USE OF WASTEWATERS FOR IRRIGATION OF ENERGY CROPS AS A STRATEGY TO COMBAT DESERTIFICATION

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Context

- **Desertification:**
  - **Process that leads to**
    - **loss of ecosystem services**
    - **arid, semi-arid and dry subhumid areas**

Context

- Causes:
  - climatic variation
  - anthropogenic activities
    - **Affects ¼ world's land surface, containing 1/5 of the world's population**

Context

- **Combating desertification:**
- **Introduction of alternative livelihoods that lead to less negative impacts on dryland resources**
- **Creation of economic opportunities in these lands**

Context

- **Combating desertification:**
- **Management of water resources;**
- **Conservation of soil properties;**
  - **Ensure food and water security**
  - **Ensure biological and landscape diversity**

Context

- Water
- Energy
  - Basic and fundamental Resources
  - Problem due to shortage, specially in some regions of the world

Context

⇨ Energy crop systems

- ✓ **Renewable sources of energy and biomaterials**
- ✓ **But - Intensive use of land**
  - ❖ **Water resources depletion**
  - ❖ **Mineral resources depletion (fertilisers)**
  - ❖ **Soil nutrient depletion**

Context

- **Existence of large volumes of treated wastewaters:**
  - **Nutrient rich (N, P, K, organic matter, etc.)**
  - **It takes energy resources and other resources to treat**
- **Energy crops production: Wastewater depuration (phytodepuration)?**

Aim

- To merge energy crop production with wastewater management
- **Offers dual goals:**
  - **Biomaterials/bioenergy production**
    - **Economic opportunities**
  - **Environmental benefits**

Aim

- **Environmental benefits:**
  - **wastewater remediation**
  - **Reuse of ions (nutrients) as fertilizers**
  - **Water and wind erosion and runoff control**
  - **Soil properties restoration induced by vegetation**
  - **Carbon sequestration**

Energy crops

- **To reverse desertification**
- **Species need to:**
  - **display low water and nutrient demands**
  - **present commercial value for a specific region**
  - **have few environmental constraints,**
  - **no competition with food crops,**
  - **be integrated with waste management**

Wastewater reuse

- In water-scarce regions,
  - marginal-quality waters
    - an increasingly important component of agricultural water supplies
      - economic, social and environmental benefits
      - But also with some limitations

Wastewater reuse - benefits

- ⇨ **Fulfillment of growing water demands**
- ⇨ **Scarcity/seasonality of rainfall is counterbalanced**
- ⇨ **Preservation of freshwater supplies**
- ⇨ **Groundwater recharge**
- ⇨ **Minimization of fertilizer needs**
- ⇨ **Reduced energy use and chemical pollution from wastewater treatment**
- ⇨ **Reduced contamination of water bodies**

Wastewater reuse - benefits

- ⇨ Nutrient and water resource recycling
- ⇨ Restoration of soil properties
- ⇨ Biological and landscape diversity increment
- ⇨ Increased plant growth and productivity
- ⇨ Increased carbon sequestration
- ⇨ Increased energy savings
- ⇨ Reduction of GHG emissions

Wastewater reuse - benefits

- ⇨ **Creation of economic opportunities in water-scarce regions**
- ⇨ **Economically viable use of biomass**
- ⇨ **Reduction of cultivation costs**
- ⇨ **Reduction of water treatment costs**
- ⇨ **Prevention of rural exodus**
- ⇨ **Creation of employment**

Wastewater reuse - constraints

- Low effluent availability in terms of volume to match crop needs
- Matching hydraulic loading and contaminant remediation by the crop
- Variability of effluent production and quality over time
- Distance between wastewater treatment plant and fields
- Availability of land

Wastewater reuse - constraints

- Land use change
- Matching effluent production with crop-growing season
- Need for a storage facility for wastewater
- Wastewater quality may limit its application
  - Excess dissolved salts, Na, heavy metals, chlorine

Wastewater reuse - constraints

- **Leaching and runoff of contaminants to water bodies**
- **Accumulation of contaminants in the soil**
- **Yields can be affected**
- **Biomass quality may limit its industrial use**
- **Reduced public and stakeholders' acceptance**

Case studies

• **Growth, Productivity and Biomass Quality of Kenaf Irrigated with wastewaters – the effect of ammonium ion**

(Fernando et al 2011)

Aim of the Study

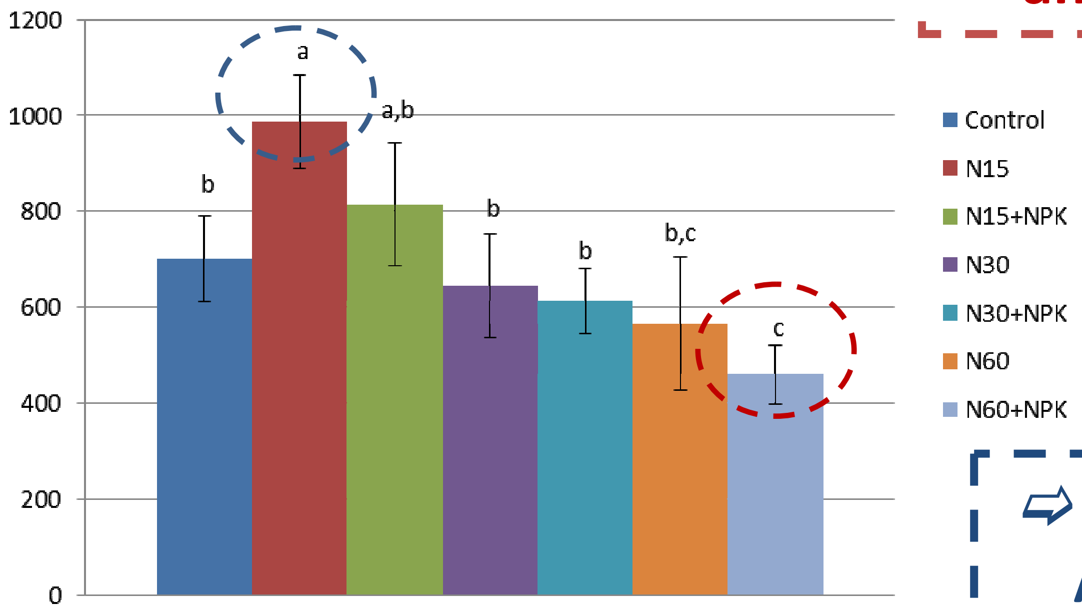
- to evaluate
  - growth responses
  - quality and biomass productivity
    - Kenaf (G4)
    - irrigated with wastewaters
      - Different NH4 concentrations

Ammonium ion

- **Important source of nitrogen for many plant species**
  - **But it can also be toxic**
- **Problematic in treated wastewaters**
  - **Toxic to most fish species**
  - **High dissolved O_2 consumption**
  - **Contributes to eutrophication**
  - **Water disinfection is more difficult**

Results

Aerial Productivity



⇨**Statistical differences among treatments**

⇨**N15**

⇨**Higher**

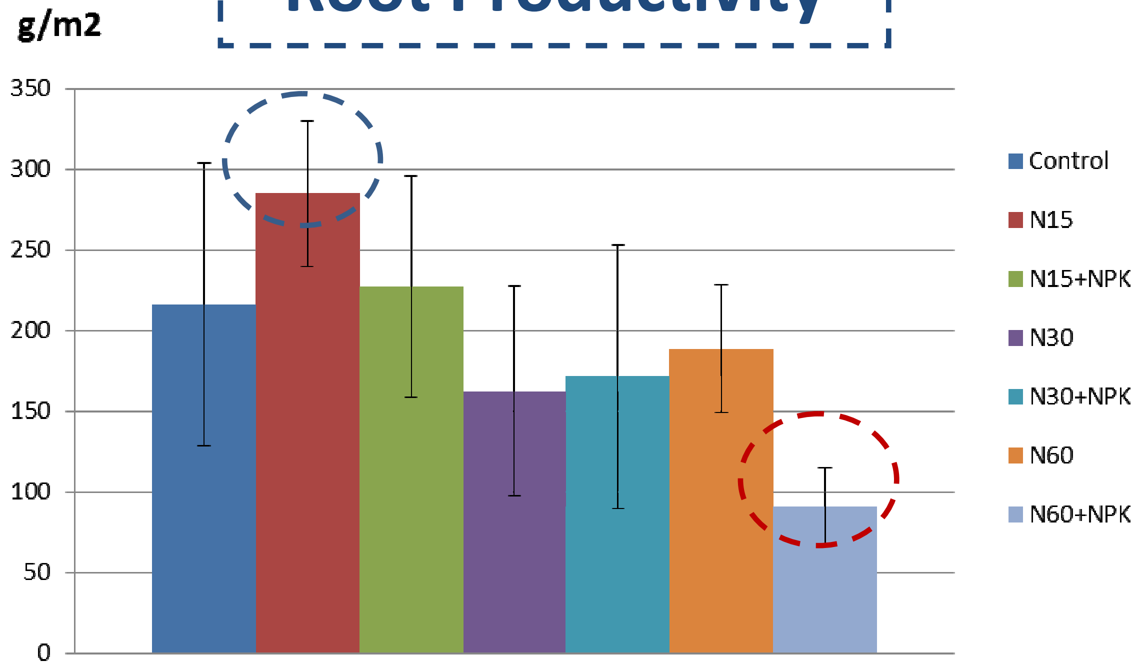
⇨**N60+NPK**

⇨**Lower**

⇨ **↑NH4**

Affects productivity

Root Productivity



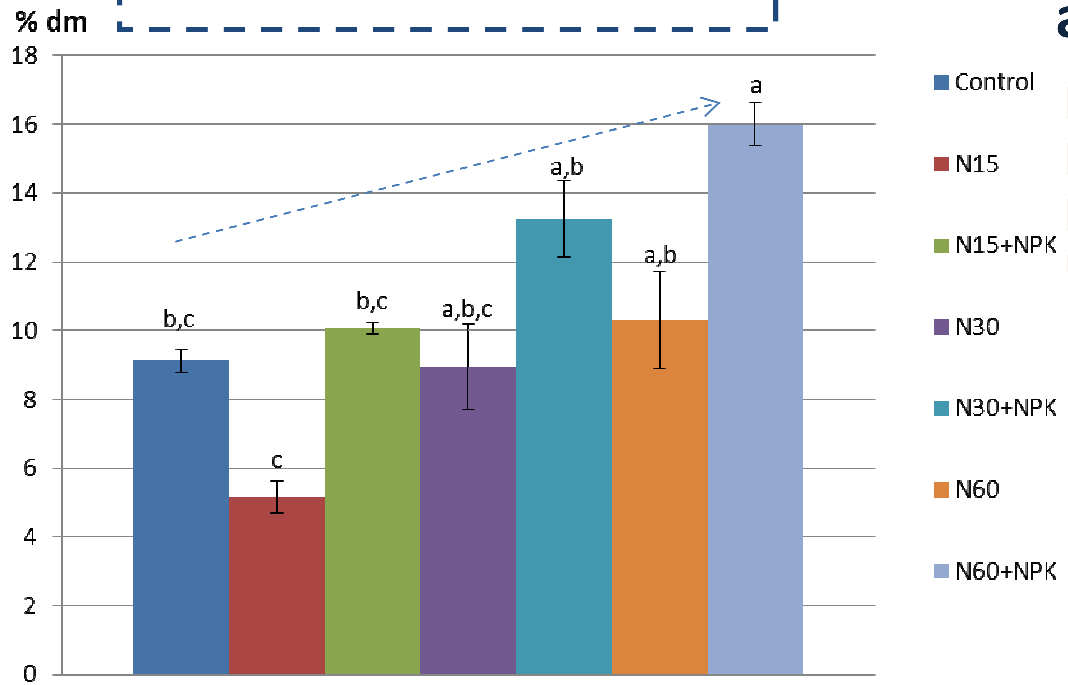
⇨No differences among treatments

⇨But, ↑NH4 affects root development

⇨**N15**
⇨Higher

⇨**N60+NPK**
⇨Lower

Ash Content - core



⇨Statistical differences among treatments

⇨ ↑NH4

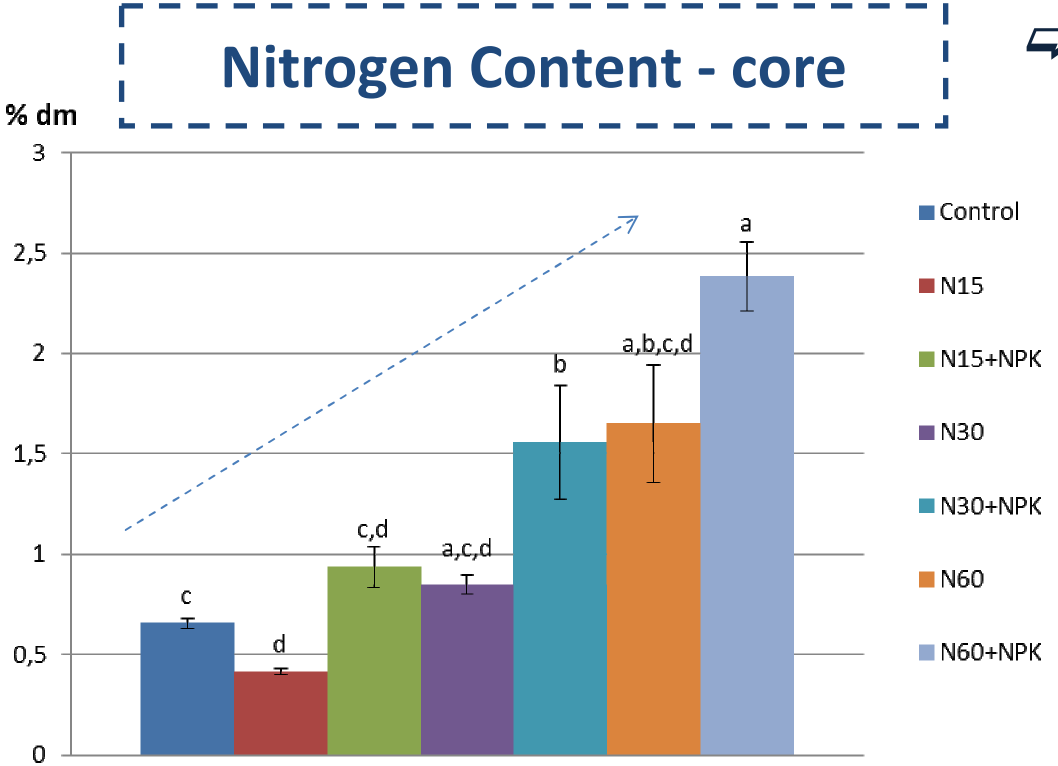
↑ ash content

Bark and Leaves

⇨ Same trend

Ash content Roots

⇨ Not affected



⇨Statistical differences among treatments

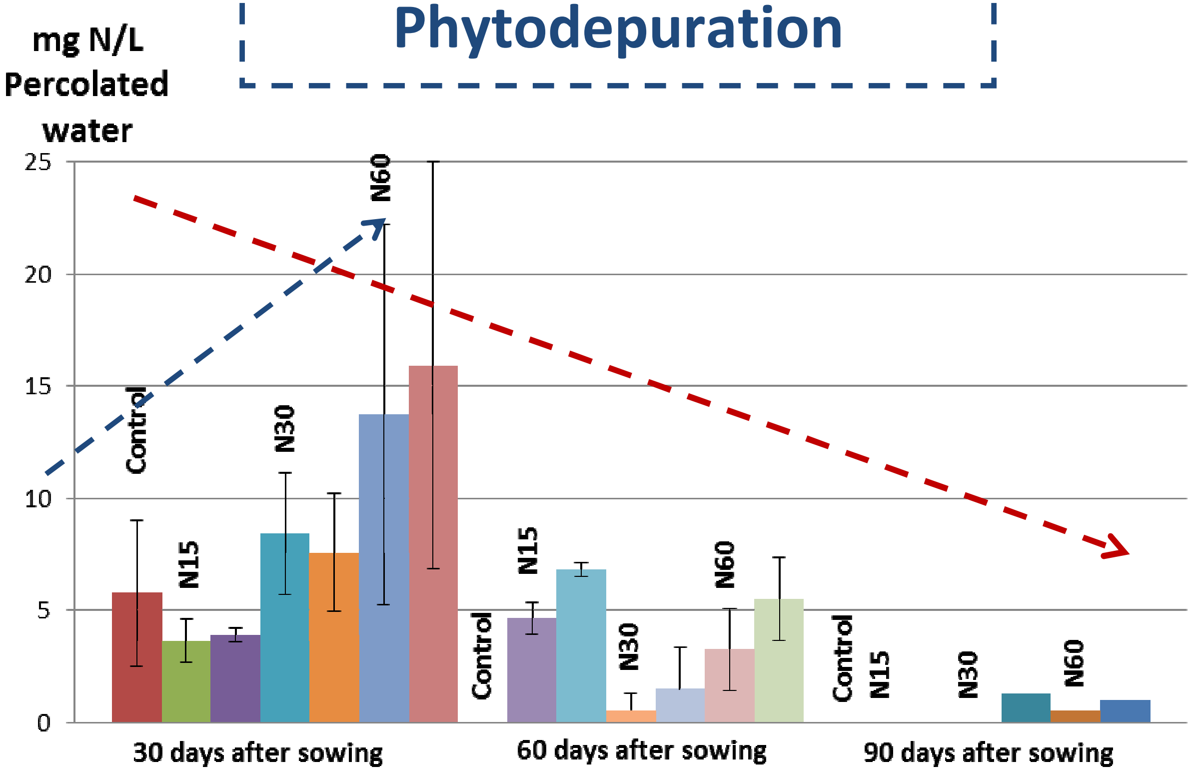
⇨ ↑NH4
↑ N content

Bark and Leaves
⇨ Same trend

N content Roots
⇨ Not affected

Results

Phytodepuration



- ⇨ ↑ NH4
- ⇨ ↑ N leached

- ⇨ Along the growing season
- ⇨ ↓ N leached

Roots

- ⇨ Biological filter

Case studies

•Growth, Productivity and Biomass Quality of Miscanthus Irrigated with Zn /Cu contaminated wastewaters

(Bandarra et al 2013)

Aim of the Study

- to evaluate
  - quality and biomass productivity
    - *Miscanthus* x *giganteus*
    - *Miscanthus floridulus*
    - *Miscanthus sinensis*
    - irrigated with wastewaters contaminated with Zn/Cu
    - Evaluation percolated water+soil

Zn and Cu ions

- Problematic in wastewaters
  - Risk of polluting ground and surface water
    - Run-off, Leaching
  - excess
    - could be a threat to human health
      - by entering the food chain
    - to environment
      - by affecting the ecosystems services

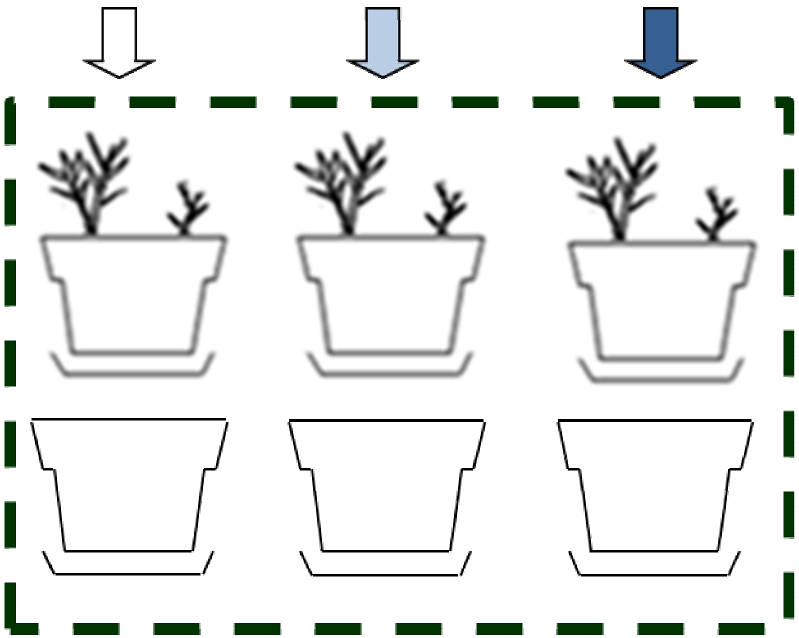
Experimental Layout

Control | 10 mg/dm^3 Zn | 1 mg/dm^3 Cu

2 rhyzomes/pot

May-January 2013

M x giganteus
M. sinensis
M. floridulus



Full irrigation
950 mm

No plants

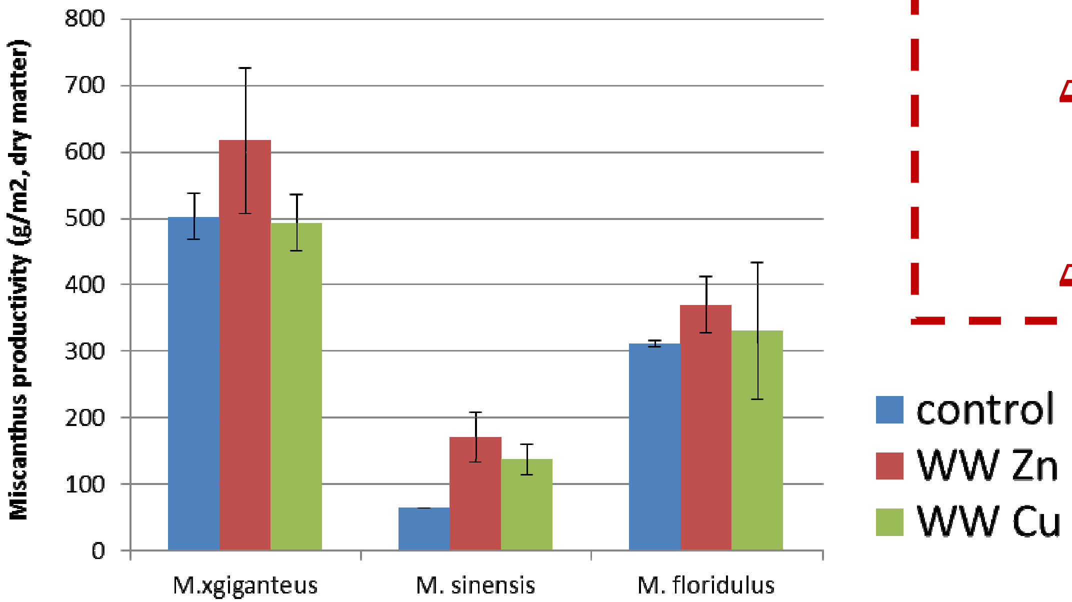
replicates

6 g N.m^{-2}
23 g P_2O_5.m^{-2}
17 g K_2O.m^{-2}

Collection of the percolated water + soil – end of season

Results - Productivity

Aerial Productivity

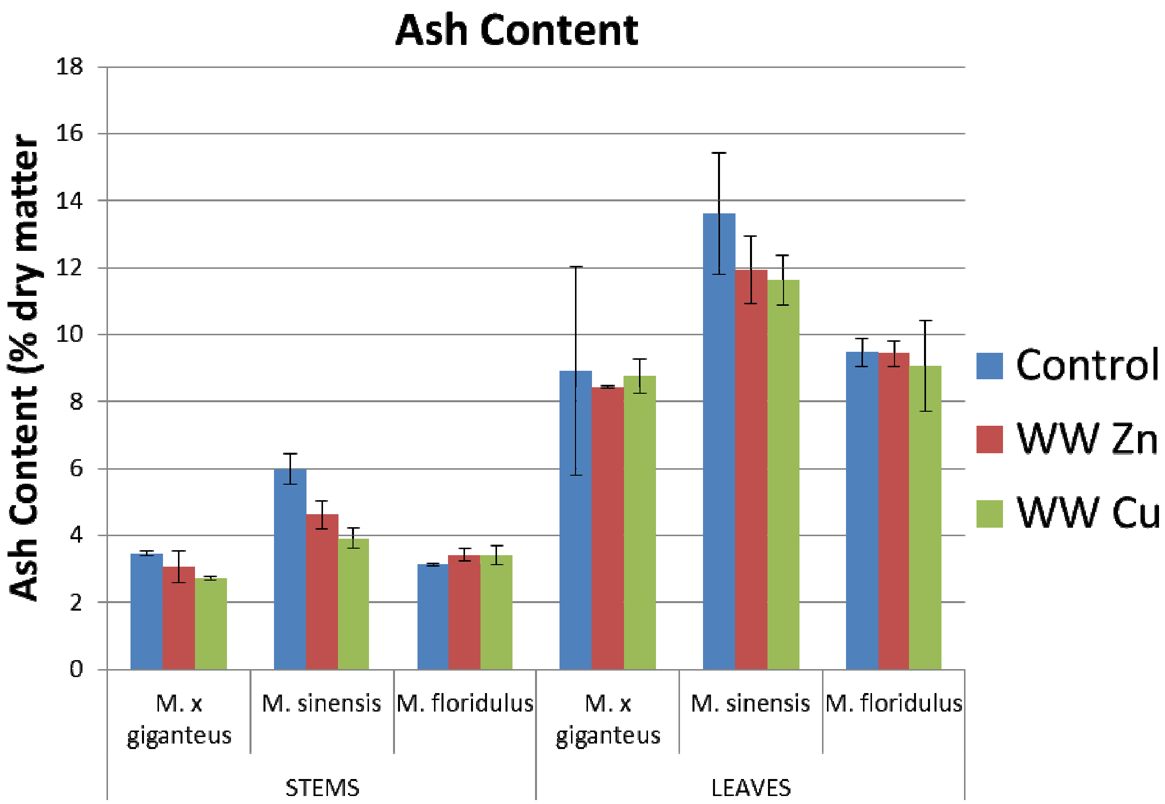


- ⇨ Zn/Cu WW
  - ⇨No effects on productivity
  - ⇨ trend → stimulation, especially Zn
  - ⇨ Zn/Cu: *M. sinensis*

Best: M. x giganteus

Worst: M. sinensis

Results – Biomass Quality

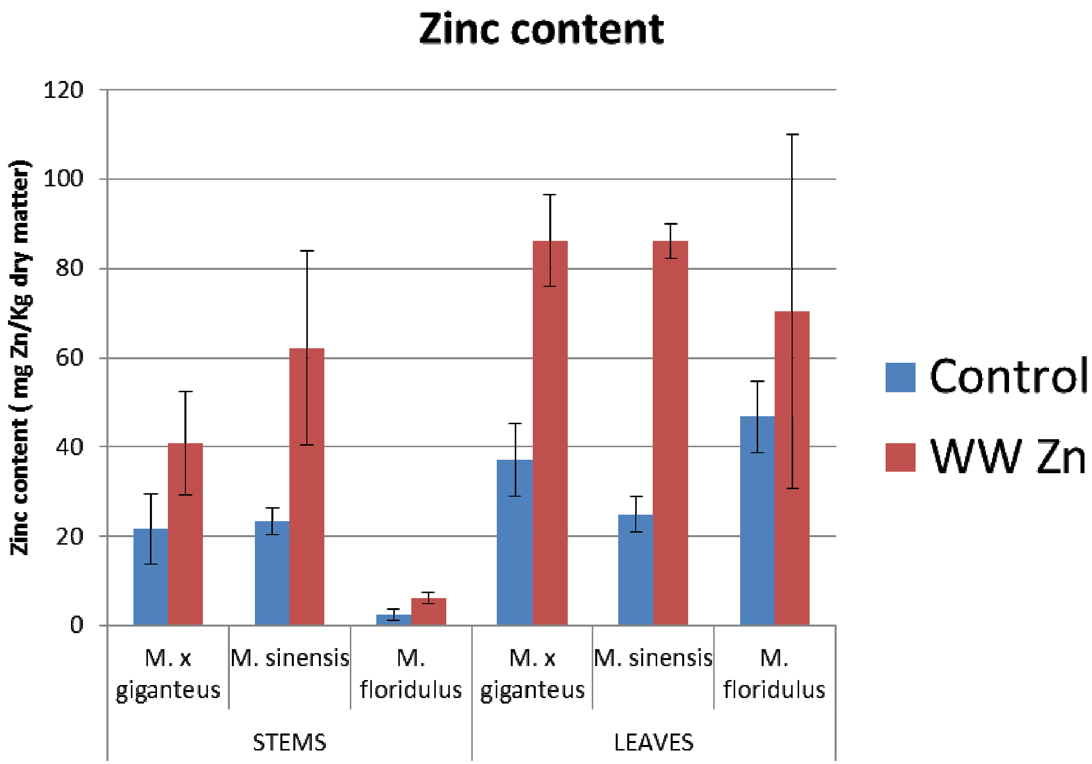


⇨ Zn/Cu no effect

Leaves > stems

↑ *M. sinensis* due to concentration effect

Results – Biomass Quality



⇨ **WWZn**

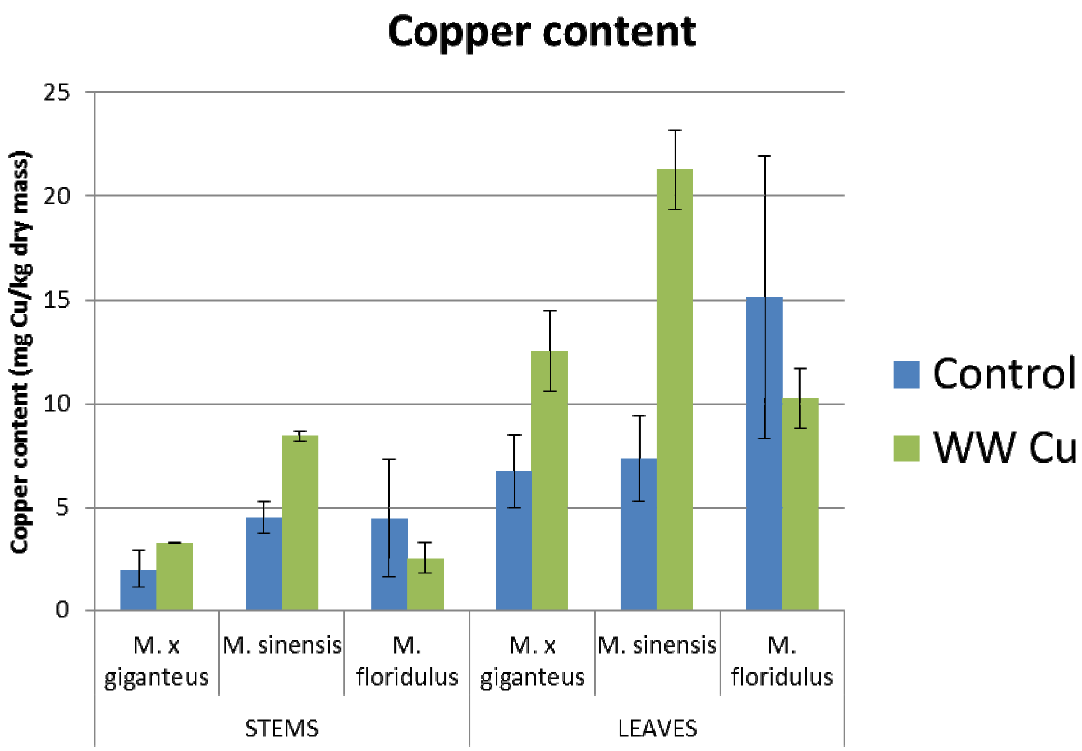
↑Zn biomass

Leaves > stems

M. floridulus

low phytoremediation with stems

Results – Biomass Quality



⇨ WWCu

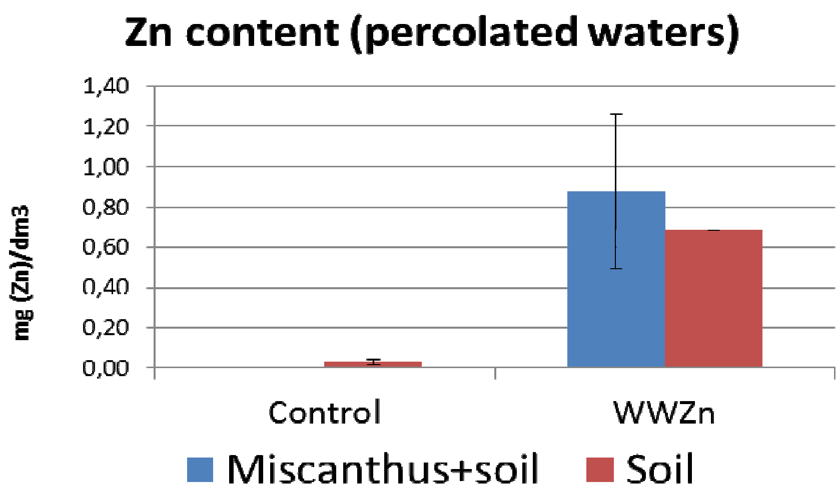
↑Cu biomass

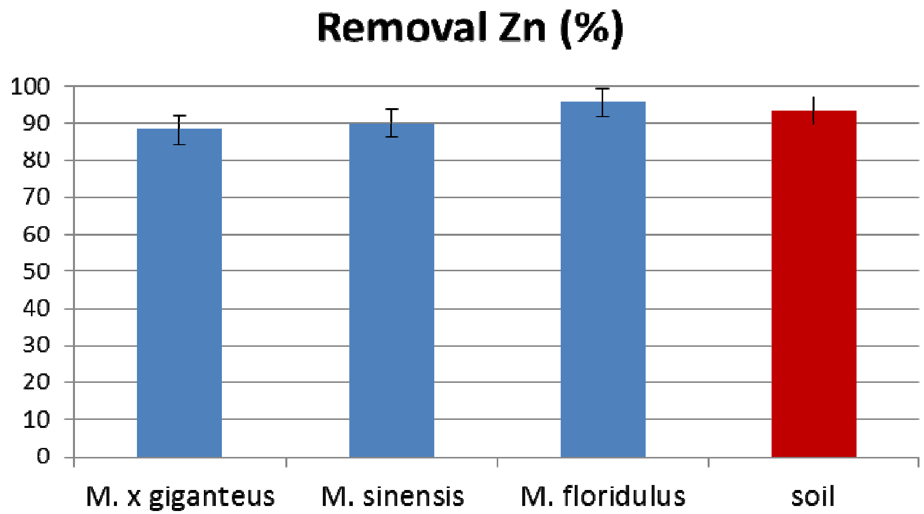
Leaves > stems

M. floridulus

low Cu phytoremediation

Results – percolated waters

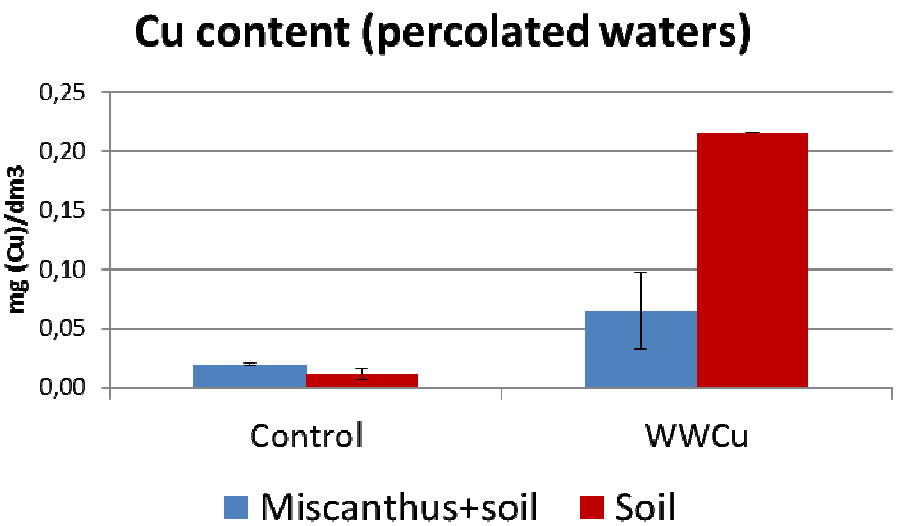


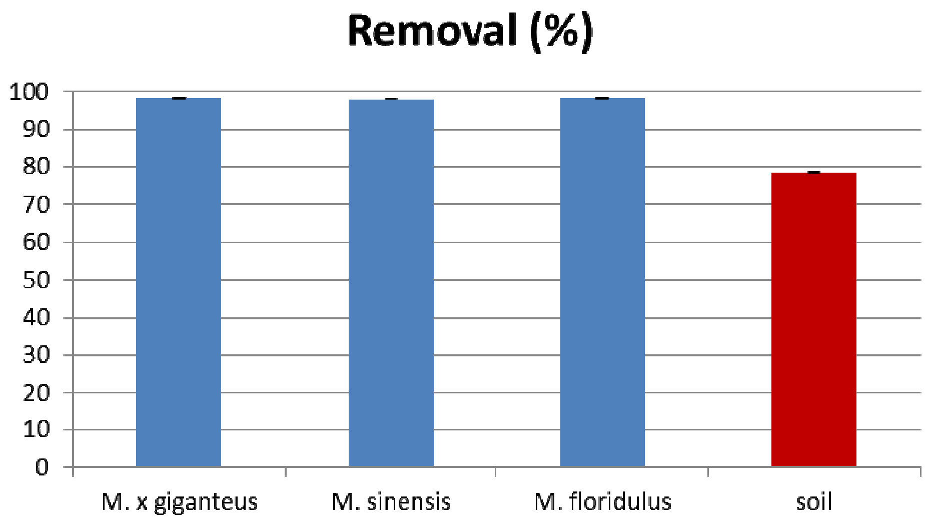


⇨Irrigation WWZn→ ↑ Zn in the percolates

⇨No ≠ soil / soil+Miscanthus→88-96% Zn removal

Results – percolated waters

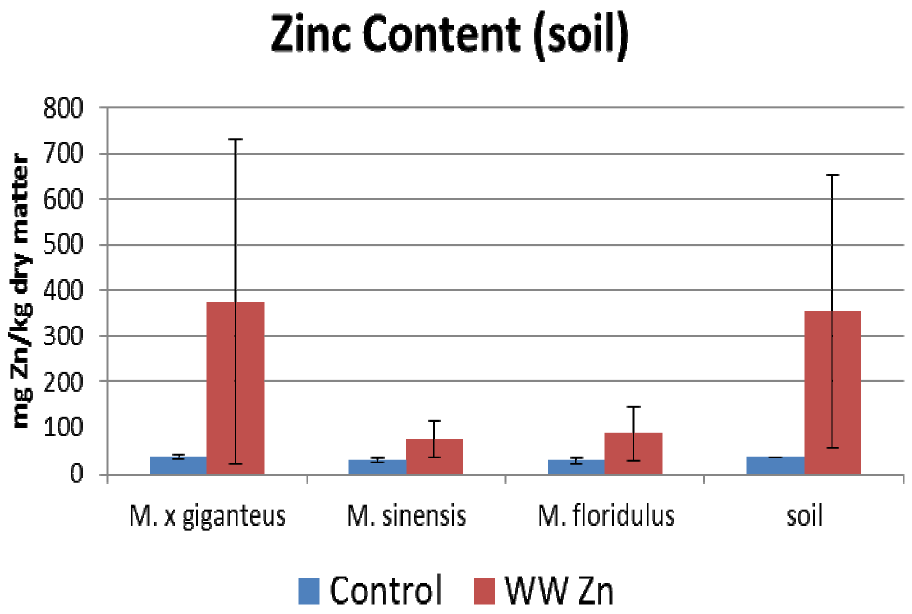


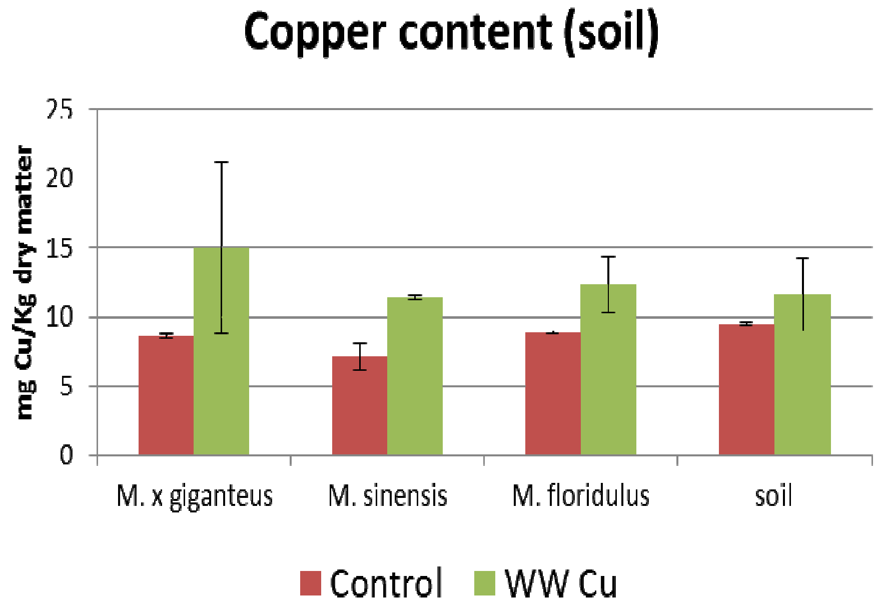


⇨Irrigation WWCu→ ↑ Cu in the percolates

⇨soil+Miscanthus better then soil→79-98% Cu removal

Results – soils





⇨**Irrigation WWZn/Cu→ ↑ Zn/Cu in the soil**

⇨**No differences between soil/soil+biomass systems**

Conclusions and recommendations

⇨ establishment of energy crops in degraded lands

⇨combined with wastewater irrigation,

⇨ represents an opportunity

⇨ to produce sustainable biomass

⇨ in water-scarce regions

Conclusions and recommendations

⇨ **Recommendations**

⇨ **site-specific factors should be properly assessed to evaluate the adequacy among crop, location and wastewater irrigation**

⇨ **bench-scale treatability studies should be conducted prior to field implementation**

Conclusions and recommendations

⇨ **Future options**

⇨ **identify species and varieties which can tolerate the changes likely to come as a result of climate change**

⇨ **to breed plants for stress tolerance**

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Thank you

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