Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

VIII ISHS Symposium on Mineral Nutrition of Fruit Crops
27th – 30th June 2017, Bolzano – Italy

LEAF AND ROOT UPTAKE OF NITROGEN FROM SIMULATED ATMOSPHERIC DEPOSITION IN POTTED APPLE TREES

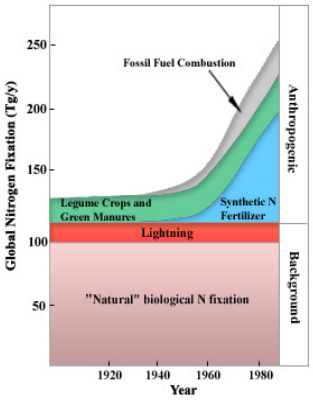
Damiano Zanotelli, Pietro Panzacchi, Francesca Scandellari, Elena Mosca, Massimo Tagliavini

Bolzano June 27, 2017

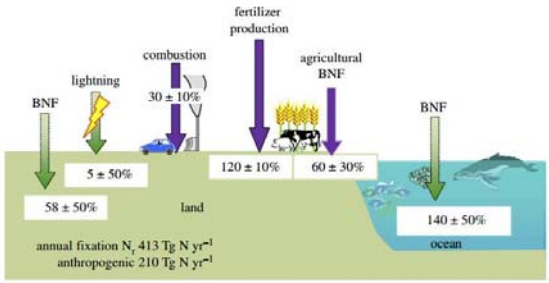
Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

The N cycle

The anthropogenic activities doubled the amount of reactive Nitrogen (N_r) circulating in the terrestrial and marine ecosystems



From Vitousek et al., 1993

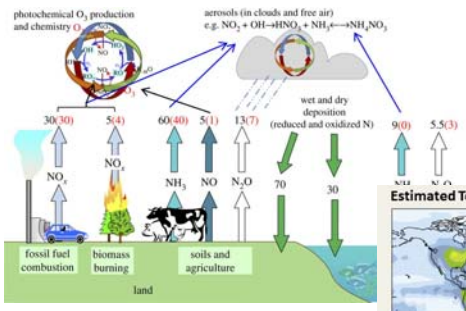


From Fowler et al., 2013

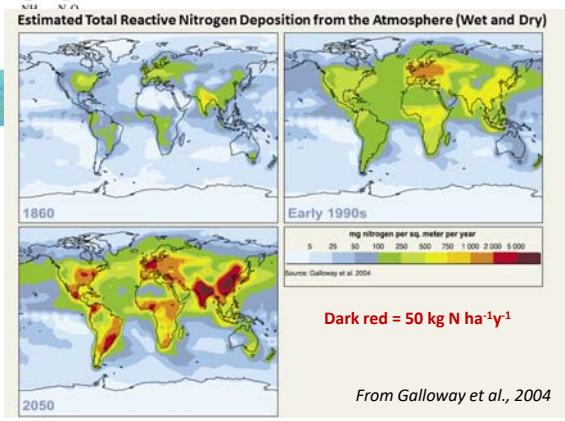
unibz
Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

The N deposition

Increased availability of N_r, increases N_r emission to the atmosphere and N_r return to the terrestrial and marine ecosystems in form of wet and dry deposition



The main sources of global reactive Total N (N_r). Fluxes (Tg N y^{-1}) reported in black represent the total emission, while values in red indicate the anthropogenic contribution.
From Fowler et al., 2013



Dark red = 50 kg N $ha^{-1}y^{-1}$

From Galloway et al., 2004

unibz
Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

RATIONALE

- Leaves of terrestrial plants have retained the ability to take up water-soluble nutrients, typical of aquatic plants.
- N from atmospheric depositions might contribute to nitrogen nutrition of fruit tree crops, similarly to foliar nutrient supplies.
- N depositions are partially intercepted by the canopy of trees and partially reach the soil.
- Foliar and root N uptake might differentially affect above- and below-ground growth

OBJECTIVES OF THE STUDY

- Study the N uptake of apple trees as a consequence of an increased simulated N deposition
- Separate the effect of foliar vs. soil uptake of simulated N deposition on
  - Tree growth and
  - Within tree N partitioning

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

Experimental set up

Plant material:

- 2 year old apple tree cv. Gala on M9
- 23L pots filled with of local soil (sandy loam) at the beginning of the growing season (April 2015)
- 5 replicates (trees)
- In a tunnel to avoid rain and wet N depositions

Num. = 5 replicates x 6 treatments
+ 5 control trees

Experimental design

Simulation of N deposition:

2 types of distribution	3 Nitrogen levels		
	1. *9 kg ha^{-1}*	2. *18 kg ha^{-1}*	3. *36 kg ha^{-1}*
Foliar	N1F	N2F	N3F
Soil	N1S	N2S	N3S

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

^{15}N fertilizer

^{15}N natural abundance

- 0.366 at. % (atmospheric N_2)

Type of fertilizer

- $^{15}NO_3{}^{15}NH_4$ 10.3 at.%

Simulated nitrogen deposition

- We considered a projection of the canopy for each young apple tree of ~ 0.28m^2 (r = 0.3m)
- The amount of fertilizer given was calculated based on the N content of ammonium nitrate (35%) and the target N level:
  - N1 (9 kg ha^{-1}) → 232.7 mg tree^{-1}
  - N2 (18 kg ha^{-1}) → 487.9 mg tree^{-1}
  - N3 (36 kg ha^{-1}) → 907.6 mg tree^{-1}

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

^{15}N applications

- Seven applications from mid July to mid October with a biweekly frequency
- Ammonium nitrate was supplied in a water solution with the aid of a manual sprayer
- The same amount of ^{15}N with respect to the N level was given either to the canopy (**foliar**) or to the **soil**
- Caution was used to avoid contamination of the soil in foliar treatments

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

^{15}N applications

Foliar application

Soil application

Nitrogen derived from N deposition (N_{dfd})

$$N_{dfd} = \frac{^{15}N_{excess}\,organ}{^{15}N_{excess}\,fertilizer} * N_{content}\,organ$$

$^{15}N_{excess}organ$ = at.%^{15}N organ- at.%^{15}N control

$^{15}N_{excess}fertilizer$ = at.%^{15}N fertilizer - at.%^{15}N control

$N_{content}organ$ = %N organ* dry biomass sample

Biomass measurements

Biometric measurements

- Trunk diameter and cumulative shoot length were measured at the beginning of the ^{15}N supply treatments (July 2015) and before plant removal (November 2015)

Biomass characterization

- When removed at the end of the growing season, apple trees were divided in five organs, which were dried in oven (65°C) and weighed

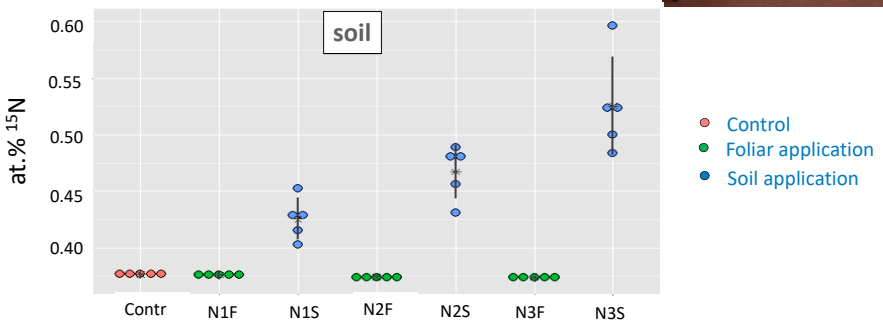
Below-ground biomass

Above-ground biomass

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

^{15}N analysis

All the collected plant material analysed with the Delta V™ Isotope Ratio Mass Spectrometer (Thermo Fisher) to assess total C, N and ^{15}N concentration



unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

RESULTS

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

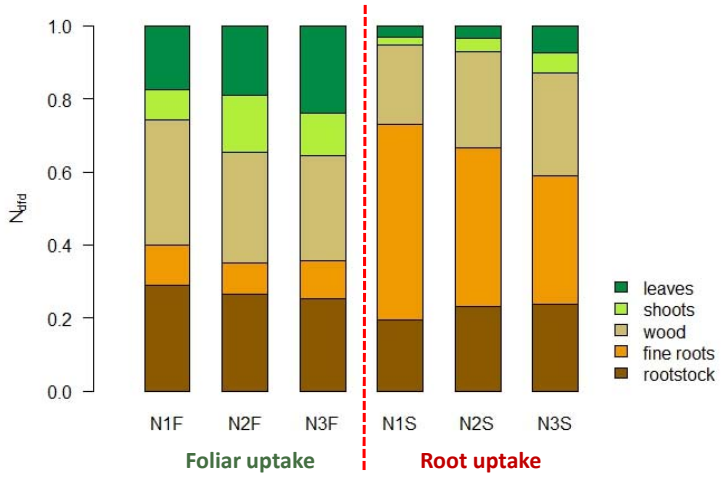
Nitrogen derived from deposition
Sum of the N_{dfd} of all organs

N level	Foliar uptake		Root uptake	
	mg/tree	% of N applied	mg/tree	% of N applied
N1 (x1)	**50** *a*	21	**75** *a*	32
N2 (x2)	**130** *b*	26	**252** *b*	52
N3 (x4)	**258** *c*	28	**528** *c*	58

- In both cases we observed an increasing percentage of N_{dfd} uptake with increasing N rates
- Root uptake higher than foliar uptake, regardless the rate.

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

Nitrogen derived from deposition
Relative distribution of N_{dfd} in the



unibz

Partitioning of Nitrogen derived from deposition

N_{AG} / N_{TOTAL}

N level	Foliar application	Soil application
	$\%N_{AG}/N_{TOT}$	$\% N_{AG}/N_{TOT}$
N1	60	34
N2	63	36
N3	65	41
Average	*63*	*37*

- More N_{dfd} was found in belowground organs when N was applied to soil
- When N was applied to the canopy, most N_{dfd} was in the aboveground organs
- The higher the N deposition, the higher its allocation to AG organs

unibz

Effects of N deposition on tree growth

average of foliar and soil supply

N level	Δ shoot length	Shoot dw	Leaf dw	Fine Roots dw
	(cm/tree)	(g/tree)	(g/tree)	(g/tree)
N1	41.1 *b*	14.4 *b*	33.9	55.6
N2	96.3 *a*	20.4 *a*	36.1	49.5
N3	102.8 *a*	19.9 *a*	38.3	60.7

- Shoot biomass and shoot lenght increased when N was supplied at the two highest N rates (N2 and N3)
- The shoot growth increase occurred regardless the way N was absorbed (root or foliar uptake)

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

Final remarks

- The experimental setup allowed to study the differential effects of N uptake from depositions, if available to the canopy (AG) or to the soil
- In the young apple trees, 25% of total supplied N was taken up when applied to leaves and 47% when applied to the soil
- The N uptake increased at increasing levels of N deposition
- Shoot growth did not further increase from N2 (18 kg N ha^{-1}) to N3 (36 kg N ha^{-1})
- Regardless the N level, more N_{dfd} was found AG when it was intercepted by the canopy, as compared to root uptake.
- Increasing the N deposition level slightly increased N allocation to AG organs, regadless the type of uptake

unibz Fakultät für Naturwissenschaften und Technik
Facoltà di Scienze e Tecnologie
Faculty of Sciences and Technology

Final remarks

- Effects of N deposition cumulate over years and trees might adapt to increased N deposition.
- Under natural conditions, N depositions reach both the canopy and the soil, so, both foliar to root uptake occur, with ratios depending on many factors, including leaf area index.


Thanks to all collaborators
and to you for your attention!