CULTIVATION AND FERTILIZATION OF *SALIX VIMINALIS* AND *ROBINIA PSEUDOACACIA* BIOENERGY CROPS TO REDUCE THE FOSSIL FUEL DEPENDENCE OF RURAL AREAS IN HUNGARY

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INTRODUCTION

Hungary → tradition in utilizing woody (arboreal) biomass for heat generation

→ appr. **1 million hectares** with unfavourable ecological conditions → perspective for alternative soil usage, e.g. **growing of energy crops** → utilization of biomass in small 1-2 MW **municipal district-heating power plants** → reducement the **unemployment** and **fossil fuel (natural gas) dependence** of underdeveloped rural areas

→ beside **Populus** species, the two most suitable woody plant species for establishment of **short rotation coppice** (SRC) bioenergy plantations are **basket willow** (*Salix viminalis* L.) and **black locust** (*Robinia pseudoacacia* L.) in Hungary.

Growing of energy crops

Salix viminalis **L. (basket willow, „energy willow”, perennial woody energy crop) → 10-12 t/ha aboveground annual dry yield in SRC plantations**

Robinia pseudoacacia **L. (black locust, perennial woody energy crop) → 6-12 t/ha aboveground annual dry yield in SRC plantations → 23% of the forested land (410 000 ha)**

Willow growing is the most appropriate in deep-located areas covered temporarily with water, while **black locust growing** can be the most efficient in loose (dry) sandy soils.

AIMS

Since most of the **SRC** (short rotation coppice) **plantations** were established during the recent past decade in Hungary, it is not enough revealed how soil application of **artificial fertilizers** and **various biowastes** can affect the **yield** and **chemical composition** of the combustible wood of bioenergy crops.

The **aim of our work** was to study these questions..

MATERIALS AND METHODS

Open-field long-term term experiment with energy willow

Salix triandra x Salix viminalis cv. Inger

Short rotation coppice: plantation **April 2011**, 1st harvest **January 2013**

SOIL TREATMENTS (June 2011 + 2nd AN June 2012)

Control

Ammonium nitrate (AN - 100 kg/ha) →

Municipal biocompost (MBC - 20 kg/ha)

AN+MBC

Municipal sewage sludge compost

(MSSC - 15 t/ha)

Willow bioash

(WB - 600 kg/ha) →

MSSC+WB

AN+WB

Rhyolite tuff (RT – 30 t/ha)

AN+RT

Leaf sampling (September 2011)

Investigation the elemental composition (macronutrients: N, P, K, Ca, Mg →micronutrients: Fe, Cu, Mn, Zn → toxic elements: As, Cd, Pb) of willow leaves

Measuring the diameter of willow shoots (December 2012)

→ at 50 cm and 100 cm shoot height

Harvesting, measuring of yield parameters (January 2013)

→maximum shoot lenght, shoot yield/plot

Open-field experiment with black locust

Treatments of soil: June 2009, May 2010, May 2011

1) Control **(soil of plots were untreated).**
2) Ammonium nitrate: **300 kg/ha**
3) Calcium-magnesium carbonate + ammonium nitrate (ammonium nitrate with dolomite): **300 kg/ha**

Soil sampling:
June 2009, December 2009
June 2011,
→ nitrate and nutrients in soil

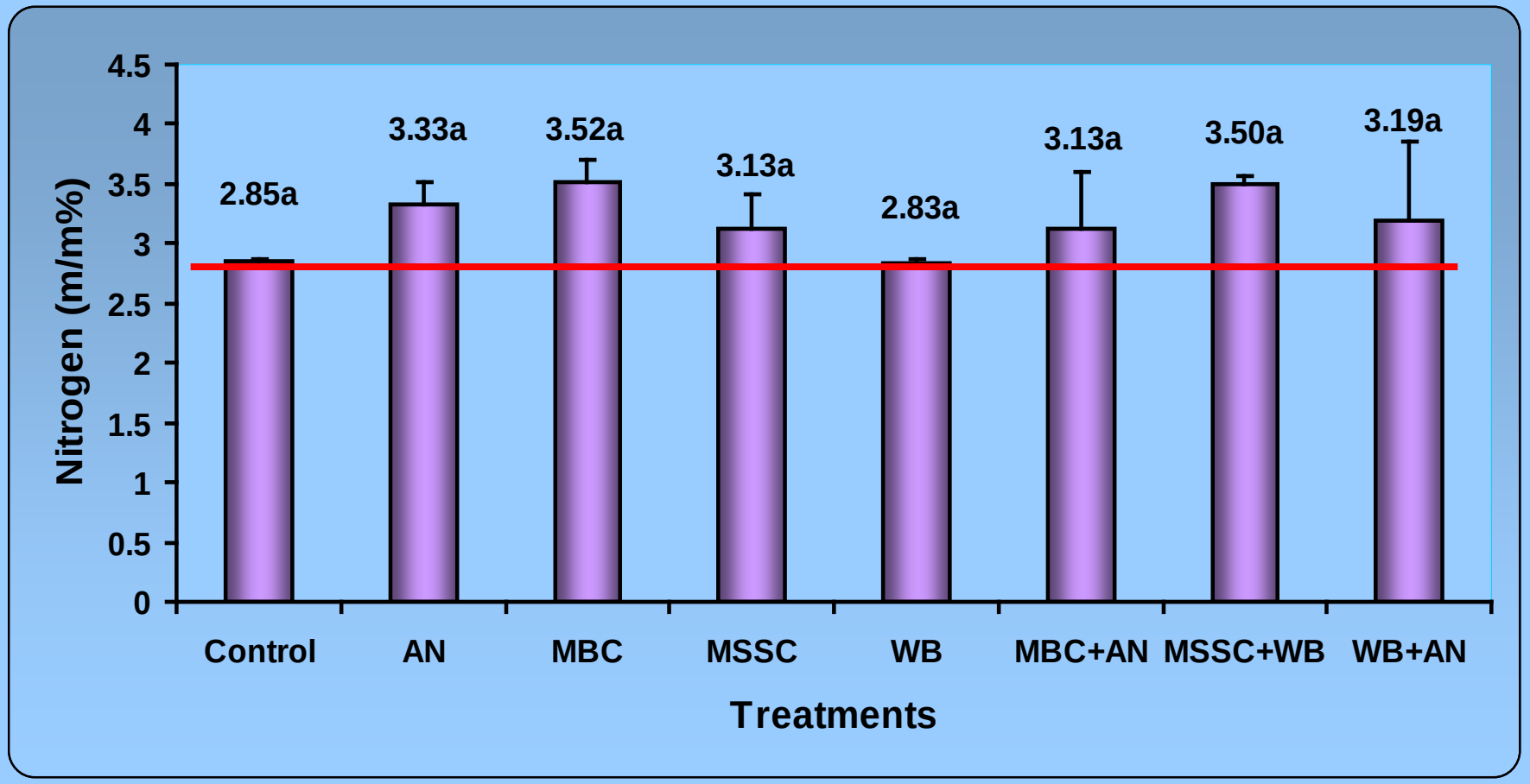
Leaf sampling: October 2009 → macro- and micronutrients in leaves

Measuring of growth parameters:

February 2010 → cut off of 2-year-old cultures

March 2012 → cut off of 4-year-old cultures

RESULTS - willow



Effect of ammonium nitrate (AN - 2x100 kg/ha), municipal biocompost (MBC – 20 t/ha), municipal sewage sludge compost (MSSC – 15 t/ha) and willow bioash (WB-600 kg/ha) on the uptake of nitrogen in the leaves of basket willow 12 weeks after treatments.

Data are means of 3 replications. Tukey's b-test. Means within the columns followed by the same letter are not statistically significant at P<0.05.

Concentration of essential macroelements in the leaves of basket willow 12 weeks after soil treatments

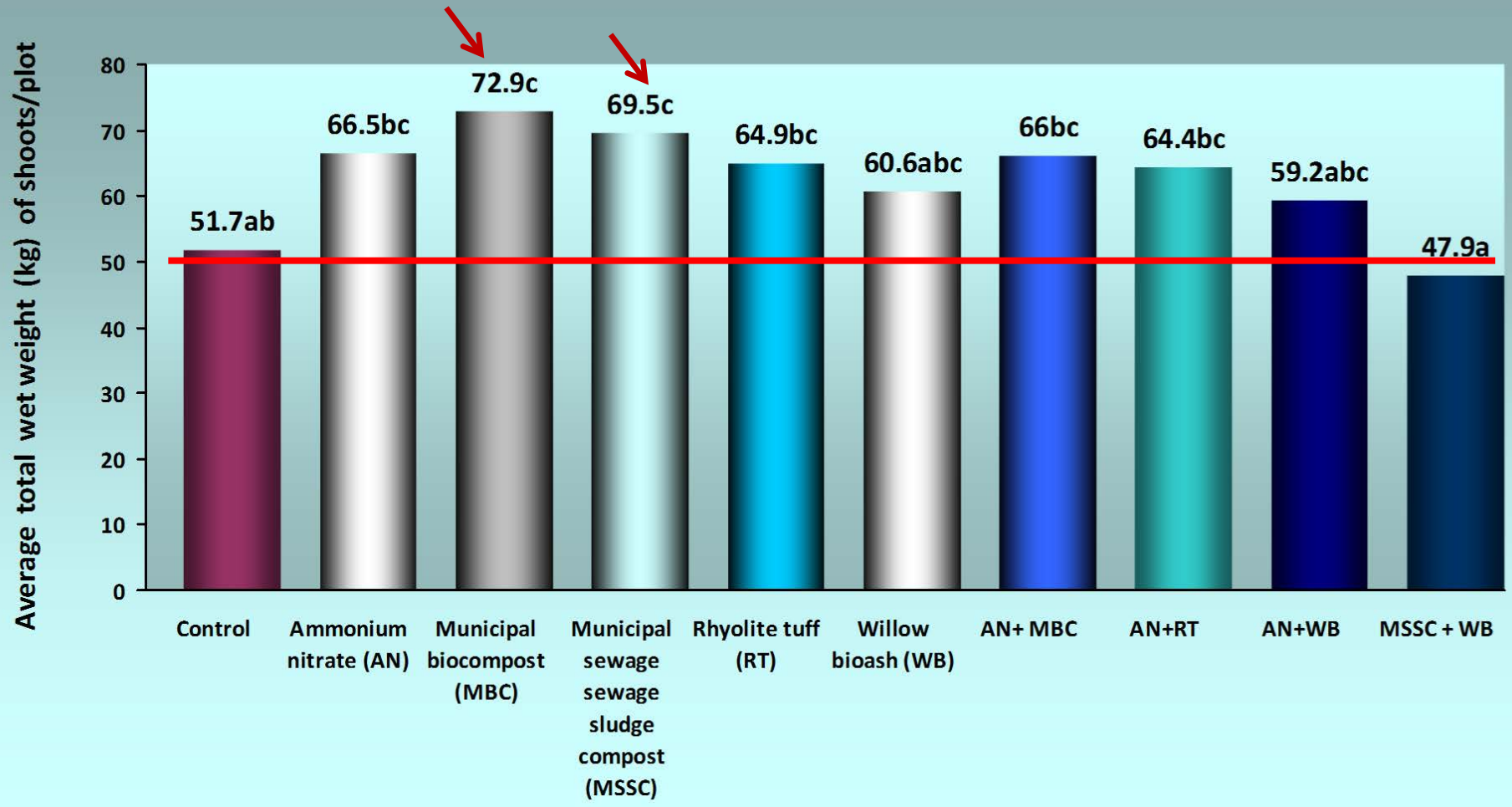
Treatments	P	K	Ca	Mg
	mg/g dry matter			
Control	5.038a	11.906a	10.187bc	5.180a
Ammonium nitrate (AN)	3.199ab	13.391a	9.353ab	4.560a
Municipal biocompost (MBC)	3.143ab	12.695a	7.349a	4.365a
Municipal sewage sludge compost (MSSC)	3.411ab	13.698a	8.655ab	4.254a
Willow bioash (WB)	4.026ab	12.414a	9.831abc	4.447a
MBC + AN	3.537ab	13.410a	9.287ab	4.392a
MSSC + WB	2.822b	14.125a	12.126c	5.034a
WB + AN	3.243ab	13.052a	9.979abc	4.580a

Data are means of 3 replications, standard deviations are in parenthesis. Tukey's b-test. Means within the columns followed by the same letter are not statistically significant at P<0.05.

Concentration of selected toxic elements in the leaves of basket willow 12 weeks after soil treatments

Treatments	As	Cd	Pb
	μg/g dry matter		
Control	1.66ab	0.99a	u.d.l.
Ammonium nitrate (AN)	1.86ab	0.57a	u.d.l.
Municipal biocompost (MBC)	1.65ab	0.34a	u.d.l.
Municipal sewage sludge compost (MSSC)	1.86ab	0.57a	u.d.l.
Willow bioash (WB)	1.92ab	0.56a	u.d.l.
MBC +AN	0.66a	0.44a	u.d.l.
MSSC + WB	0.86ab	0.36a	u.d.l.
WB +AN	2.11b	0.55a	0.44

Data are means of 3 replications, standard deviations are in parenthesis. u.d.l.= under the detection limit: Cd-0.02 μg/g, Pb-0.30 μg/g. Tukey's b-test. Means within the columns followed by the same letter are not statistically significant at P<0.05.



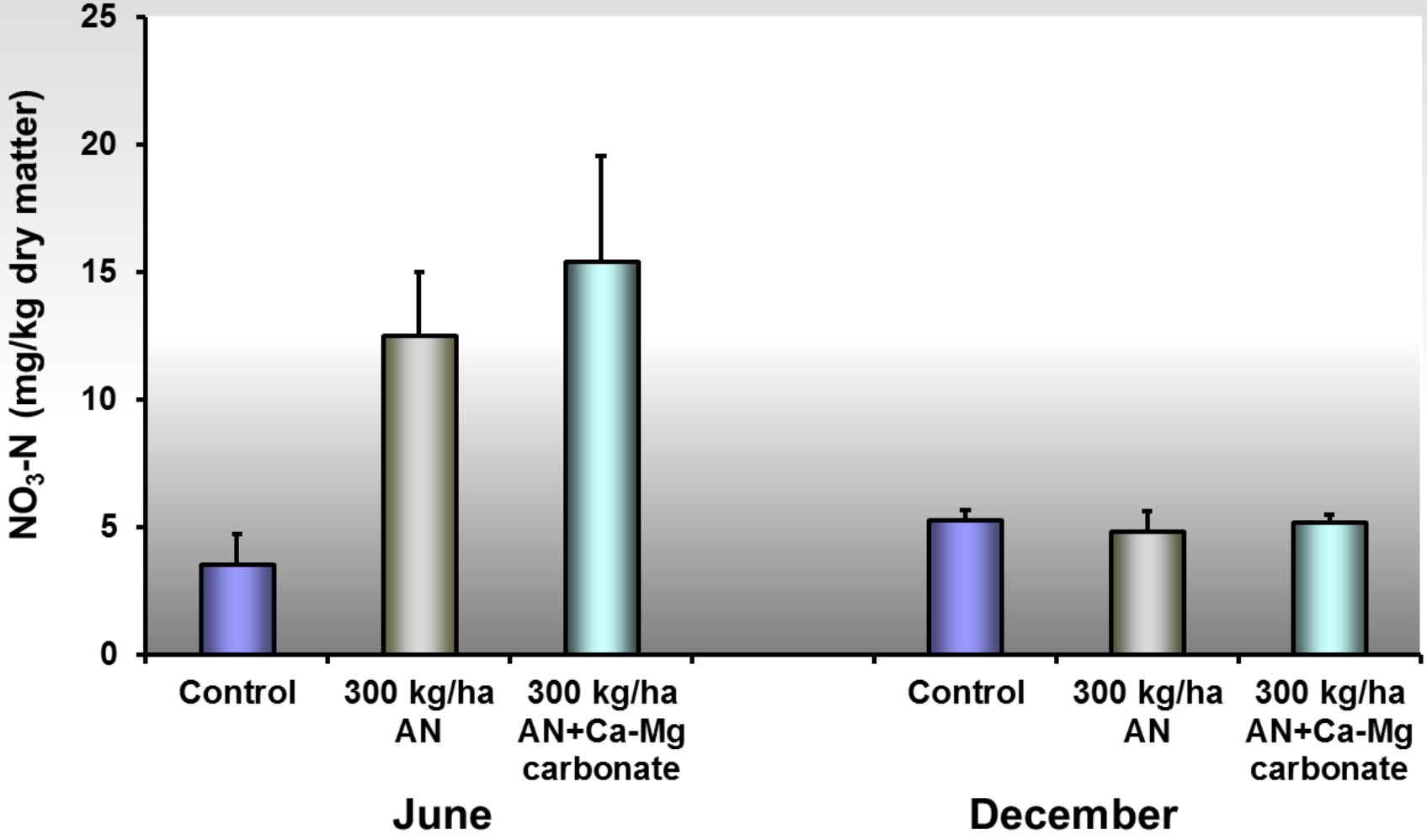
Effect of various soil treatments on the wet shoot yield of willow. (open-field experiment, Nyíregyháza, January 2013).

Data are means of 3 replications. Tukey's b-test. Means within the columns followed by the same letter are not statistically significant at P<0.05.

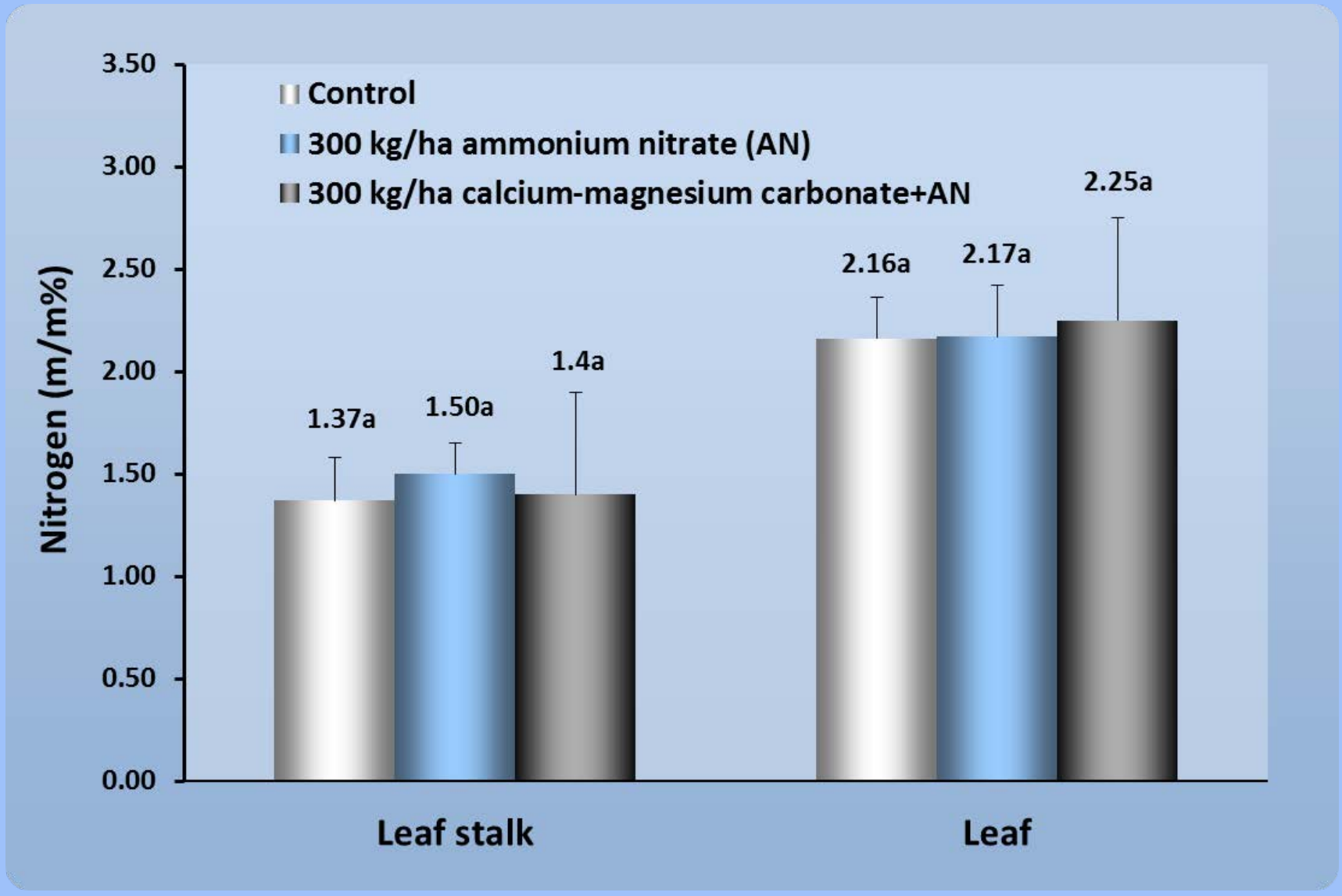
CONCLUSIONS - willow

Nineteen months after the soil treatments mostly the **macroelement-rich amendments** (AN, MBC, MSSC) enhanced significantly (up to 25%) the harvested shoot yield of willow plants. Most of the treatments **enhanced the uptake of N** (9.8-23.5%) and **K** in willow leaves, but concentration of **P, Mg, Ca, and Fe** in leaves was reduced. **Toxic element** (As, Cd, Pb) accumulation of willow roots or shoots was negligible.

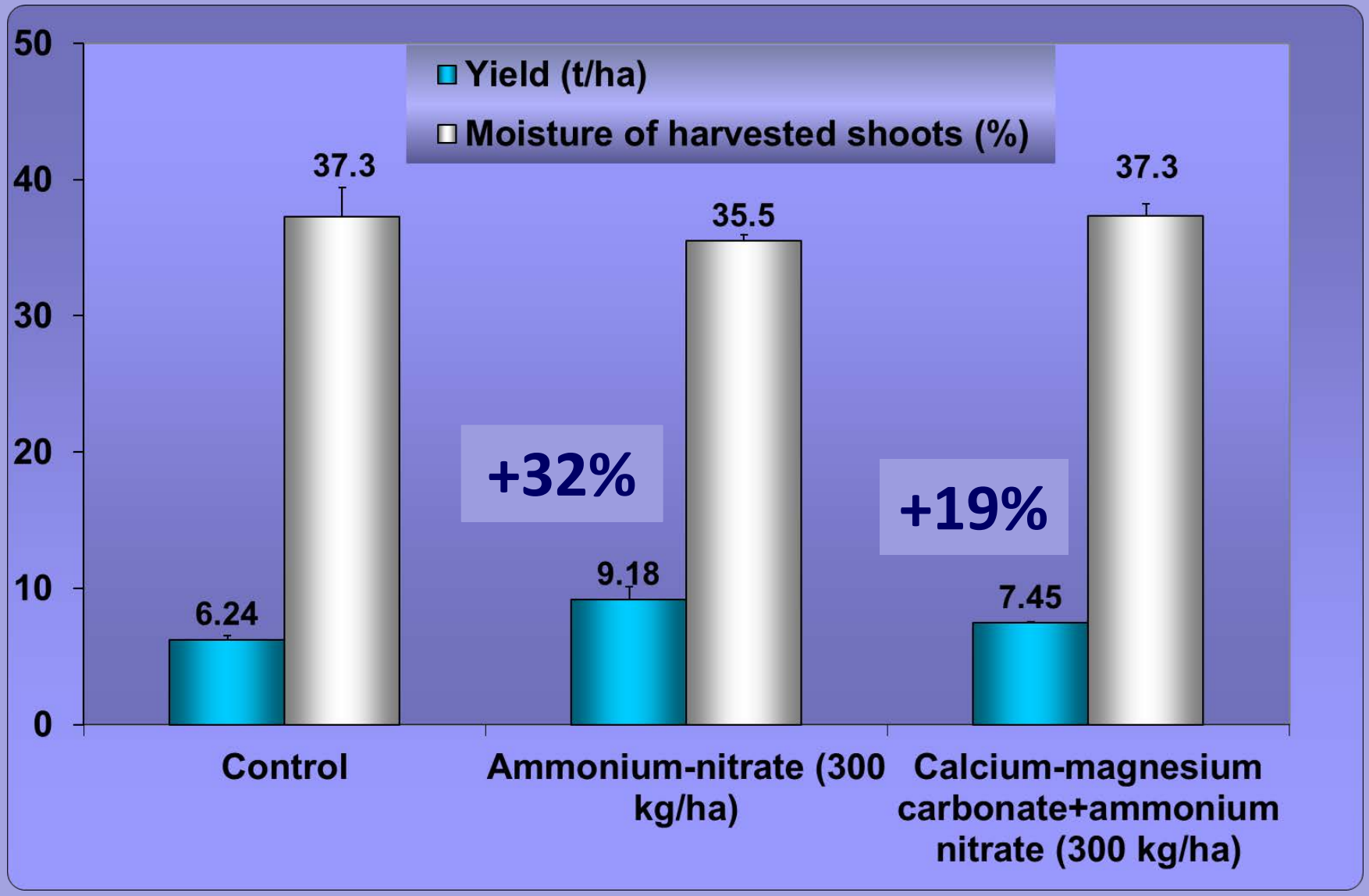
RESULTS – black locust



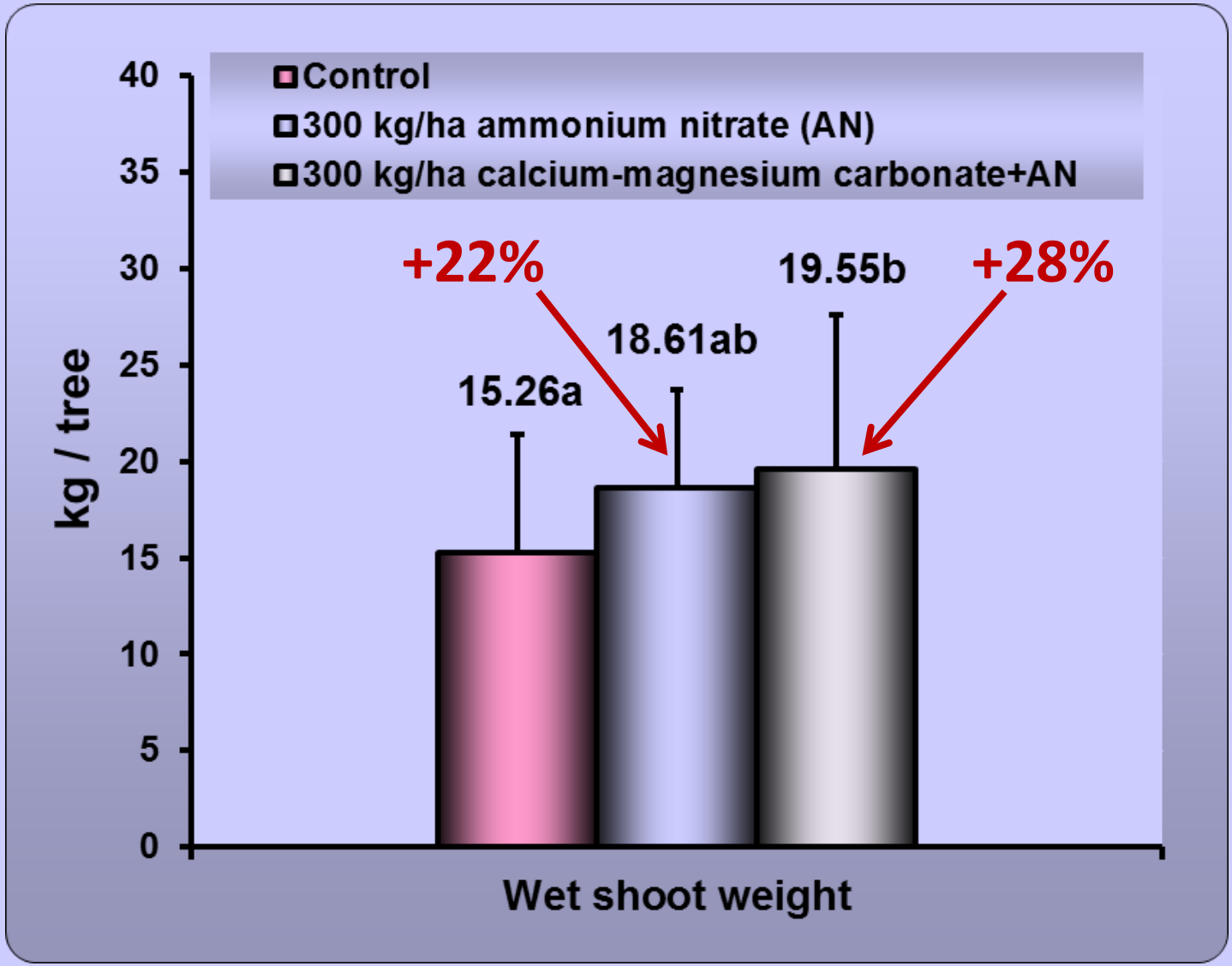
Nitrate concentration in the soil of black locust experiment (June 2009; December 2009)



Effect of nitrogen fertilizers on the nitrogen uptake of leaves in 2-year-old black locust (open-field experiment, Nyíregyháza, 2009).



Effect of nitrogen fertilizers on the wet yield and moisture content of harvested shoots in 2-year-old black locust (open-field experiment, Nyíregyháza, 2009).



Effect of 3 times (2009, 2010, 2011) repeated nitrogen fertilization on the wet shoot yield of 4-year-old black locust (open-field experiment, Nyíregyháza, 2012, n=30).

CONCLUSIONS – black locust

Both nitrogen fertilizers increased three to five times the nitrate concentration of the upper soil. The nitrogen uptake of the leaves and leaf stalks (petiolus), however, was only slightly changed in treated cultures.

3 years after the first N fertilization, when whole trees were harvested, 22%-28% higher aboveground wet weight was detected in fertilized cultures, as compared to untreated controls.

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Thank you for your attention, and here is the end ☺