
Fabio G. Achinelli, Guillermo Doffo, Pablo Etchevers and Virginia M. C. Luquez.
Renewable sources in Argentina: 9.4% of the primary energetic matrix (5% is from bioenergy).

Growing interest on dendroenergy.

Most of dendroenergy rely on *Pinus* spp. or *Eucalyptus* spp. wood residues (130 Mw).

Large companies (Arauco Argentina; Papel Prensa) and also small and mid-size companies.
Forest plantations for dendroenergy production are rare in Argentina.

Scarcity of data make difficult the development of new projects.

Bustamante (2011) reported SRC yields of 28 t.ha^{-1}.year^{-1}. No SRC commercial plantation with Salicaceae in Argentina.

More than 40,000 ha of SRF-like Salix spp. plantations. Yields: 2.0 - 12.0 t.ha^{-1}.year^{-1}; none were planted for dendroenergy.
SRC-like systems with *Salix* spp. are cultivated as stoolbeds.

We don´t know how could they perform as dendroenergetic crops.

- Yields?
- Biomass quality for dendroenergetic applications?
- Impact of silvicultural factors on yields?

✓ **SRC field experiment to evaluate effects of drip irrigation, genotype and planting density on yield and quality of biomass.**
- Field trial in La Plata, Buenos Aires, Argentina (34°59´09” S; 57°59´42” O; 28 m elev.; 985.4 mm rainfall).

- Planting date: September, 2012.

- 3 factor experiment; (8 treatments).

  **Irrigation** (2): rainfed vs. drip irrigation.

  **Planting density** (2): 13,333 pl./ha vs. 20,000 pl./ha

  **Clonal composition** (2):

  *Salix alba `Yaguarete INTA-CIEF´
  *Salix matsudana x Salix alba `Barrett 13-44 INTA´
- Split-split plot design replicated in three complete blocks.

Block I

Block II

Block III

Sample
\[ n = 24 \text{ central stools} \]

Sub-subplot
(Yaguarete or Barrett 13-44)

Subplot
(13,333 or 20,000 pl/ha)

Main plot
(irrigation or rainfed)

(net surface: 1740 m\(^2\))

MATERIALS AND METHODS - field experiment layout
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-Irrigation: flow regulated drip lines.

-100µ black plastic mulch for all treatments.

-Planting material: dormant cuttings; 0.7 m long.

-No sprout thinning neither fertilization during rotation.
MATERIALS AND METHODS - site conditions and irrigation water

- typic argiudoll agricultural soil.

- good status of conservation.

- fertile soil, despite of Bt argillic horizon.

- irrigation water is drinkable, non saline to slightly saline.

- topography gradient blocked in the design.

<table>
<thead>
<tr>
<th>Soil</th>
<th>typic argiudoll</th>
</tr>
</thead>
<tbody>
<tr>
<td>epipedon</td>
<td>mollic</td>
</tr>
<tr>
<td>Bt</td>
<td>argillic horizon</td>
</tr>
<tr>
<td>pH</td>
<td>6.63</td>
</tr>
<tr>
<td>E.C. (mS/cm)(1:2.5)</td>
<td>0.176</td>
</tr>
<tr>
<td>O.M. (%)</td>
<td>2.8</td>
</tr>
<tr>
<td>total N (%)</td>
<td>0.123</td>
</tr>
<tr>
<td>P (Bray-I; mg/kg)</td>
<td>20.8</td>
</tr>
<tr>
<td>exch. K (meq/100 g)</td>
<td>1.09</td>
</tr>
<tr>
<td>CEC (meq/100 g)</td>
<td>17.3</td>
</tr>
<tr>
<td>micro elements</td>
<td>well stocked</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>27.8</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>46</td>
</tr>
<tr>
<td>clay (%)</td>
<td>26.2</td>
</tr>
<tr>
<td>Texture</td>
<td>Medium loam</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Irrigation water</th>
<th>slightly saline</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.75</td>
</tr>
<tr>
<td>Total salinity (mg/l)</td>
<td>552</td>
</tr>
<tr>
<td>E.C. (dS/m)</td>
<td>0.86</td>
</tr>
<tr>
<td>SAR (meq/l)</td>
<td>3.4</td>
</tr>
</tbody>
</table>
MATERIALS AND METHODS - measurements

- Rotation length: 1 year.
- Manual harvest in winter (4 seasons measured).
- Yield as dry weight (105°C; t.ha⁻¹.year⁻¹).
- Stool survival (%).
- Upper heating value (UHV; cal/g).
- Total ash content (TAC; %).
- Statistical analysis: standard ANOVA procedures.
RESULTS – overview of survival and yield responses

- **Survival**: Mortality in only on 3 of 24 plots; 4.1% - 8.33% dead stools in Yaguareté plots, independently of density or irrigation.

Summary of statistical ANOVA analysis for the effects of silvicultural factors on yields.

<table>
<thead>
<tr>
<th>Growing season</th>
<th>Irrigation</th>
<th>Planting density</th>
<th>Clonal composition</th>
<th>Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 - 2013</td>
<td>-</td>
<td>**</td>
<td>***</td>
<td>clone x pl. density *</td>
</tr>
<tr>
<td>2013 - 2014</td>
<td>***</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>2014 - 2015</td>
<td>**</td>
<td>ns</td>
<td>*</td>
<td>ns</td>
</tr>
<tr>
<td>2015 - 2016 (+)</td>
<td>**</td>
<td>*</td>
<td>***</td>
<td>irrig. x pl. density **</td>
</tr>
</tbody>
</table>

- irrigation was not carried out this season

ns= non-significant; *marginally significant 0.1>p>0.05; **significant 0.05>p>0.01; ***highly significant p<0.01

(+) data not included in the Abstract
RESULTS - Yield responses 2012-2013

-columns of equal colour followed by the same letter do not differ, DGC test (0.05)

-clone x density interaction marginally significant; p = 0.0637

-means followed by the same letter do not differ, DGC test (0.05)

✓ 2012 - 2013: the establishment season under waterlogged soil conditions

- columns of equal colour followed by the same letter do not differ, DGC test (0.05).
* water lamina applied during the growing season

- Irrigation: the only factor with statistically significant effects on biomass production through three seasons.
RESULTS - UHV and TAC of samples from 2013-2014 harvest

- **UHV (cal/g):** 4654 cal/g (all samples).

- **LHV (cal/g):** 4334.1 cal/g (all samples).

- **TAC (%):** marginally significant differences (0.05<p<0.1) between clones and irrigation.

<table>
<thead>
<tr>
<th></th>
<th>mean TAC (%)</th>
<th>C.I. (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated</td>
<td>1.96</td>
<td>(1.81-2.11)</td>
</tr>
<tr>
<td>Rainfed</td>
<td>2.13</td>
<td>(1.98-2.28)</td>
</tr>
<tr>
<td>Barrett 13-44</td>
<td>1.95</td>
<td>(1.85-2.05)</td>
</tr>
<tr>
<td>Yaguareté</td>
<td>2.15</td>
<td>(2.05-2.24)</td>
</tr>
</tbody>
</table>

✓ **UHV and TAC are similar to those published elsewhere, and initially compatible with firing and co-firing processes.**
RESULTS - Yield responses 2015 - 2016

- columns followed by the same letter do not differ, DGC test (0.05).

- irrigation x density interaction significant; p = 0.027
- means followed by the same letter do not differ, DGC test (0.05)

✔ For now, best combination would be a drip irrigated, low density (13,333 plants/ha) short rotation coppice with clone Barrett 13-44.
RESULTS - Yield responses

soil water storage - rainfall?
soil depletion?

<table>
<thead>
<tr>
<th>Growing season</th>
<th>Rainfall (mm)</th>
<th>Irrigation (mm)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-2013</td>
<td>1231.3</td>
<td>0</td>
<td>1231.3</td>
</tr>
<tr>
<td>2013-2014</td>
<td>900.5</td>
<td>543</td>
<td>1443.5</td>
</tr>
<tr>
<td>2014-2015</td>
<td>876</td>
<td>843</td>
<td>1719</td>
</tr>
<tr>
<td>2015-2016</td>
<td>845.8</td>
<td>516</td>
<td>1361.8</td>
</tr>
</tbody>
</table>

Mean August - April (series yrs. 1964 - 2014) = 786.8 mm

We interpret yields from irrigated plots as estimations of the maximum yields attainable with this genetic and site characteristics.

Productivity of willows in agricultural soil is highly dependent on irrigation, and probably of rainfall. Yaguareté is more sensitive to water availability than Barrett 13-44 (embolism?).

Additional data is needed to define yield tendencies: yield relates to rainfall or yield declines reveal nutrient depletion?

Nutrient export determinations and aerial biomass partitioning are underway.
- This research was funded by PIA 10007 IBRD 7520 AR from Ministry of Agroindustry, Argentina.

-Special thanks to FAO for their support by granting a scholarship for the assistance to this event.

Thank you!

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