OPTIMISATION OF PERENNIAL GRASSES FOR BIOMASS PRODUCTION IN MEDITERRANEAN AREA

OPTIMA (289642)
Work programme topics addressed:
Call: FP7 - KBBE-2011-5

KBBE.2011.3.1-02: Perennial grasses: optimising biomass production – SICA

Coordinator: Salvatore L. Cosentino
University of Catania, Italy

Danilo Scordia
OPTIMA Project manager

Twinning event  Day II, 31 October 2013, Hotel Hof van Wageningen, Wageningen, The Netherlands
Project timeframe

|----------|----------|----------|----------|--------------|----------|----------|
OPTIMA - objectives

Identify high-yielding perennial grasses for the Mediterranean area, within optimized production chain that will provide stable source for both biomass and new plant derived bio-products.

OPTIMA will explore the potentialities of perennial grasses on underutilized or abandoned marginal lands.
Consortium: 21 Partner from 12 countries (IT, GR, ES, PT, NL, BE, DE, HU, IR, Argentina, India, China); 6 SME
OPTIMA Project

WP9 - Management

WP8 – Dissemination

WP1 Plant Physiol.
WP2 Plant Biotech.
WP3 Plant Agron.
WP4 Farm-scale marginal lands
WP5 Bio-based & Energy markets
WP6 Environ. Studies
WP7 Integrate d assess.

WP1 Early emergence & RGR; Osmotic regulation; Photosynthesis & gas exchange under stress conditions; Senescence regulation & drying -
WP2 SNT markers develop. New genotypes; Phylo-geographic anal.; Illumina SNP OPA develop.; Core collection
WP3 Collection & Characterization endemic grasses; Potential yields & yield gap studies;
WP4 Intercropping on marginal lands; Yield gap on marginal lands; Long term yield in existing plantations; Good agric. & environ. practices
WP5 Charact. feedstock quality; Bio-based products & chains; Pilot tests of pyrolysis and torrefaction; Market analysis & regulatory framework
WP6 EIA; Carbon storage; Eddy covariance; Energy balance; Phytoremediation
WP7 LCA; Cost analysis; Socio-economic assessment; SWOT analysis; System description
Why perennial grasses?

Generally perennial grasses are attractive for biomass production due to their high yield potential, the high contents of lignin, cellulose and hemicellulose polysaccharides, and their positive social and environmental benefits

<table>
<thead>
<tr>
<th>Environmental benefits</th>
<th>Socio-Economic benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>– less water consumption;</td>
<td>– development of new markets (e.g. biofuels and green products);</td>
</tr>
<tr>
<td>– low fertilizers and pesticides requirements;</td>
<td>– new sources of income and employment in rural areas;</td>
</tr>
<tr>
<td>– low GHG emissions;</td>
<td>– development of regional economic structures;</td>
</tr>
<tr>
<td>– phytoremediation capacity;</td>
<td>– biodiversity increase;</td>
</tr>
<tr>
<td>– reduction of soil degradation and erosion;</td>
<td>– potential inland renewable energy sources (&gt; energy security);</td>
</tr>
<tr>
<td>– adaptability to marginal lands;</td>
<td>– improve the education, training, and assistance services provided for farmers.</td>
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<tr>
<td>– permanent soil cover;</td>
<td></td>
</tr>
<tr>
<td>– natural habits for wildlife.</td>
<td></td>
</tr>
</tbody>
</table>
No-food lignocellulosic cell wall

- Products
  - PHENOLS
  - ORGANIC ACIDS
  - OXYGENATES
  - FUELS
  - SPECIALTIES
  - FEEDSTOCK REFINERIES
  - BIOFUELS
  - SYNGAS
  - HEAT & POWER

- Applications
  
<table>
<thead>
<tr>
<th>High</th>
<th>Added Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

- Chemical structures of lignocellulosic cell wall components:
  - p-Coumaryl alcohol
  - Coniferyl alcohol
  - Sinapyl alcohol

- Diagram showing plant cell wall components:
  - Crystalline cellulose
  - Hemicellulose
  - Lignin

- Plant cell layers:
  - Cell wall
  - Macrofibril
  - Pentose
  - Hexose

- Key dimensions:
  - 10-20 nm

What does OPTIMA study?

**Arundo donax L.**
- Spontaneous C3 species in Mediterranean regions;
- Rhizome or stem cuttings propagation;
- Temperature requirements: 10-35°C and low water demand;
- Growing season Spring-Summer.

**Miscanthus x giganteus** Greef et Deuter
- High yielding C4 species in temperate regions;
- Hybrid from *Miscanthus sinensis* x *Miscanthus sacchariflorus*;
- Temperature requirements: 10-35°C and high water demand;
- Growing season Spring-Summer.

**Panicum virgatum L.**
- C4 grass with a wide range of climatic adaptability;
- Propagation by seeds;
- High tolerance to severe water stress conditions;
- More drought tolerant than *Miscanthus*.

**Cynara cardunculus L. var. altilis**
- C3 species native of Mediterranean;
- Growing season: autumn-spring;
- Temperature requirements: 5-40°C.
4FCROPS outcome: EU allocation of perennial grasses (Zegada-Lizarazu et al., 2010)
<table>
<thead>
<tr>
<th></th>
<th>Switchgrass</th>
<th>Miscanthus</th>
<th>Giant reed</th>
<th>Cardoon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area of origin</strong></td>
<td>North America</td>
<td>South East Asia</td>
<td>Asia and Mediterranean</td>
<td>Mediterranean</td>
</tr>
<tr>
<td><strong>Available genetic resource</strong></td>
<td>Many var. available</td>
<td>Many var. available</td>
<td>Wild genetic base</td>
<td>Wild genetic base</td>
</tr>
<tr>
<td><strong>Photosynthesis system</strong></td>
<td>C4</td>
<td>C4</td>
<td>C3</td>
<td>C3</td>
</tr>
<tr>
<td><strong>Yield (t ha⁻¹)</strong></td>
<td>10 - 25</td>
<td>10 - 38</td>
<td>7 - 61</td>
<td>15 - 22</td>
</tr>
<tr>
<td><strong>Raw material characteristic</strong></td>
<td>Lignocellulosic biomass</td>
<td>Lignocellulosic biomass</td>
<td>Lignocellulosic biomass</td>
<td>Lignocellulosic biomass/Oil seed</td>
</tr>
<tr>
<td><strong>Adaption range in EU</strong></td>
<td>Cold and warm regions of EU</td>
<td>Cold and warm regions of EU</td>
<td>Warm region of southern EU</td>
<td>Mediterranean regions</td>
</tr>
<tr>
<td><strong>Rotation time</strong></td>
<td>15 yrs</td>
<td>15 – 20 yrs</td>
<td>15 – 20 yrs</td>
<td>4 – 5 yrs</td>
</tr>
<tr>
<td><strong>Establishment</strong></td>
<td>Seed</td>
<td>Rhizomes</td>
<td>Rhizomes or stem cuttings</td>
<td>Seed</td>
</tr>
<tr>
<td><strong>Harvest time</strong></td>
<td>Early spring</td>
<td>Winter/Early spring</td>
<td>Winter/Early spring</td>
<td>Summer</td>
</tr>
<tr>
<td><strong>Required machinery</strong></td>
<td>Normal farm equipments</td>
<td>Special farm equipments</td>
<td>Special farm equipments</td>
<td>Special farm equipments</td>
</tr>
<tr>
<td><strong>Fertilizers input (kg ha⁻¹ N):</strong></td>
<td>0 - 70</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>50 - 100</td>
</tr>
<tr>
<td><strong>Pesticide and herbicides</strong></td>
<td>First year and post-harvest</td>
<td>First year and post-harvest</td>
<td>First year and post-harvest</td>
<td>First year and post-harvest</td>
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</tbody>
</table>
## Novel grass species

<table>
<thead>
<tr>
<th>Species</th>
<th>Name</th>
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<tbody>
<tr>
<td><strong>Saccharum spontaneum</strong> L. ssp. aegyptiacum (Willd.) Hackel</td>
<td></td>
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<tr>
<td><strong>Lygeum spartum</strong> Loefl. ex L.</td>
<td></td>
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<tr>
<td><strong>Cymbopogon hirtus</strong> (L.) Janchen</td>
<td></td>
</tr>
<tr>
<td><strong>Sorghum halepense</strong> (L.) Pers.</td>
<td></td>
</tr>
<tr>
<td><strong>Phalaris arundinacea</strong> L. ssp. arundinacea</td>
<td></td>
</tr>
<tr>
<td><strong>Dactylis glomerata</strong> L.</td>
<td></td>
</tr>
<tr>
<td><strong>Lolium arundinaceum</strong> (Schreb.) S.J.</td>
<td></td>
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<tr>
<td><strong>Lolium perenne</strong> L.</td>
<td></td>
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<tr>
<td><strong>Ampelodesmos mauritanicus</strong> (Poir.) Dur &amp; Schinz</td>
<td></td>
</tr>
<tr>
<td><strong>Oryzopsis miliacea</strong> (L.) Asch. et Schweinf.</td>
<td></td>
</tr>
<tr>
<td><strong>Phragmites australis</strong> (Cav.) Trin. ex. Stend</td>
<td></td>
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</tbody>
</table>
OPTIMA research topics
WP1 – Plant and Leaf Physiology (leader UB)

UCD - impact of cold on germination rates and early plant performance in switchgrass

INDEAR – Physiology of switchgrass under salinity and water stress

IBERS - Miscanthus early season leaf development under water stress (4 reps 249 genotypes)

UB/UB - Giant reed and cardoon under salinity and water stress
INDEAR – Switchgrass RNA seq. under stresses

INDEAR – Genome reduction under stress

HZAU – Giant reed tags depths distribution in each individual (GBS-Tags)
WP3 – Plant agronomy, leader UNICT (Task 3.1)

UNICT – Wild species propagation material

- S. halepense seeds
- Rhizome of S. spontaneum
- Mother plant C. hirtus

CNR – Ampelodesmos in riparian area

UNICT – Wild species in collection field

- Saccharum spontaneum
- Sorghum halepense
- Cymbopogon hirtus

CRES – Pennisetum (sx) vs Miscanthus (dx)
WP3 – Plant agronomy 1/2 (Task 3.2)

UNICT – Giant reed stem propagation

UNIBO – Switchgrass hydro-sowing

PRIMUS – Miscanthus propagation

CRES – Giant reed rhizome (sx) and stem cutting (dx) propagation
WP3 – Plant agronomy 2/2 (Task 3.2)

UNICT – Saccharum under water stress

100% ETM rest. Rainfed

UNIBO – Switchgrass harvest strategy

UNIBO – Switchgrass under salinity stress

UNICT – Giant reed under salinity stress

UPM – Giant reed under waters stress
WP4 – Farm scale productivity of PG on marginal lands (1/2), leader CRES

CRES – Giant reed irrigated vs marginal

UNICT – PG intercropping

UNICT – 5 ha Giant reed field

UNIBO – Switchgrass long term

UNICT – Giant reed (up) and Miscanthus (down) long term
WP4 – Farm scale productivity of PG on marginal lands (2/2)

UPM – Cardoon cultivation on marginal land

UPM – Cardoon mechanical harvesting

CRA-ING and SPAPPERI – Giant reed mechanical harvesting

Graphical representation of slope classes in the field
WP5 – Energy products and plant derived by-products (leader BTG)

BTG and CRES – Giant reed ash test

Ash Arundo

BTG – Pirolisys (up) and torrefaction (down) pilot plants

2ZK– Biomass densification
WP6 – Environmental impact assessment (leader UNIBO)

UNIBO – Eddy covariance tower in switchgrass field

UNICT – Soil erosion mitigation by PG

PRIMUS – PG on red mud in Hungary

FCT-UNL – Energy balance

Energy in

Cultivation

Yield

... by-products

Energy out

...
WP7 – Integrated assessment of sustainability (leader IFEU)
WP8 – Dissemination (leader CRES) 1/6

International Conference:


Sustainable resource supply to meet the RED 2020 targets in EU27. Calliope Panoutsou, Imperial College London. 2nd Iberoamerican Congress on Biorefineries (http://www.ciab2013.org/), Jaen Spain, 11th April 2013. Oral presentation by Calliope Panoutsou – IMPERIAL.

Giant Reed Screening to Salinity Levels. S.L. Cosentino, V. Copani, G. Testa, S. Sidella, G. Patanè, D. Scordia. 21st European Biomass Conference and Exhibition, 3-7June 2013, Copenhagen, Denmark. Oral presentation by D. Scordia - UNICT.

Growth, Productivity and Biomass Quality of Miscanthus Irrigated with ZN and CU Contaminated Wastewaters. V. Bandarra, B. Barbosa, S. Boléo, J. Costa, M. P. Duarte, A. L. Fernando, B. Mendes, S. Sidella. 21st European Biomass Conference and Exhibition, 3-7June 2013, Copenhagen, Denmark. Oral presentation by A. L. Fernando - FCT-UNL.


**WP8 – Dissemination (leader CRES) 4/6**

**Physiological and Productive Responses of Native Perennial Grasses to Environmental Constraints in Mediterranean Environments.** V. Copani, L. Cosentino, G. Testa, S. Virgillito, D. Scordia. 21st European Biomass Conference and Exhibition, 3-7June 2013, Copenhagen, Denmark. Visual poster (UNICT).


**Carbon Fluxes and Yield Variability of Switchgrass in Northern Italy: Preliminary First Year Data.** N. Di Virgilio, O. Facini, A. Monti, M. Nardino, A. Zatta. 21st European Biomass Conference and Exhibition, 3-7June 2013, Copenhagen, Denmark. Visual poster (UNIBO).

**Evapotranspiration and Water Use Efficiency on a Northern Italy Switchgrass First Year Plantation.** O. Facini, N. Di Virgilio, M. Nardino, F. Rossi. 21st European Biomass Conference and Exhibition, 3-7June 2013, Copenhagen, Denmark. Visual poster (UNIBO).

**Establishment of Miscanthus rhizomes in mediterranean environment.** S.L. Cosentino, V. Copani, G. Scalici. 21st European Biomass Conference and Exhibition, 3-7June 2013, Copenhagen, Denmark. Visual poster (UNICT).
WP8 – Dissemination (leader CRES) 5/6

National Conference:

**Valorização de Resíduos e Biomassa** by Fernando et al. 1as Jornadas Técnicas, CVR, Guimarães, Portugal, 15 June 2012. (oral communication by Ana Luisa Fernando – FCT-UNL).


**BIO4SUD (Biofuels for Sustainable Development of Southern Europe) conference (19-20/11/12, Thessaloniki – Greece)** one oral and poster presentation by CRES ([www.bio4sud.gr](http://www.bio4sud.gr)).
Workshops

Final workshop organized by Crops2Industry (www.crops2industry.eu) entitled **Non-food crops for a European bio-based industry and sustainable agriculture**, Bologna - Italy, 31/01/2012. Presentation of OPTIMA project. Cosentino SL.

Workshop entitled **Agronomy and logistics of fibre crops**, organized by FIBRA project (www.fibrafp7.net), Rome - Italy, 20/03/2013. Presentation of OPTIMA project. Scordia D.

Workshop entitled **Can European Agriculture Feed Sustainably both the Energy and Biobased Industries of the Future?**, organized by FIBRA, OPTIMA and EUROBIOREF. Parallel event on 21st European Biomass Conference, Copenhagen – Denmark, 06/06/2013.

- Perennial grasses for second generation biofuels and biobased products. Cosentino SL.
- Marginal land in EU. P.Soldatos (AUA)
Acknowledgements
Il annual OPTIMA meeting, 30 September – 02 October
University of Madrid, Spain
Thank you for your kind attention

Danilo Scordia
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www.optimafp7.eu

Twinning event Day II, 31 October 2013, Hotel Hof van Wageningen, Wageningen, The Netherlands