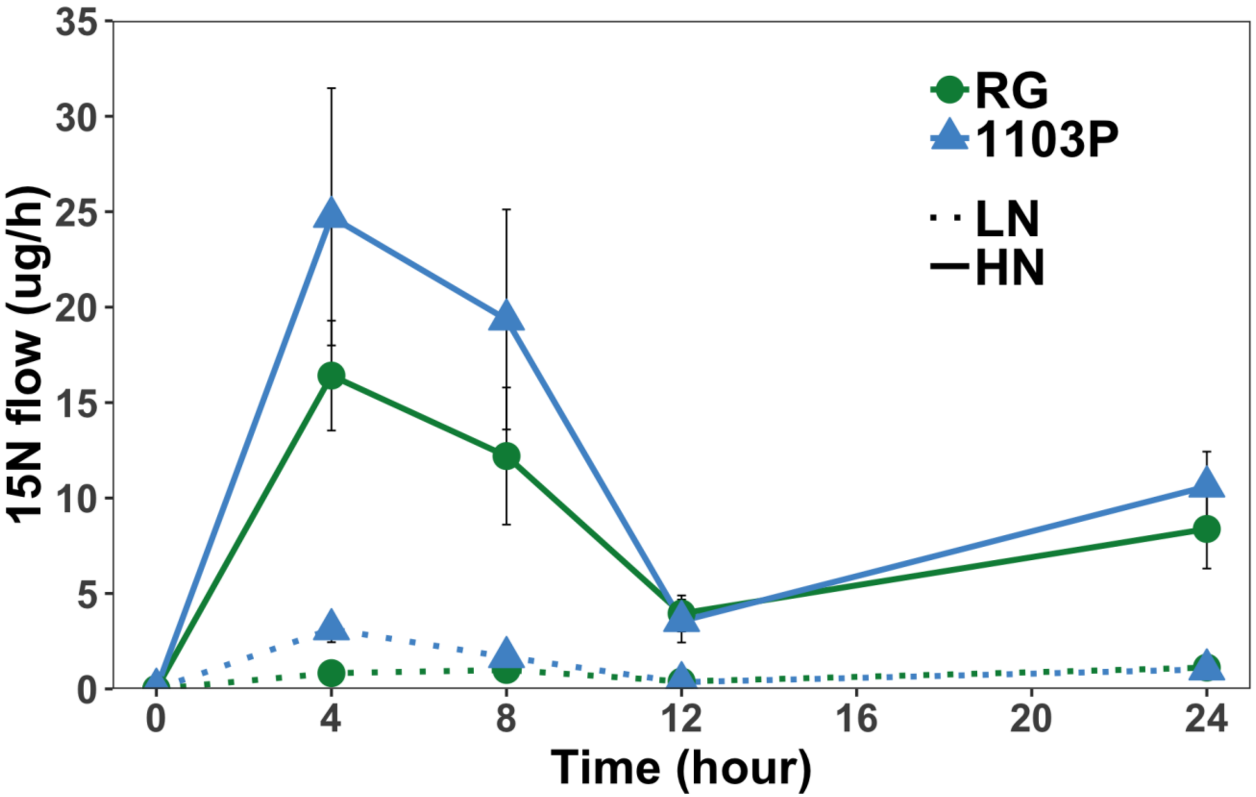

**Organization harvest:**

1. Leaf transpiration (LiCor)
2. Leaf xylem sap (pressure chamber)
3. Leaf area
4. Leaf sample
5. Root sample

**Calculate N flow rate per leaf** (items 1–3)

**Gene expression and $^{15}NO_3$ analysis** (items 4–5)

# Part 2: Nitrate root-to-shoot transport




- **Higher $^{15}N$ flow in 1103P results of higher transpiration and xylem sap loading**

➡ **N root-to-shoot transport is higher for 1103P**

# Conclusions

**Genetic variability observed:**

- Vigor
- C and N metabolites allocation
- Biomass allocation
- Carbon assimilation
- Nitrogen transport

**Mechanisms linked to vigor response:**

- Carbon metabolism can explain variability of scions vigor
- N availability affects rootstocks vigor response:
  - Different biomass allocation strategy which affect N storage capacity across years
  - Different N transport which need further characterization

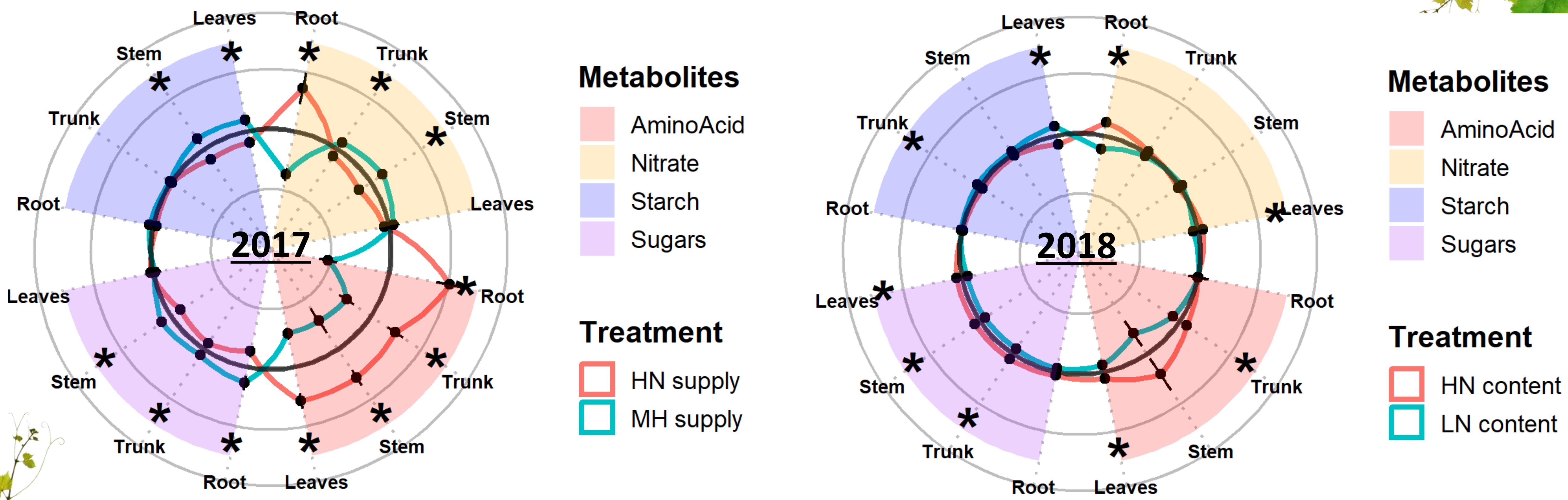

**Funding:**
- OWRI

**OWRI undergraduate scholar:**
- Joey Orton
- Alexander Tauss

**Plant material:**
- Duarte nursery (Joel Myers)

**Technical support:**
- Matthew Scott (USDA)

# C and N metabolites response



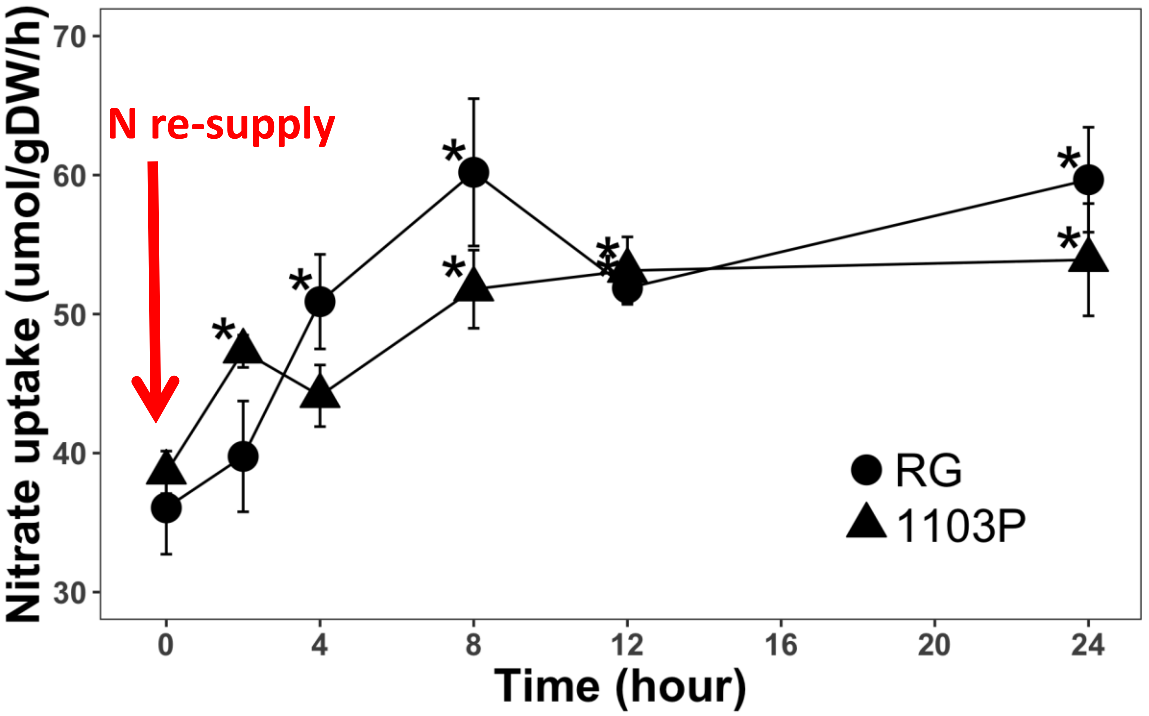

- **Amino acids concentration increases in all plant part.**
- **Remobilization of sugars and starch to sustain N assimilation**
- **Nitrate in root and Amino acids were used to sustain the growth in N limiting availability**

➡ **Scions and rootstocks have the same metabolite response to varying N supplies**

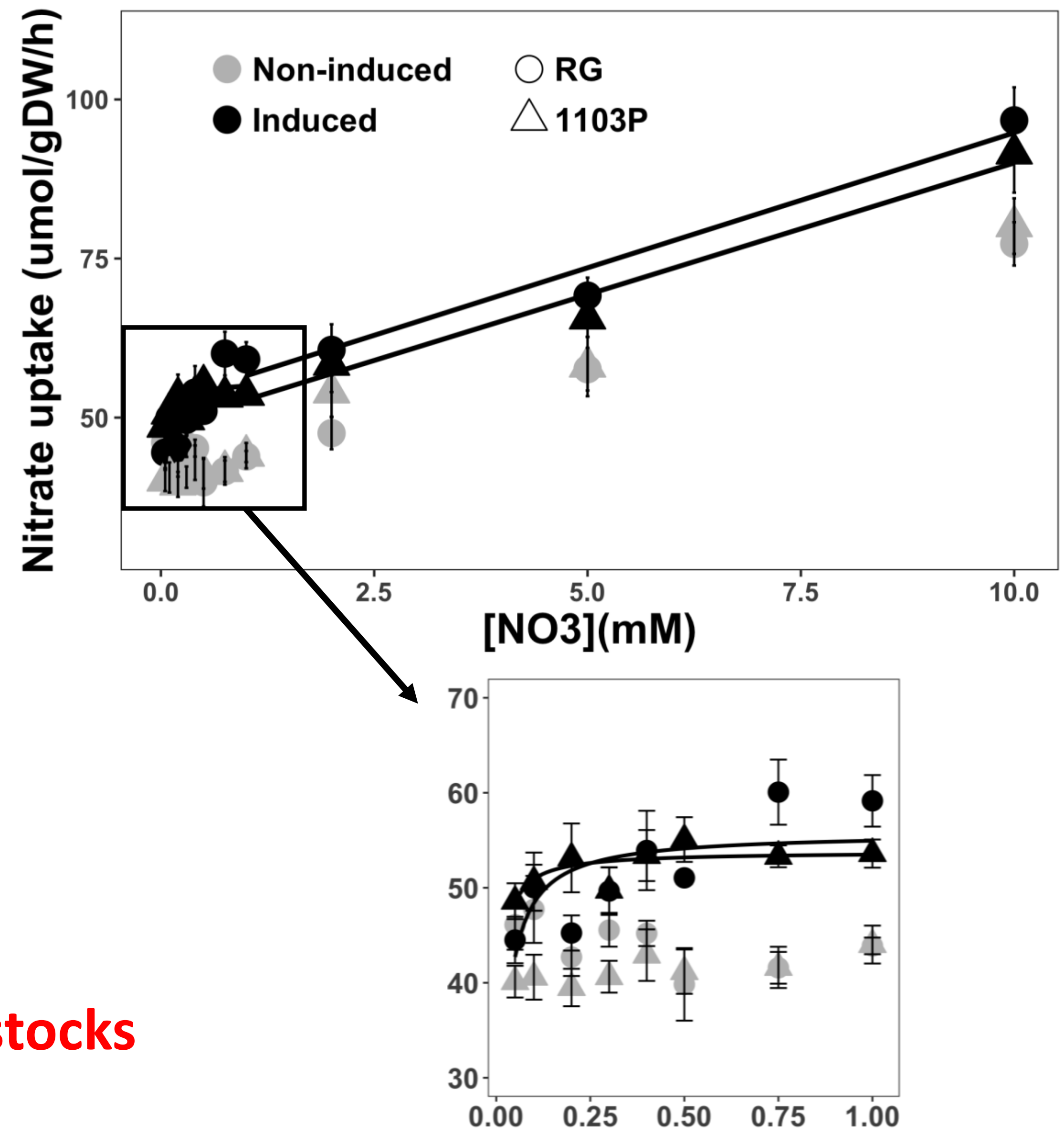
➡ **Expected response of metabolites to varying N supplies**

# Nitrate uptake properties

**Regulation of nitrate uptake**




**Capacity of nitrate uptake**

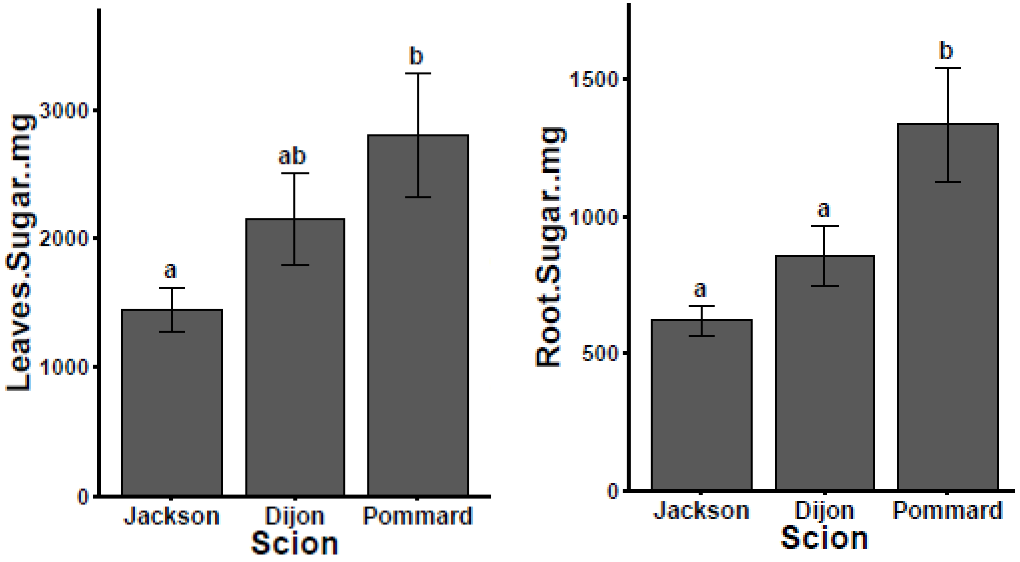



- **Maximum nitrate uptake observed after 8 hours**
- **Two nitrate uptakes transport system**

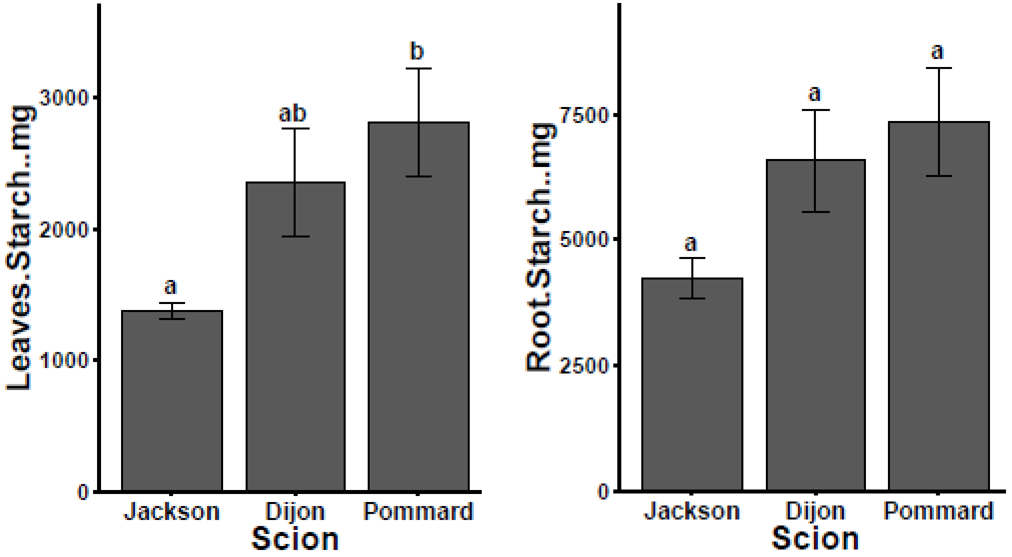
➡ **No difference between rootstocks**

# Carbon metabolism is different between scions

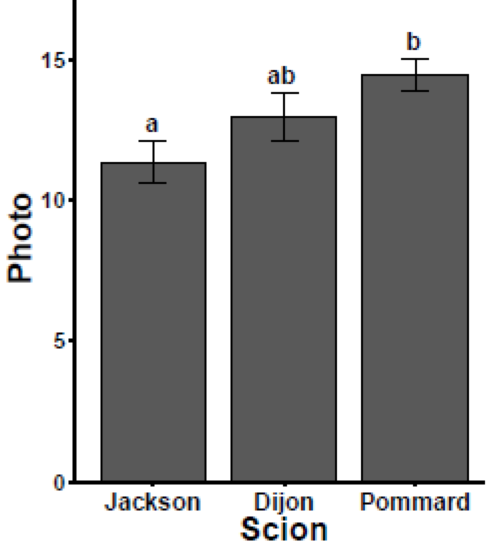
## Soluble sugars content in leaves and roots




## Insoluble starch content in leaves and roots

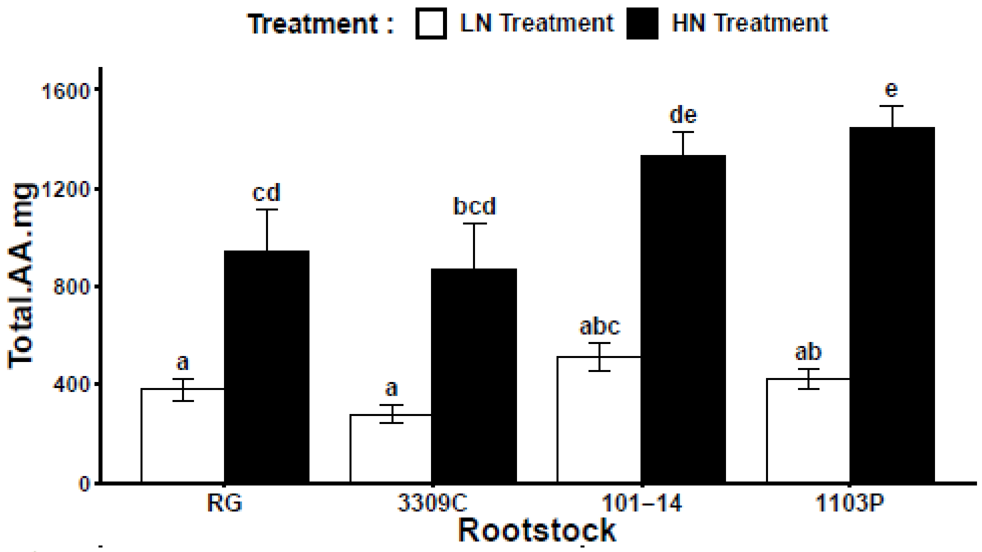



## Carbon assimilation rate

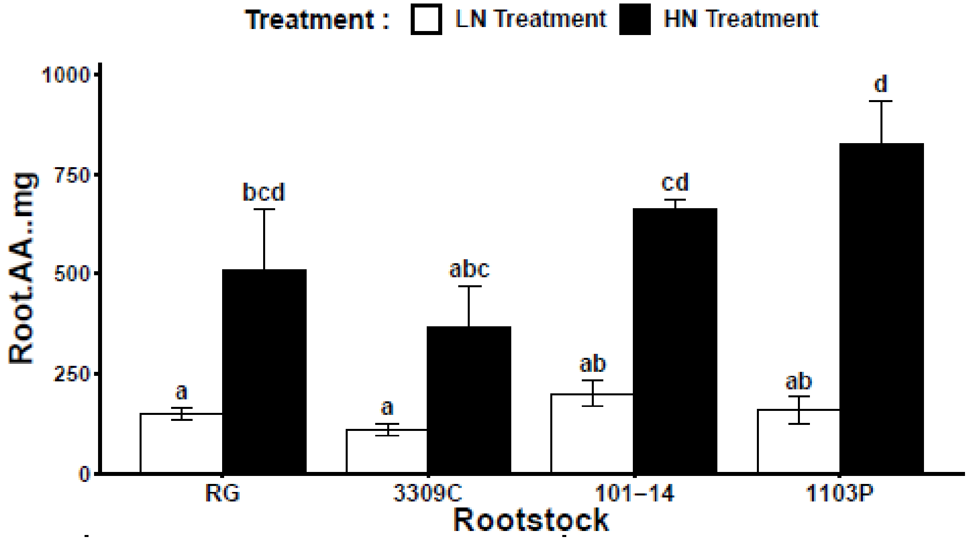


# Nitrogen reserve is different between rootstocks

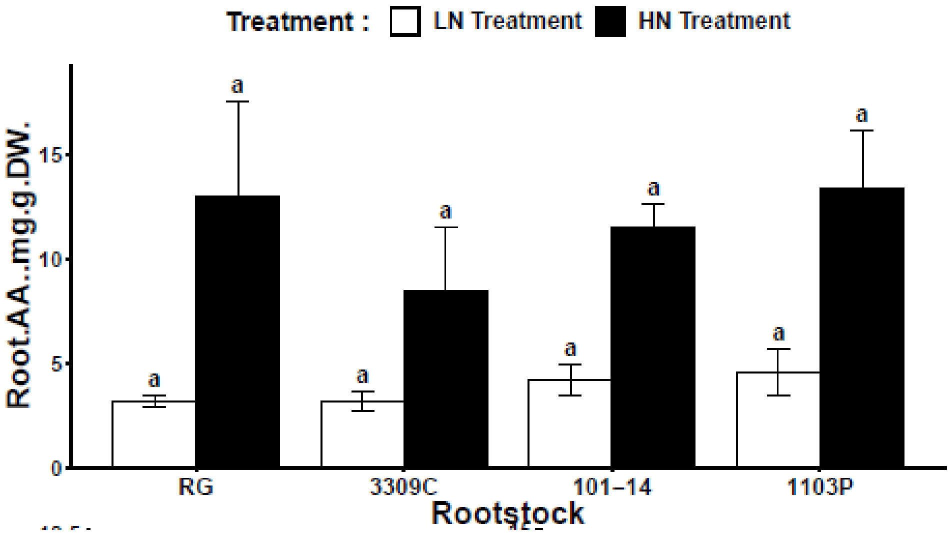
### Total amino acids content at the end of 2017




### Amino acids content in roots at the end of 2017




### Amino acids concentration in roots at the end of 2017




**Increasing biomass allocation to roots is responsible for higher amino acids storage while no difference are observed at the concentration level.**