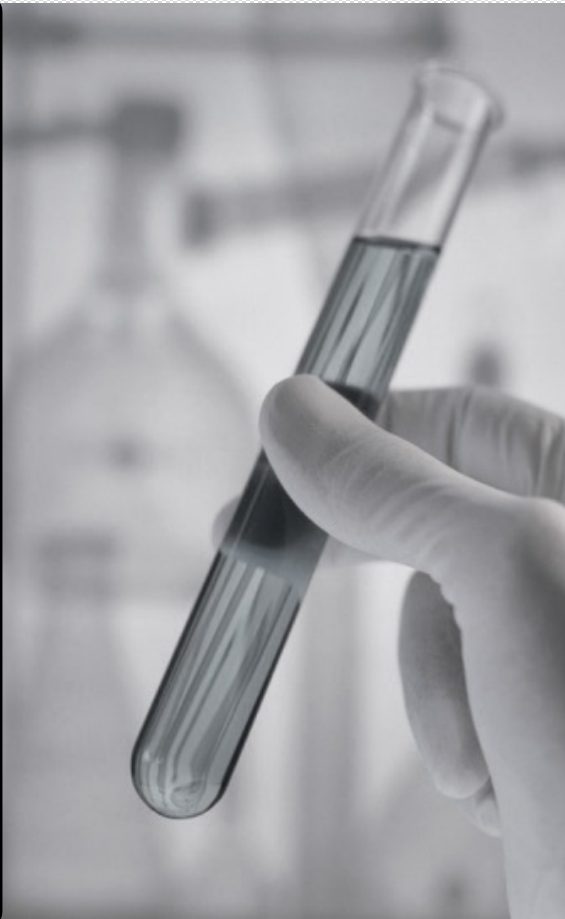
Fuel properties' comparison of allochthonous *Miscanthus x giganteus* and autochthonous *Arundo donax* L.: a study case in Croatia

Vanja Jurišić, Nikola Bilandžija, Tajana Krička, Josip Leto, Ana Matin, Ivan Kuže

University of Zagreb Faculty of Agriculture



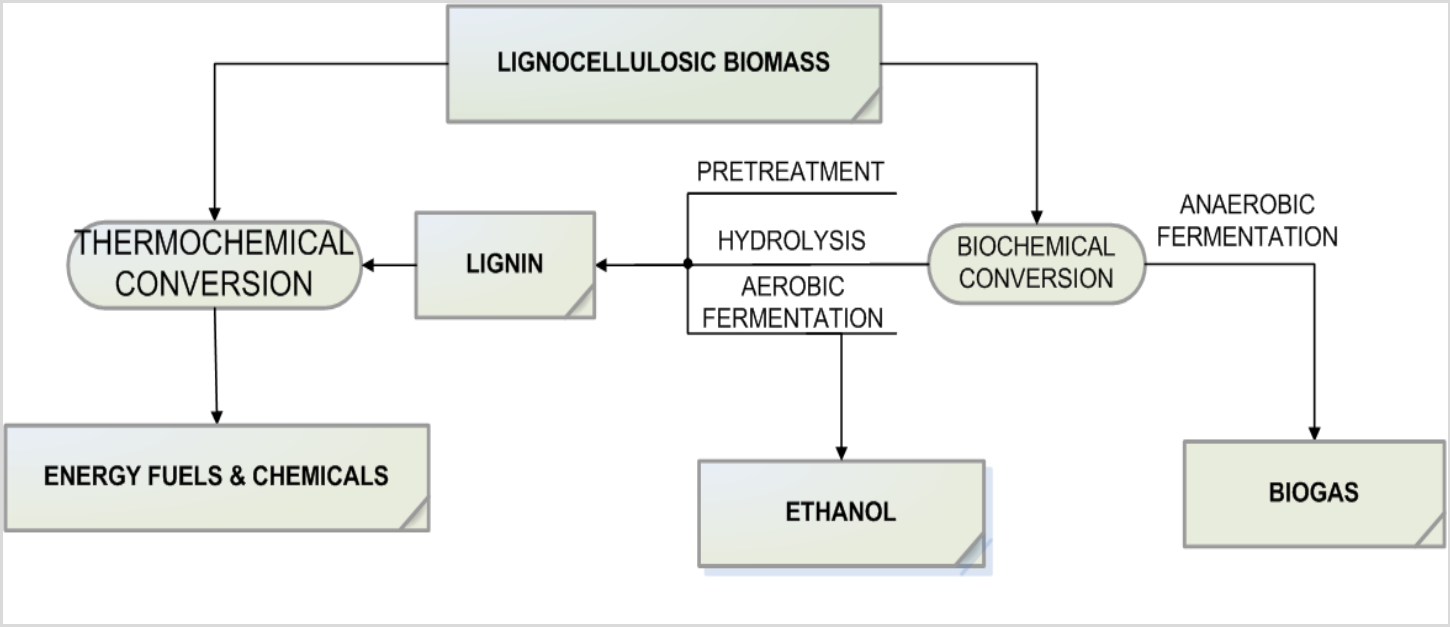
Outline

- Bioenergy production drivers
- Biomass conversion
- *M. giganteus* vs *A. donax*
- Objective of the research
- Materials and methods
- Results
- Conclusions

Bioenergy production drivers

- Biomass action plan (EC, 2005) ➔ increase reliance on RES.
- Biomass action plan (EC, 2005) ➔ at least a 20 % reduction in GHG emissions by 2020, compared to 1990.
- 2009/28/EC ➔ target of 20 % share of RES in overall energy consumption.
- 2009/28/EC ➔ 10 % share of renewable transport fuels.
- Biomass contribution
  - Transport – 23 Mtoe (increase of 16.6 Mtoe),
  - Energy – 150 Mtoe 2010 to ~230 Mtoe 2020.
- Biomass ➔ agricultural (crop residues) and forest resources.
- EC advisories on crop residues ➔ max. 30 % of potentially available biomass can be used for energy production.
- Lignocellulosic, energy crops can be used for production of heat and electricity (*via* direct combustion), or production of biofuel and biogas.

Biomass conversion



- Choice of the process is based on biomass properties:
  - physical - calorific value,
  - chemical - C, H, O, N, S, and ash.
- Properties vary with species, growing environment, management, and delayed harvest period.

M. giganteus vs *A. donax*

- European FAIR programme – established in 1997, introducing *Miscanthus* hybrids, and *Arundo donax* L. into EU agriculture for energy production.

- Advantages - grow rapidly and give high yields.

Objective of research

To determine fuel properties of the *M. giganteus* and *A. donax* L. biomass, harvested in the period of their maximum yield, relevant for direct combustion and energy production.

Materials and Methods

Materials

- *M. giganteus* harvested at two locations, Ličko Petrovo Selo (sample LPS) and Zelina Breška (sample ZB), on lower quality soils; harvest was carried out in the period of high yield availability.

- *A. donax* biomass was harvested at three locations, Orašac (sample OR), Brgat (sample BR), and island of Pag (sample PA), again, on lower quality soils and in the period of high yield availability.

- Before the analysis, samples were dried and ground in a laboratory grinder.

Materials and Methods

Methods

- Proximate analysis
  - moisture content (CEN/TS 14774-2:2009),
  - ash (CEN/TS 14775:2009),
  - fixed carbon and volatile matter (CEN/TS 15148:2009),
  - coke (CEN/TS 15148:2009).
- Ultimate analysis
  - total carbon, hydrogen, nitrogen (CEN/TS 15104:2009),
  - sulphur (CEN/TS 15289:2009),
  - oxygen content was calculated by difference.
- Calorimetry
  - HHV, LHV (CEN/TS 14918:2009).
- Statistical analysis
  - SAS system package version 8.00 (SAS Institute, 1997).

Results

Proximate analysis of *M. giganteus* and *A. donax* grown at different locations

Location	MC, %	AC, % db*	CK, % db	FC, % db	VM, % db
		Miscanthus x giganteus			
LPP	$46.34^{bc}\pm2.31$	$1.37^{b}\pm0.16$	$11.42^{b}\pm0.18$	$10.05^{b}\pm0.22$	$89.81^{b}\pm0.002$
ZB	$43.27^{c}\pm1.15$	$1.65^{b}\pm0.24$	$11.91^{b}\pm1.55$	$10.25^{b}\pm1.72$	$89.57^{b}\pm0.02$
		Arundo donax L.			
OR	$46.91^{ab}\pm1.68$	$1.40^{b}\pm0.25$	$8.57^{c}\pm0.34$	$7.17^{c}\pm0.09$	$92.73^{a}\pm0.001$
BR	$49.45^{a}\pm1.61$	$2.33^{a}\pm0.25$	$14.12^{a}\pm0.12$	$11.79^{a}\pm0.13$	$87.93^{c}\pm0.001$
PA	$48.14^{ab}\pm1.47$	$2.43^{a}\pm0.33$	$12.42^{b}\pm0.27$	$9.99^{b}\pm0.06$	$89.75^{b}\pm0.001$
Significance	0.0122*	0.0007***	<0.0001***	0.0004***	0.0003***

Legend:

- % db = % on dry basis;
- MC = moisture content; AC = ash content; CK = coke; FC = fixed carbon; VM = volatile matter;
- significance: *** p<0.001,** p<0.01,* p<0.05, NS=non-significant

Results

Ultimate analysis of *M. giganteus* and *A. donax* grown at different locations

Location	C*, % db	S, % db	H, % db	O, % db	N, % db
			Miscanthus x giganteus		
LPP	$49.75^{a}\pm0.24$	$0.08^{d}\pm0.001$	$4.06^{b}\pm0.03$	$45.68^{d}\pm0.17$	$0.43^{c}\pm0.11$
ZB	$49.31^{b}\pm0.08$	$0.08^{e}\pm0.002$	$3.98^{c}\pm0.07$	$46.41^{b}\pm0.01$	$0.22^{d}\pm0.03$
			Arundo donax L.		
OR	$49.43^{b}\pm0.001$	$0.12^{b}\pm0.001$	$4.18^{a}\pm0.001$	$45.78^{d}\pm0.001$	$0.49^{c}\pm0.001$
BR	$49.06^{c}\pm0.001$	$0.11^{c}\pm0.001$	$4.03^{bc}\pm0.001$	$46.17^{c}\pm0.001$	$0.63^{b}\pm0.001$
PA	$47.62^{d}\pm0.001$	$0.14^{a}\pm0.001$	$3.88^{d}\pm0.001$	$47.10^{a}\pm0.001$	$1.26^{a}\pm0.001$
Significance	<0.0001***	<0.0001***	<0.0001***	<0.0001***	<0.0001***

Legend:

- % db = % on dry basis;
- C = carbon; S = sulphur; H = hydrogen; O = oxygen; N = nitrogen;
- significance: *** p<0.001,** p<0.01,* p<0.05, NS=non-significant

Results

Heating values of *M. giganteus* and *A. donax* grown at different locations

Location	HHV, MJ/kg	LHV, MJ/kg
Miscanthus x giganteus		
LPP	$18.08^{a}\pm0.14$	$17.20^{a}\pm0.14$
ZB	$17.88^{a}\pm0.19$	$17.02^{a}\pm0.20$
Arundo donax L.		
OR	$17.20^{b}\pm0.06$	$16.28^{bc}\pm0.06$
BR	$17.26^{b}\pm0.05$	$16.39^{b}\pm0.05$
PA	$16.99^{c}\pm0.05$	$16.14^{c}\pm0.05$
Significance	<0.0001***	<0.0001***

Legend:

- HHV = higher heating value; LHV = lower heating value;
- significance: *** $p<0.001$,** $p<0.01$,* $p<0.05$, NS=non-significant.

Conclusions

- Study on *Miscanthus x giganteus* and *Arundo donax* L. biomass showed certain variations in all investigated samples, with regard to the type of biomass and harvest locations.
- **Ash content:** The only significant difference in values between species ➔ *A. donax* had somewhat higher ash content, which makes it less favourable fuel;
- **Moisture content:** higher ➔ due to the harvest time ➔ other harvest periods could be considered;
- **Hydrogen content:** somewhat lower then expected ➔considering higher oxygen levels, there should be no significant effect on combustion properties;
- **Nitrogen and sulphur contents:** low ➔low emissions of NO_x and SO_2;
- **HHV**: in expected range for herbaceous biomass (approx. 18 MJ/kg).
- Having in mind the applicable CEN/TS standard, it can be concluded that both investigated types of biomass have *good fuel properties*, *do not have significant environmental impact*, and thus are suitable for utilization as raw materials in direct combustion, and production of electricity and/or heat.

THANK YOU FOR THE ATTENTION!