# Foliar concentration of macro- and micronutrients between 2004 and 2014 in response to irrigation at Pfynwald

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Pfynwald workshop 16.11.2015

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# Context of the work - master thesis

**Morphological parameters:**

1. Leaf area index (LAI)
2. Macromorphology of needles and shoots
3. Needle histology

**Chemical parameters:**

1. Isotope analysis: $\delta^{18}O$, $\delta^{13}C$ and $\delta^{14}N$
2. Non structural carbohydrates (NSC) analysis
3. **Nutrient elements (macro- and micronutrients)**

# Methods and material

**Material:**

- 4 branch harvests (2004, 2006, 2012 & 2015)
- 2 treatments x 4 plots x 5 trees = 40 samples
- 3 needle ages (1 to 3-year-old needles)

**Method: analysis by the Central Laboratory, WSL**

- CN analysis (NC-2500)
- Element analysis with ICP-OES : Al, B, Ba, Ca, Fe, K, Mg, Mn, P, S, Zn, (Cd, Co, Cr, Cu, Mo, Na, Ni, Pb)

**Statistical Analysis:**

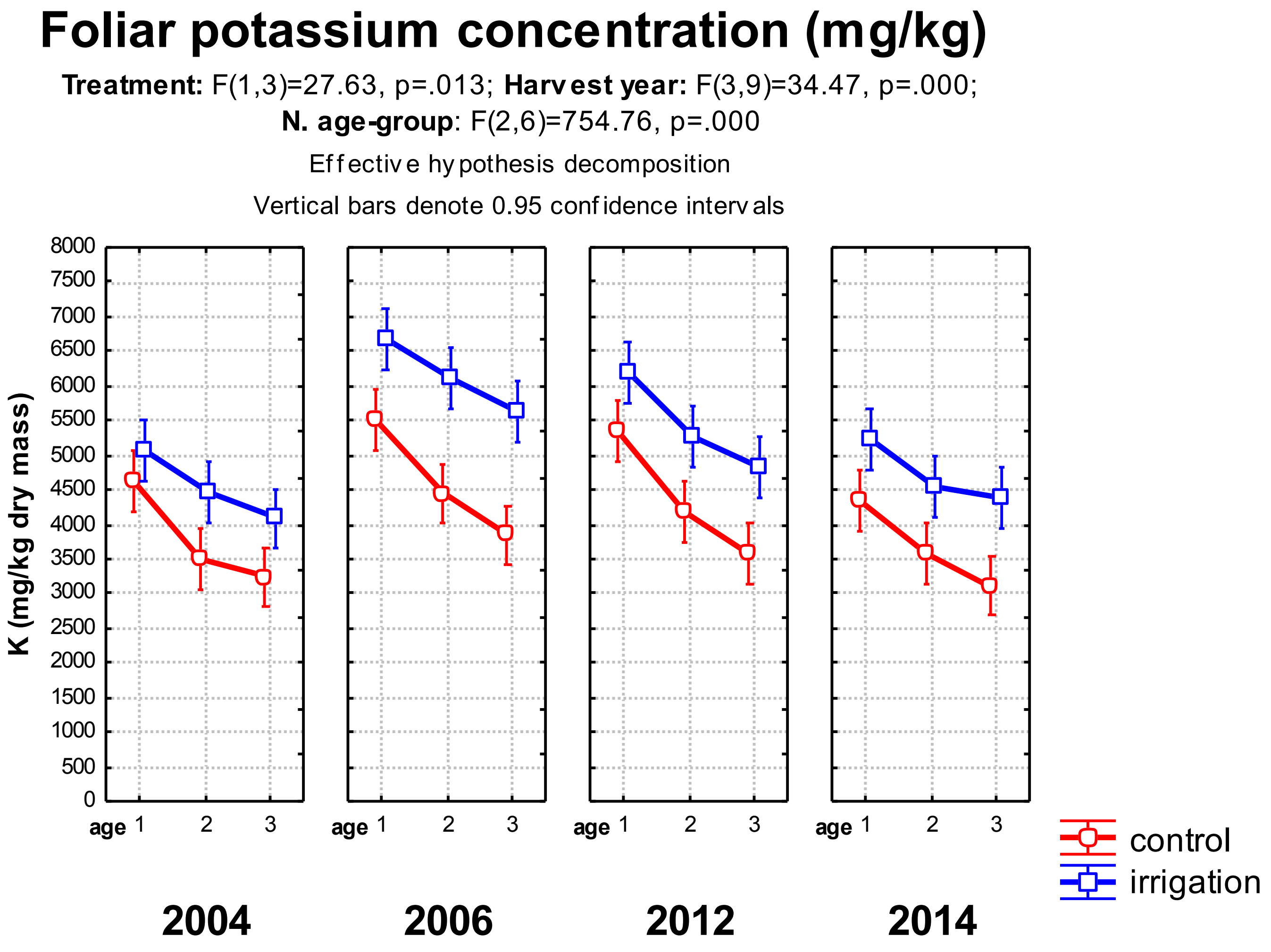
- Repeated measures ANOVA with STATISTICA (StatSoft)

| n. age-group | harvest | | | |
|---|---|---|---|---|
| | 2004 PS | 2006 PS, PV | 2012 PS, PV, CR | 2015 PS, PV, TL |
| 2002 | | | | |
| 2003 | | | | |
| 2004 | | | | |
| 2005 | | | | |
| 2006 | | | | |
| 2007 | | | | |
| 2008 | | | | |
| 2009 | | | | |
| 2010 | | | | |
| 2011 | | | | |
| 2012 | | | | |
| 2013 | | | | |
| 2014 | | | | |

PS = Patrick Schleppi, PV = Pierre Vollenweider, CR = Carmen Rovina, TL = Theresia Lindner

# Preliminary results - macronutrients

- Significantly higher concentration of K and N in irrigated plots and a tendency for S
- Decreasing concentration of these elements with needle aging



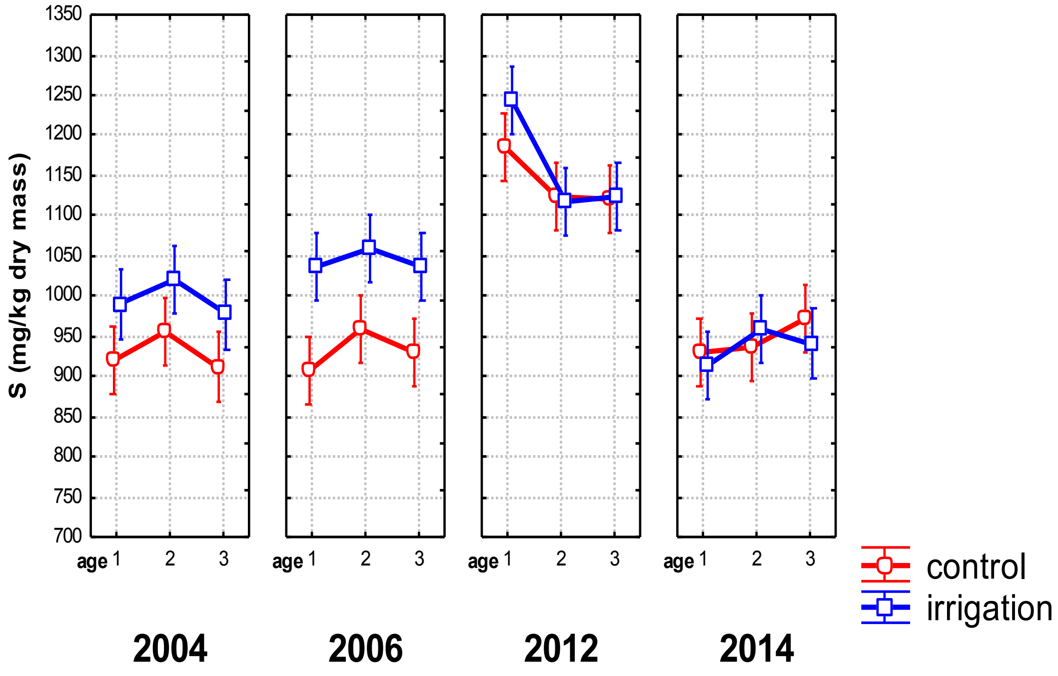
# Preliminary results - macronutrients

## Foliar sulfur concentration (mg/kg)

**Treatment:** F(1,3)=7.89, p=.067; **Harvest year:** F(3,9)=75,63, p=.000;
**N. age-group:** F(2,6)=4.37, p=.067

Effective hypothesis decomposition

Vertical bars denote 0.95 confidence intervals

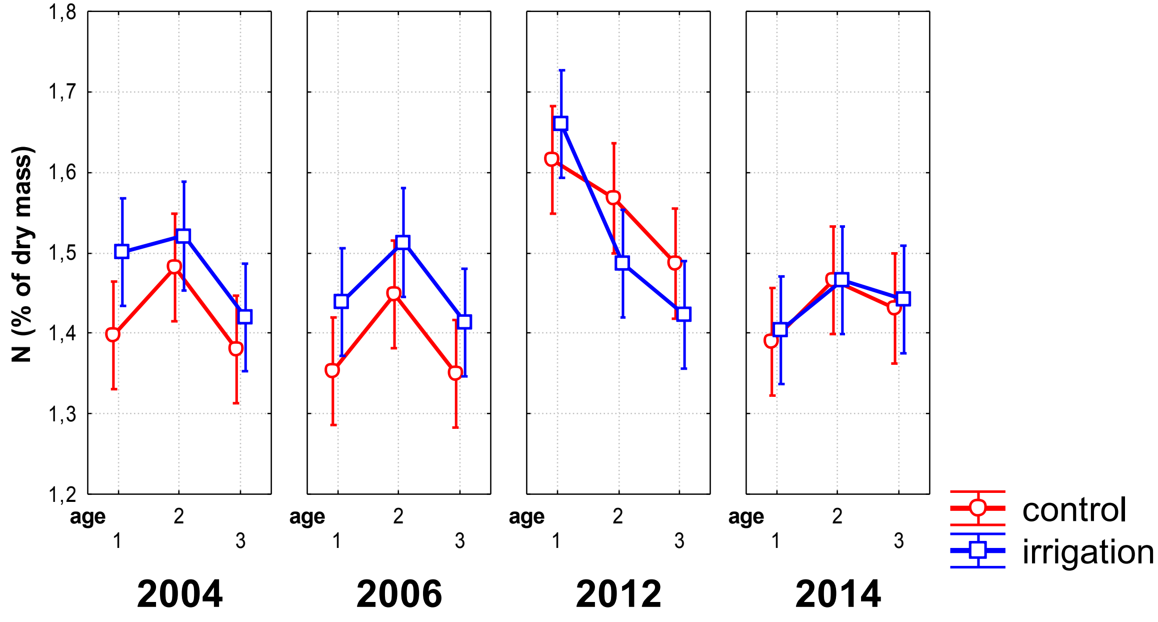



## Foliar nitrogen concentration (% of dry mass)

**Treatment:** F(1,3)=10.50, p=.048; **Harvest year:** F(3,9)=6.01, p=.016;
**N. age-group:** F(2,6)=9.98, p=.012

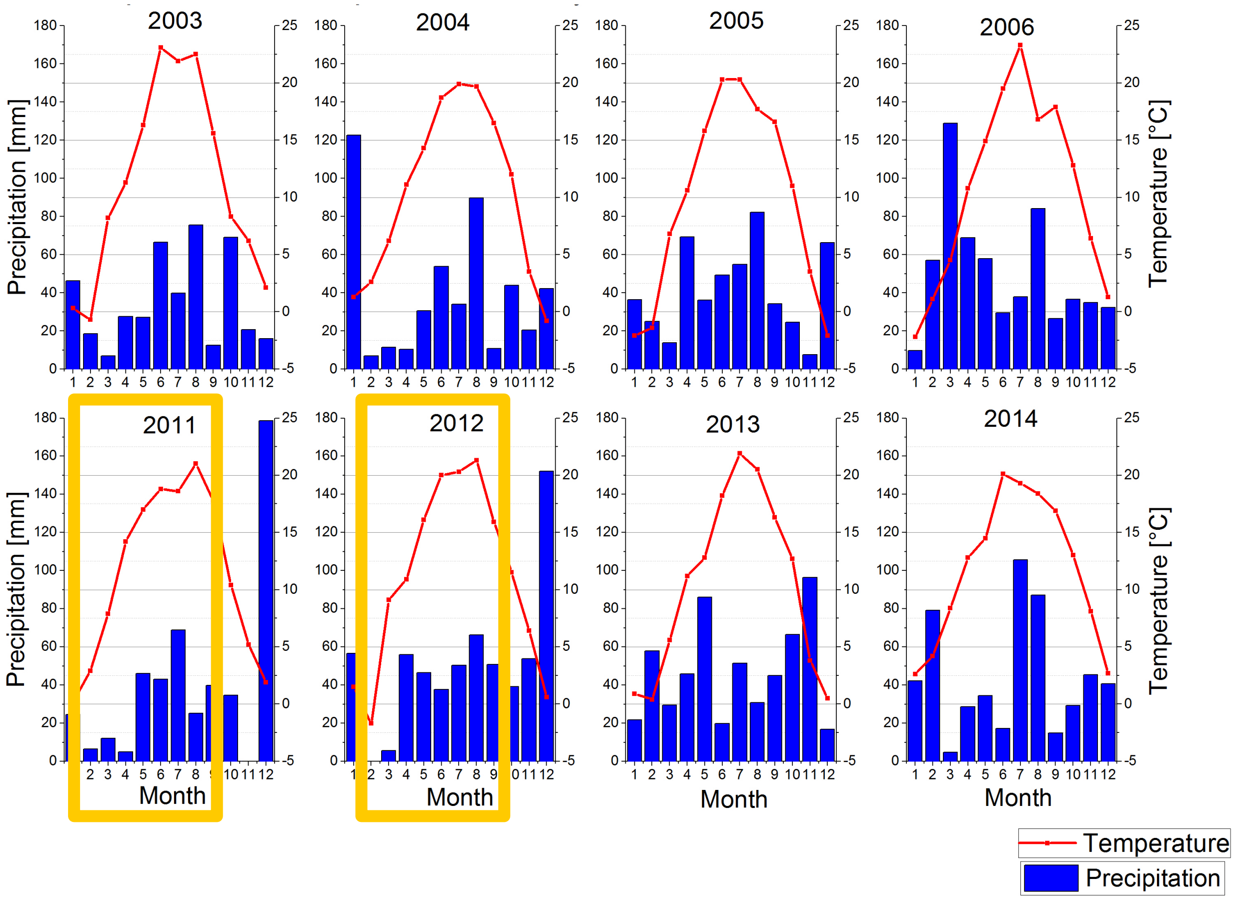
Effective hypothesis decomposition

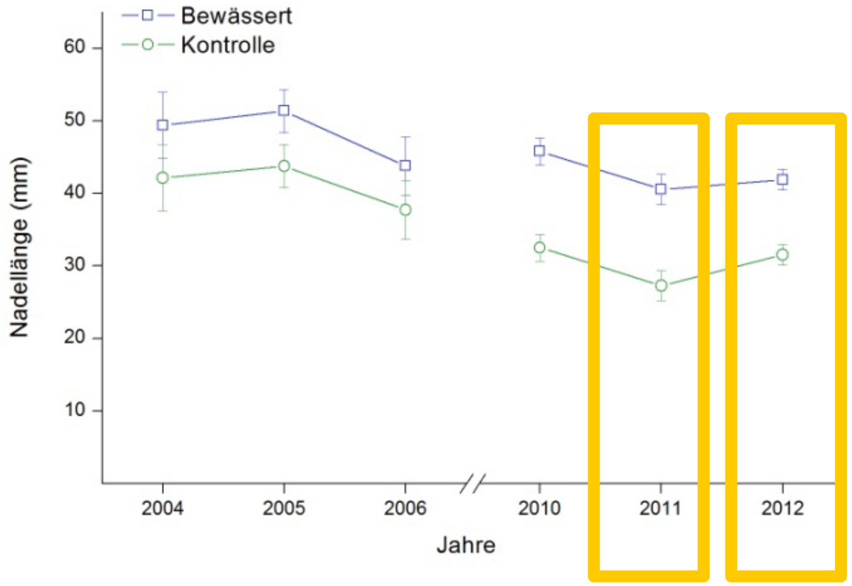
Vertical bars denote 0.95 confidence intervals



# Preliminary results - macronutrients

**Precipitation and temperature for the years 2003-2006 and 2011-2014 for Sion**

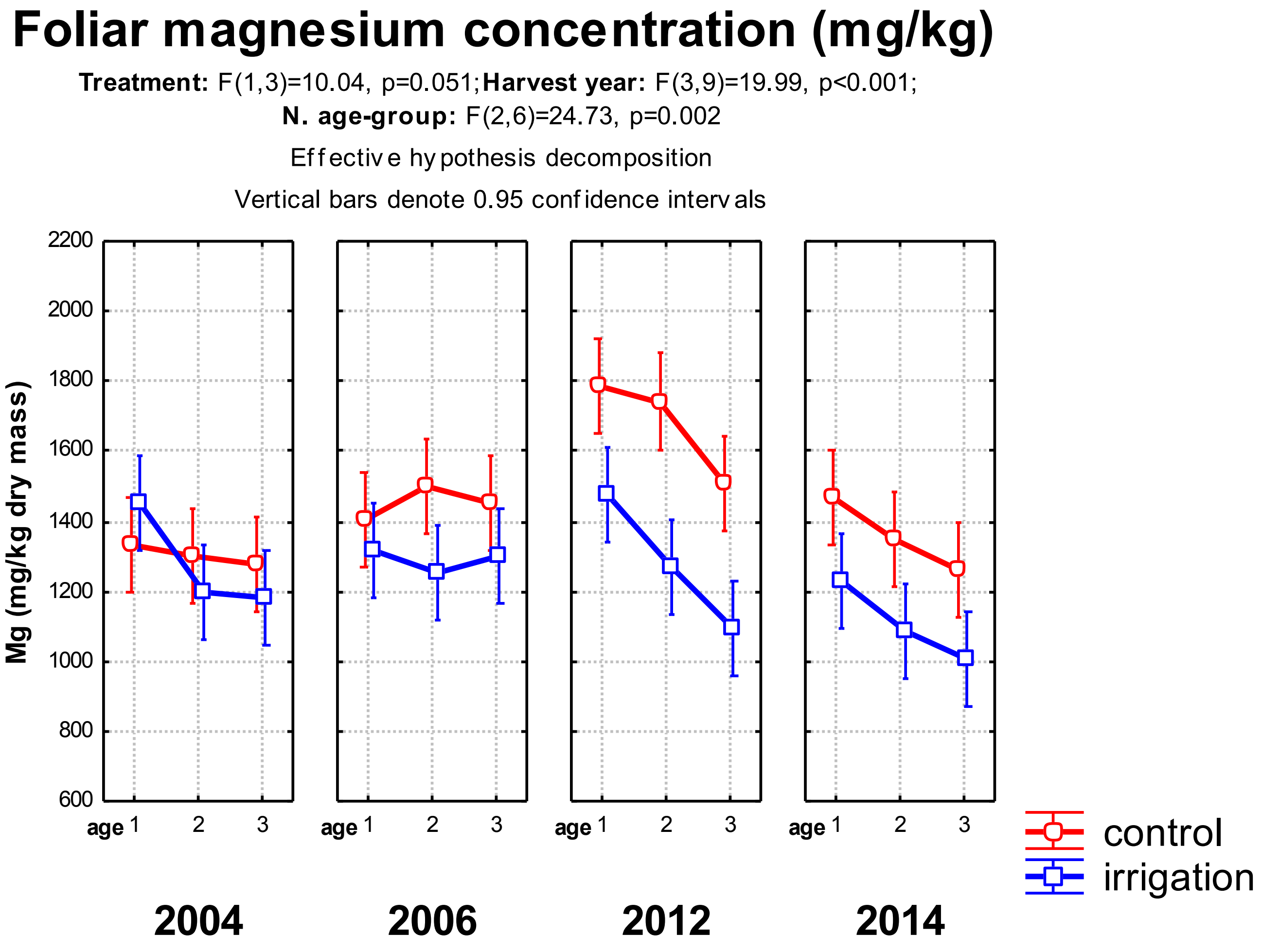



Needle length (mm) for two harvests (2006, 2012) and three needle ages for irrigated (blue) and control (green) plots , Rovina 2012

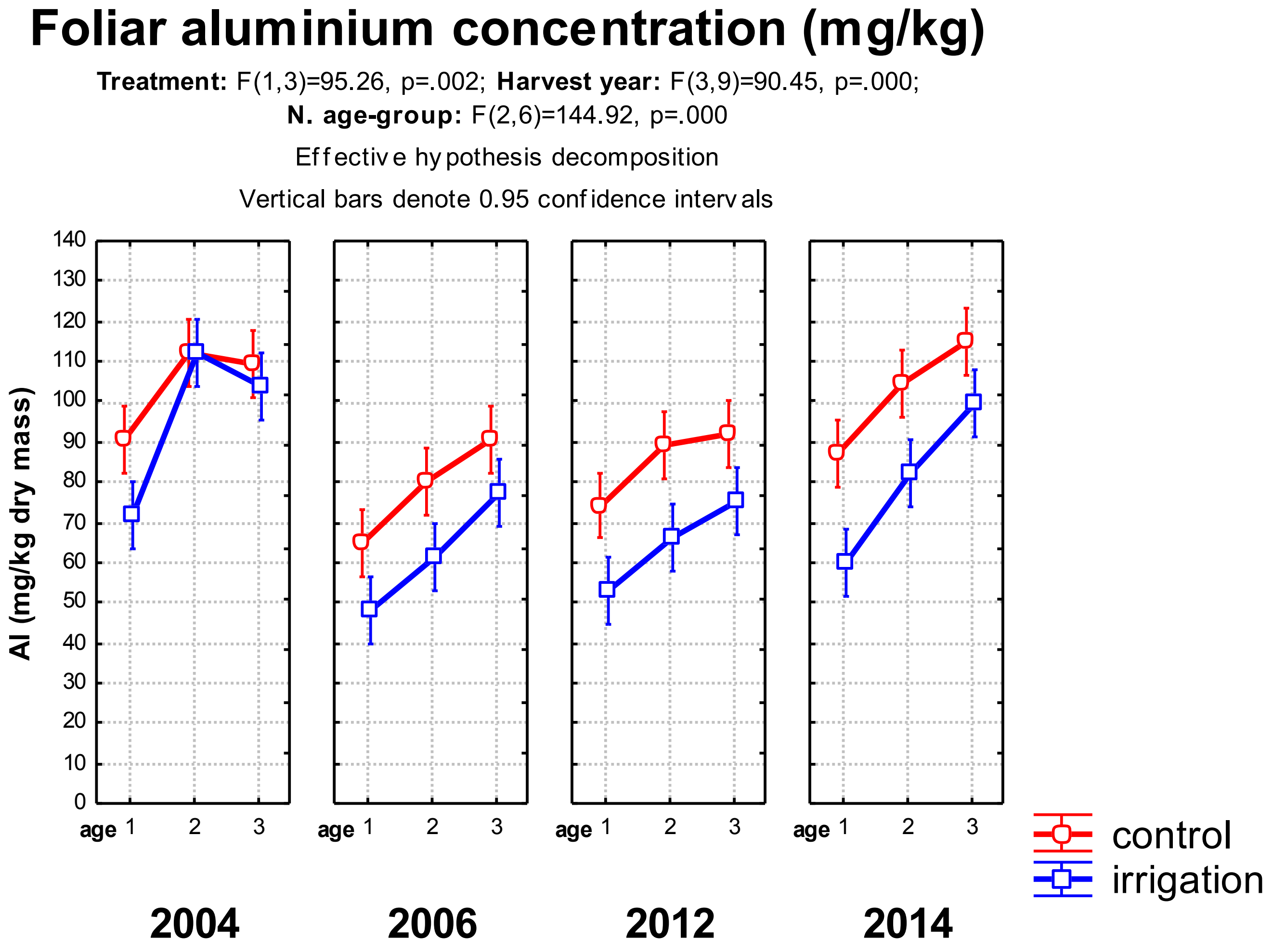
# Preliminary results - macronutrients

- Lower concentration of Mg in irrigated plots
- Decreasing concentration of this element with needle aging

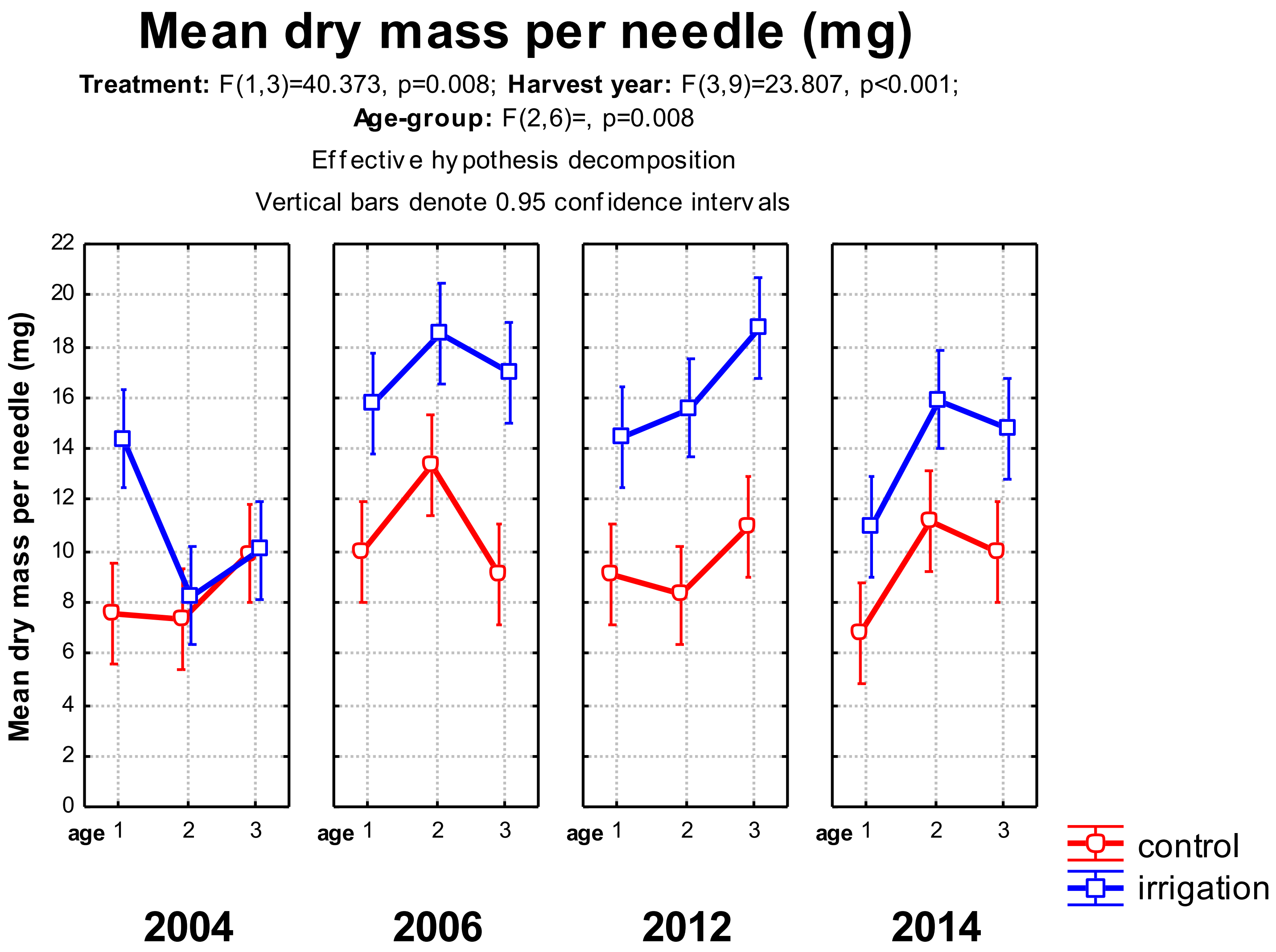


# Preliminary results - micronutrients

- Increasing concentration of Al, Fe, Zn, Mn and B with needle aging
- Significantly lower concentration of Al in irrigated plots



# Preliminary results - micronutrients



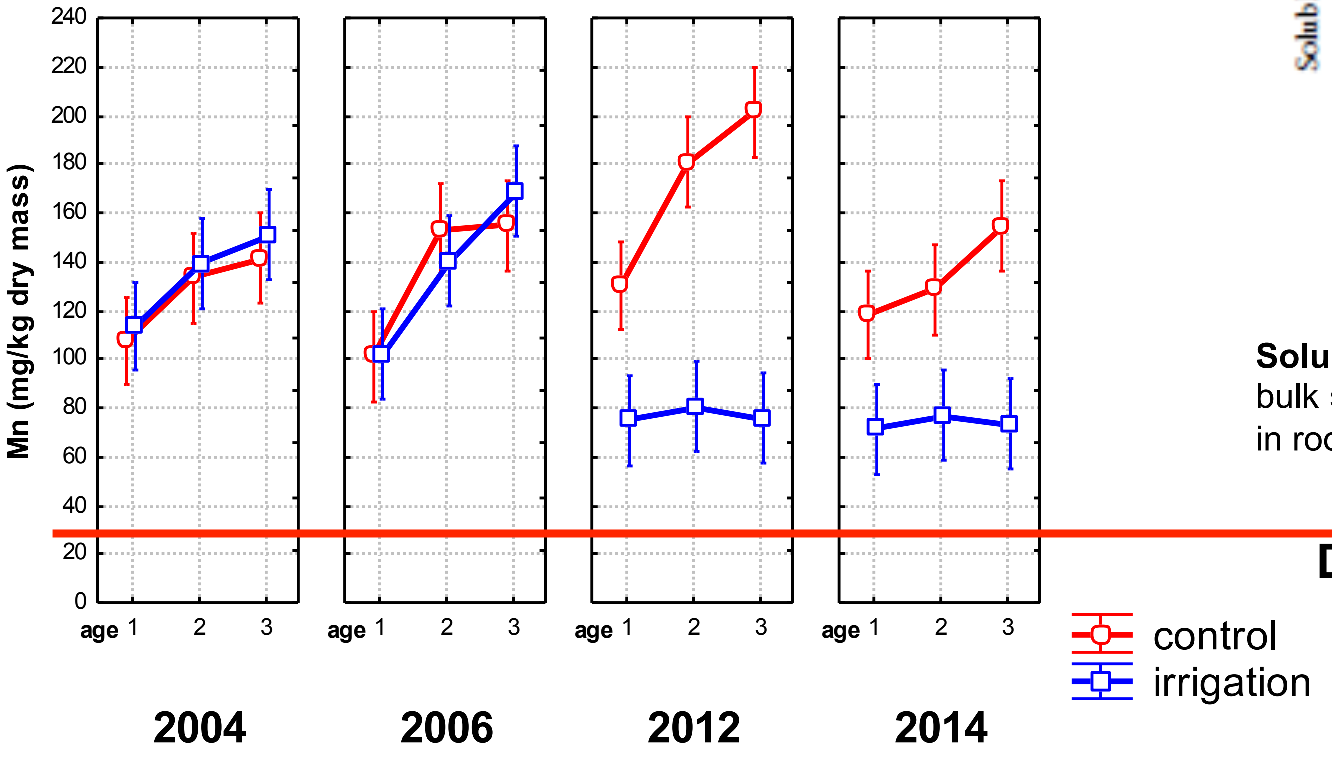
# Preliminary results - micronutrients

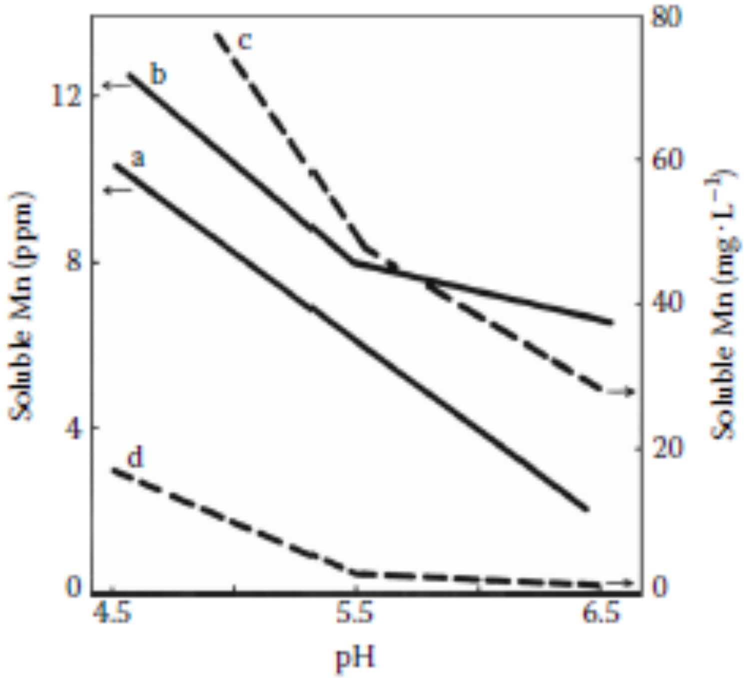
## Foliar manganese concentration (mg/kg)

**Treatment:** F(1,3)=209.63, p=.001; **Harvest year:** F(3,9)=12.87, p=.001;
**N. age-group:** F(2,6)=49.72, p=.000

Effective hypothesis decomposition

Vertical bars denote 0.95 confidence intervals

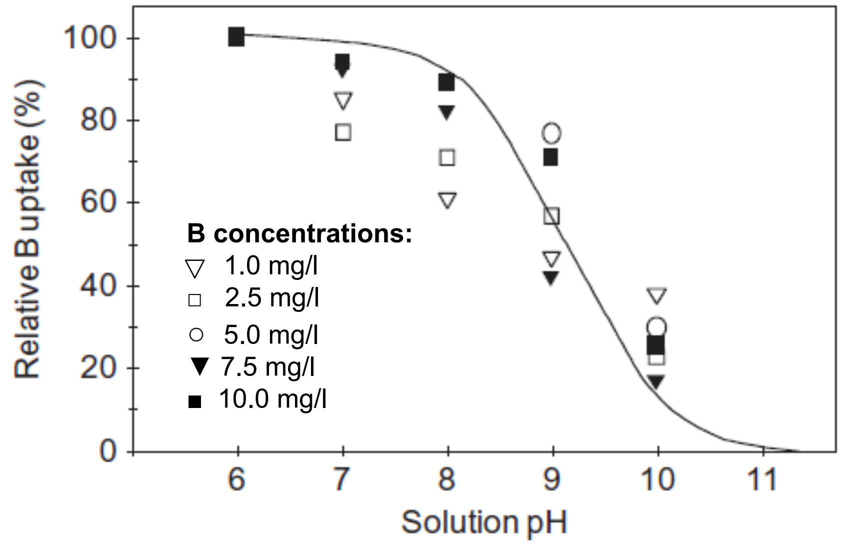



**Solubility of soil Mn at different pH values,** (a) from bulk soil, (b) from rhizosphere, (c) in citrate solution, (d) in root exudates, after 72 h (Kabata-Pendias 2011)

**Deficiency: 10-30 mg/kg**

# Preliminary results - micronutrients

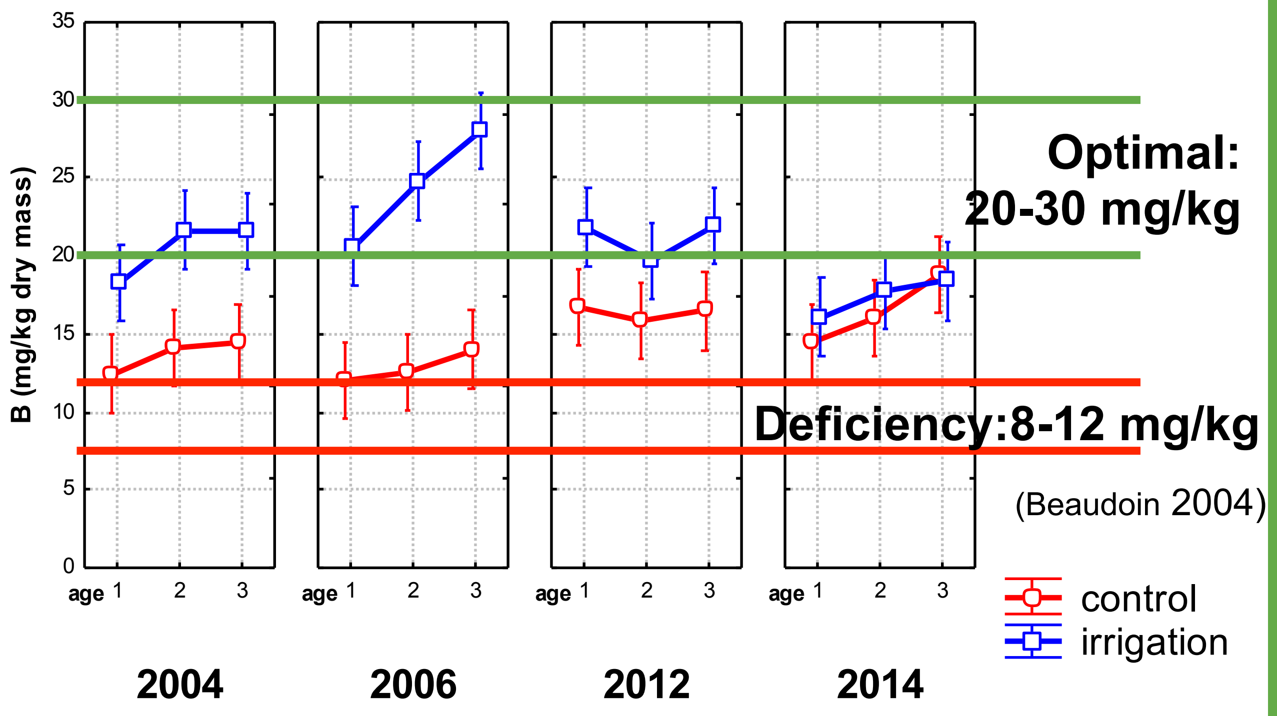



**Relative uptake of B** by barley roots, Solid line: precentage of undissociated $H_3BO_3$ (Withe 2012)

| Soil pH in Pfynwald (Nov. 2011) at three soil depths (data: F. Hagedorn) | | |
|---|---|---|
| **Depth** | **Control** | **Irrigation** |
| 0-2 cm | 5.27 | 6.47 |
| 2-5 cm | 6.22 | 6.62 |
| 5-10 cm | 6.90 | 6.93 |

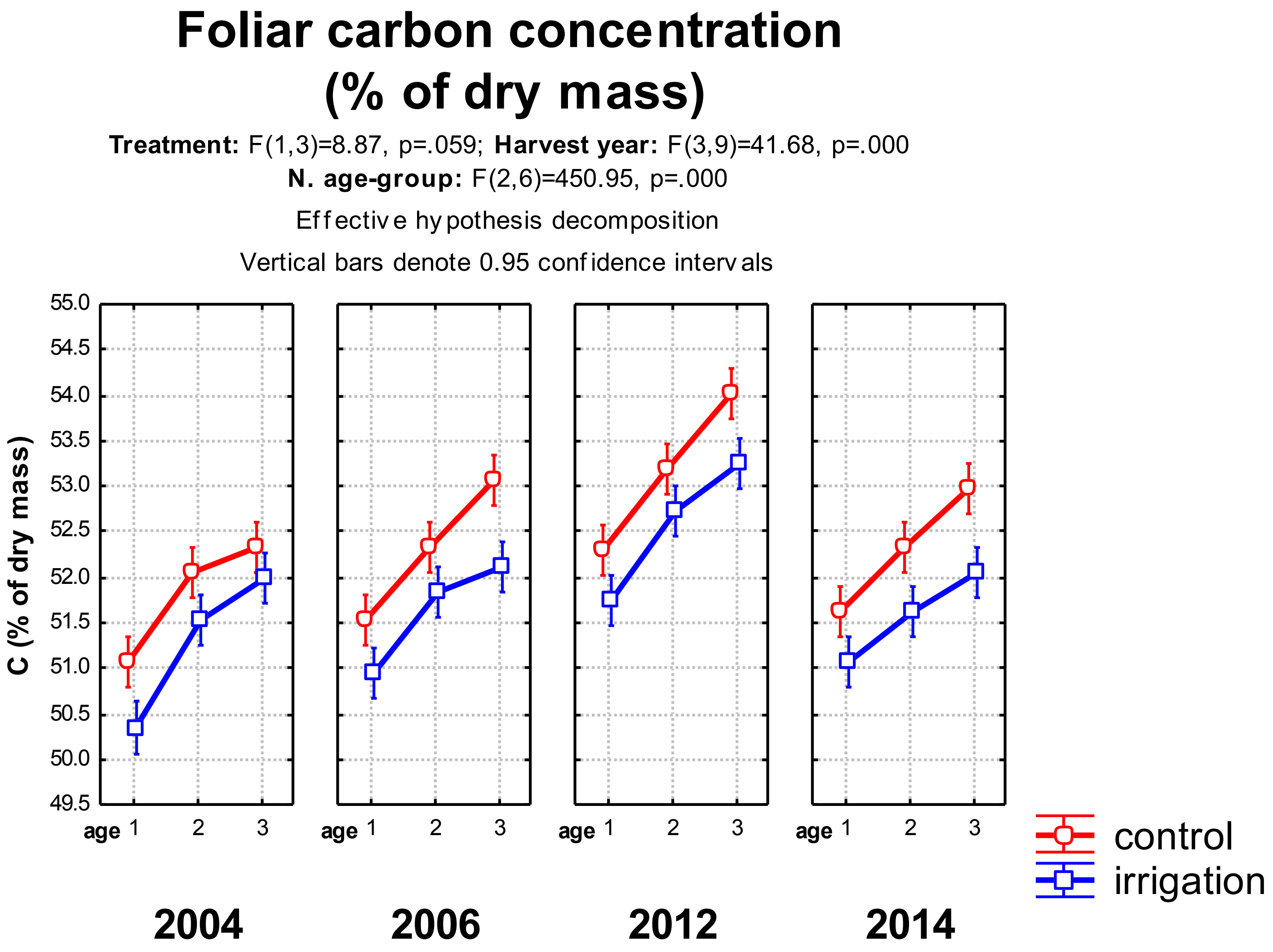
**Foliar boron concentration (mg/kg)**

**Treatment:** F(1,3)=95.59, p=0.002; **Harvest year:** F(3,9)=1.54, *p=0.270;*
**N. age-group:** F(2,6)=18.70, p=.003
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals




- Higher concentration of this element in irrigated plots
- Increasing concentration of this element with needle aging

# Preliminary results - carbon



# Conclusion and outlook

- Changes in nutrients with needle aging reflected the specific mobility of each element within phloem and its retrieval in aging foliage.
- In response to treatment, the concentration of major nutrients was raised either significantly (K, N) or marginally (S), but rarely lowered (Mg).
- Among nutrients with low phloem mobility, only Al responded significantly ($\searrow$) to treatment.
- Two elements (Mn, B) show needle concentrations close to the deficiency limit at Pfynwald.
- Since 2012, an increase in the topsoil pH in response to irrigation appears to cause a reduced uptake of both Mn and B, already leading to significant reduction of Mn concentration as compared to the control treatment.
- Further results on NSC, LAI, shoot/needle growth and morphology should provide further insights into the physiological trends responsible for changes in carbon and other elements within needles.


Foto: Pierre Vollenweider (WSL)

# References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