GROWING RICE BY DRIP WITH LESS WATER AND ARSENIC FOR GLOBAL FOOD SECURITY
Italian experience 2010-16

Alberto Vezio Puggioni
Marco Panizza

NETAFIM GBU SOUTH EUROPE
History of rice cultivation in Italy

- Probably introduced by Arabs in Sicily (14th Century)

- Middle Ages rice cultivated in botanical edges of monastic orders

- Monks select the first seed

- Cultivated over 500 years ago

- 16th Century increased area from 5,000 to 50,000 ha
RICE SURFACE IN EUROPE

<table>
<thead>
<tr>
<th>Country</th>
<th>Surface (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>237,500</td>
<td>53</td>
</tr>
<tr>
<td>Spain</td>
<td>105,000</td>
<td>23</td>
</tr>
<tr>
<td>Portugal</td>
<td>30,000</td>
<td>7</td>
</tr>
<tr>
<td>France</td>
<td>12,000</td>
<td>3</td>
</tr>
<tr>
<td>Greece</td>
<td>25,000</td>
<td>6</td>
</tr>
<tr>
<td>Romania</td>
<td>15,000</td>
<td>3</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>12,000</td>
<td>3</td>
</tr>
<tr>
<td>Hungary</td>
<td>3,000</td>
<td>1</td>
</tr>
<tr>
<td>Morocco</td>
<td>10,000</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>449,500</td>
<td>100</td>
</tr>
</tbody>
</table>

After the reduction of surface, from 2010 to 2013, the situation in 2016 is getting better for price and evolution in crop management (minimum tillage, dry sowing, etc.)
### Estimation Rice Surface in Italy at July 2016

237,500 ha in 2016

227,329 ha in 2015

+ 10,171 hectares increased

Increased surface + 4.47%

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**Source:** Ente Risi

<table>
<thead>
<tr>
<th>Gruppi Varietàli</th>
<th>Previsione Superfici 2016 (ettari)</th>
<th>Superfici 2015 (ettari)</th>
<th>Differenza (ettari)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>TONDI</td>
<td>72,800</td>
<td>56,946</td>
<td>15,854</td>
<td>27,84%</td>
</tr>
<tr>
<td>LIDO E SIMILARI</td>
<td>2,500</td>
<td>1,412</td>
<td>1,088</td>
<td>77,07%</td>
</tr>
<tr>
<td>PADANO E SIMILARI</td>
<td>350</td>
<td>820</td>
<td>-470</td>
<td>-57,32%</td>
</tr>
<tr>
<td>VIALONE NANO</td>
<td>5,200</td>
<td>6,056</td>
<td>-856</td>
<td>-14,13%</td>
</tr>
<tr>
<td>VARIE MEDIO</td>
<td>1,750</td>
<td>1,183</td>
<td>567</td>
<td>47,97%</td>
</tr>
<tr>
<td>LOTTO - ARIETE E SIMILARI</td>
<td>34,200</td>
<td>45,594</td>
<td>-11,394</td>
<td>-24,99%</td>
</tr>
<tr>
<td>SANDREA</td>
<td>8,000</td>
<td>11,039</td>
<td>-3,039</td>
<td>-27,53%</td>
</tr>
<tr>
<td>ROMA E SIMILARI</td>
<td>14,000</td>
<td>9,959</td>
<td>4,041</td>
<td>40,57%</td>
</tr>
<tr>
<td>BALDO E SIMILARI</td>
<td>10,500</td>
<td>21,037</td>
<td>-10,537</td>
<td>-50,09%</td>
</tr>
<tr>
<td>ARBORIO E SIMILARI</td>
<td>22,000</td>
<td>17,125</td>
<td>4,875</td>
<td>28,47%</td>
</tr>
<tr>
<td>CARNAROLI E SIMILARI</td>
<td>21,500</td>
<td>15,065</td>
<td>6,435</td>
<td>42,71%</td>
</tr>
<tr>
<td>VARIE LUNGO A</td>
<td>11,000</td>
<td>6,048</td>
<td>4,952</td>
<td>81,88%</td>
</tr>
<tr>
<td>LUNGO B</td>
<td>33,700</td>
<td>35,044</td>
<td>-1,344</td>
<td>-3.84%</td>
</tr>
<tr>
<td><strong>TOTALE</strong></td>
<td><strong>237,500</strong></td>
<td><strong>227,329</strong></td>
<td><strong>10,171</strong></td>
<td><strong>4,47%</strong></td>
</tr>
</tbody>
</table>

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Source: Ente Risi
ITALIAN RICE

- Italy represents with **1,496,250 tons** of paddy rice, **0.4%** of world production.
- Yield average **6.3 tons/ha** of paddy rice.
- **32%** of total Italian production is for **Risotto Varieties**.
- **68%** others.
- Export in EU: **56%** of production.
- Export in other Countries: **12%**.
- Turnover export **460-490 million of euros** (510-543 million of dollars).

In Italy are registered 185 varieties of rice

30 are actually cultivated in relevant area

The *risotto* varieties are the most important

*Risotto* is a kind of coocking process, very popular in Italy and needs kind of rice with high quantity of Amilose starch

*Its main feature is the retention of the starch jelly that due to the cooking, combine grains between them in a creamy compound*
Italian experience 2010-16
RESEARCH TOPICS

From 2010-11 we drive research in aerobic rice irrigated by drip in collaboration with R&D Netafim Corporate mainly in the bold topics:

a) **Water use reduction**
b) Fertilizer use reduction
c) **Greenhouse gas emission reduction**
d) Reduction in leaching of fertilizers
e) Power saving
f) Reduction in manpower and labor
g) **Use of various soil types and topography**
h) Reduction in diseases and pests
i) **Arsenic uptake and Rice quality**
j) Weeds control and mulching
WATER USE REDUCTION

- A different approach to reduce water inputs in rice is to grow the crop like an irrigated dry crop.
- Such as Corn or Cotton using modern irrigation technologies such as drip irrigation.
- Field experiments indicated seasonal water requirement per hectare of drip irrigated aerobic rice was 7000-8000 m³/ha.
- Potential yield of 10-12 tons/ha.
- It is about 800-900 liters to produce 1kg of Rice with Drip Irrigation (instead of 3.000-5.000 by submersion).
In 2010 decide to try drip irrigation on 13 ha of rice Roma Var.

- SDI 35 cm depth, Uniram AS compensated drip
- 90 cm between lines, 60 cm between drippers, 2.3 liters/hour
SAVE WATER BY DRIP IRRIGATION
BELLONE FARM 2011-12
OBJECTIVES
DRIPPING VS FLOODING

HWS = 125% of ET0
MWS = 100% of ET0
LWS = 75% of ET0

FS = Flooding System
MATERIALS AND METHODS

VARIETIES

CARNAROLI

VIALONE NANO

SELENIO
MATERIALS AND METHODS

EXPERIMENTAL DESIGN
### SAVE WATER: RESULTS

<table>
<thead>
<tr>
<th></th>
<th>WC [m³/ha]</th>
<th>Grain [kg/ha]</th>
<th>WU [m³/kg]</th>
<th>$W_{\text{saving}}$ [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-Kc</td>
<td>4,180</td>
<td>2,514</td>
<td>1.7</td>
<td>-52.2</td>
</tr>
<tr>
<td>I-150</td>
<td>5,880</td>
<td>3,080</td>
<td>1.9</td>
<td>-45.1</td>
</tr>
<tr>
<td>Control (flooded)</td>
<td>16,680</td>
<td>4,795</td>
<td>3.5</td>
<td>-</td>
</tr>
</tbody>
</table>
GAS EMISSION FROM RICE PADDY: CH4

Rice agriculture accounts for some 17% of the anthropogenic CH4 emissions.

Methane oxidation:
\[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]

Methanogenesis:
- Hydrogenotrophic: \( \text{CO}_2 + 4\text{H}_2 \rightarrow 2\text{H}_2\text{O} + \text{CH}_4 \)
- Acetotrophic: \( \text{CH}_3\text{COOH} \rightarrow \text{CO}_2 + \text{CH}_4 \)

Source: Institute of Biogeochemistry and Pollutant Dynamics - Zurich
**EMISSION MONITORING: ITALY TRIALS**

Example of results of gas emission from rice by drip compared with conventional measured by fluxmeter

<table>
<thead>
<tr>
<th>SENSOR#1</th>
<th>SENSOR#2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SENSOR_TYPE:</strong></td>
<td><strong>SENSOR_TYPE:</strong></td>
</tr>
<tr>
<td>CH4</td>
<td>CO2</td>
</tr>
<tr>
<td><strong>FLUX (ppm/sec):</strong></td>
<td><strong>FLUX (ppm/sec):</strong></td>
</tr>
<tr>
<td>0.001</td>
<td>0.519</td>
</tr>
<tr>
<td><strong>FLUX (moles/m^2/day):</strong></td>
<td><strong>FLUX (moles/m^2/day):</strong></td>
</tr>
<tr>
<td>0.00045</td>
<td>0.18398</td>
</tr>
</tbody>
</table>

- 75%  
- 63%  

<table>
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</tr>
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</tr>
<tr>
<td>CH4</td>
<td>CO2</td>
</tr>
<tr>
<td><strong>FLUX (ppm/sec):</strong></td>
<td><strong>FLUX (ppm/sec):</strong></td>
</tr>
<tr>
<td>0.004</td>
<td>0.623</td>
</tr>
<tr>
<td><strong>FLUX (moles/m^2/day):</strong></td>
<td><strong>FLUX (moles/m^2/day):</strong></td>
</tr>
<tr>
<td>0.00124</td>
<td>0.22074</td>
</tr>
</tbody>
</table>

- Extract from text reports of a comparison between CH4 and CO2 Drip Laterals and Paddy in submersion (after emptying)
Low levels of As are naturally present in the soil (Matshullat, 2000)
The background levels worldwide are around 5 mg kg$^{-1}$ (Mandal & Suzuki, 2002)
ARSENIC UPTAKE

The increased bioavailability of As under flooded conditions is the main reason for an enhanced As accumulation by paddy rice (Xu et al., 2008)

(Abedin et al., 2002; Fitz & Wenzel, 2002; Takahashi et al., 2004)
Water saving and reduced arsenic uptake in aerobic rice (*Oryza sativa* L.): feasibility of drip irrigation under Mediterranean climate

G. Ragaglini, F. Triana, C. Tozzini, F. Taccini, A. Mantino, A. Puggioni, E. Vered, E. Bonari
OBJECTIVE

Evaluation of the potential of drip irrigation in reducing the risk of As accumulation and water consumption in rice, compared to the flooding system in field condition.
<table>
<thead>
<tr>
<th>Source</th>
<th>As Concentration (mg kg$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOODED</td>
<td></td>
</tr>
<tr>
<td>Brown Rice</td>
<td>0.059 (±0.012)</td>
</tr>
<tr>
<td>Grain</td>
<td>0.11 (±0.1)</td>
</tr>
<tr>
<td>Straw</td>
<td>1.53 (±0.47)</td>
</tr>
<tr>
<td>Roots</td>
<td>23.33 (±7.79)</td>
</tr>
<tr>
<td>Soil</td>
<td>3.73 (±0.75)</td>
</tr>
<tr>
<td>(Williams et al., 2007)</td>
<td></td>
</tr>
</tbody>
</table>
AZ. PRIORA 2013-14 - PIEDMONT
RICE BY DRIP ON SURFACE: WEEDS CONTROL AND DELTA T° PROBLEMS
AZ. MENSANELLO 2014 – TUSCANY
RICE BY DRIP IN MARGINAL SOIL
AND BAD WATER QUALITY
AEROBIC RICE AND DRIP IRRIGATION

- Using drip irrigation: no weeds control due to the submersion.

- Using drip irrigation: no buffer of temperature due to submersion.

- North Italy: the delta of temperature can achieve 15°C and this could be an issue for rice growth.

- We challenge those issues applying drip irrigation on surface 80cm between lines and 30cm between drippers with 1 liters/hour flow.
In collaboration of Turin University we investigate two different protocols of weeds control in drip irrigation.

One for conventional varieties, the second for Clearfiled varieties.

The biodegradable mulching can help the plants to reduce the effect of delta $T^\circ$ keeping warm the area under mulch.

Can also permit to reduce the number of treatments for weeds control.
WEEDS CONTROL AND MULCHING 2015

MULCH AND DRIPPERLINES IN 1 PASSAGE ON SEEDED SOIL
WEEDS CONTROL AND MULCHING 2015

PUNCHING THE MULCH BY HAND
WEEDS CONTROL AND MULCHING 2015

MULCH STRIPS WITH HOLES

RICE BY DRIP ON SURFACE
WEEDS CONTROL AND MULCHING 2015

FIELD DAY SEPTEMBER 2015
BEST RESULT WITH PROTOCOL IN CLEARFILED VAR.
DEMO FIELD EXPO 2015
USE SLOPE AND MARGINAL SOIL

**Rice** seeded and transplanted, irrigated by drip by gravitation and solar pump

**Corn** seeded in two times irrigated by drip by gravitation and solar pump

**Sorghum** seeded in two times irrigated by drip by gravitation and solar pump

**Soybean** irrigated by drip by gravitation and by solar pump
DEMO FIELD EXPO 2015
USE SLOPE AND MARGINAL SOIL
DEMO FIELD EXPO 2015
USE SLOPE AND MARGINAL SOIL
Ceccarelli Farm is using drip irrigation in SDI from 3 years.

- Trial target: compare rice monoculture and a 3 year rotation.
- 2 different drip irrigation systems, sub-surface vs surface drip irrigation.
- 2 different fertilization system, fertigation alone vs a combined mechanical system.
RICE SDI AND MULCHING FOR ORGANIC 2016

- **Rice Weeds 2.0** is a trial in SDI for weeds control and mulching on a typical soil for rice (medium-silty)
  - Is in Garrione Farm, an historical place, in the core of the rice area

- **PSR Lombardia** is a trial in SDI for weeds control and mulching on very sandy soil
  - Is in Baldi Farm, rice growers from 4 generations
TRIALS 2016: RICE WEEDS 2.0 & PSR LOMBARDIA

- Use a **prototype machinery** for lay down the lines, mulching and rice seed

- Twin installation of drip irrigation in SDI 25 cm deep

- Two different kind of soil

- Verify and confirm the protocol for Clearfield var. (Luna CL) weeds control

- Achieve high yield by drip irrigation in shallow SDI
Drip irrigation of rice is innovative technology, reliable and sustainable. It makes use of the resources more effectively and efficiently increasing the yield.

Drip irrigation is used to provide, not only water, but also fertilizers (fertigation).

The drip uses 45-50% less water and up to 30% less nutrients to achieve the same target yield.

Water saving between 10-20,000 m3/ha.
RICE BY DRIP - RESULTS

- The **aerobic** soil condition means many advantages and environmental benefits.

- In **drip irrigation** was observed significant reduction in emissions of greenhouse gases (CO2 and CH4) and groundwater pollution.

- The use of **marginal soils** would extend the UAA of at least 20%.

- Produce more rice with less resources by limiting the **environmental impact** of the cultivation.
The **drip irrigation**, through the diffusion, is a technique which promotes aerobic conditions of the soil.

**Arsenic accumulation** in rice grain is enhanced by flood irrigation even in soil with low As content.

Drip irrigation **can greatly decrease** the risk of As accumulation in rice grain.

**Weeds control** and **temperature delta** issues can be solved using the correct protocol, right varieties, and mulch.

**Mulching** is also an opportunity for organic rice cultivation and need specific machinery.
CONCLUSION

- More than **10 years** of experience
- We can bring out of the chambers of paddy rice cultivation using the **drip irrigation**
- Drip irrigation is a candidate to be the **irrigation of the future** (SDI in crop rotation)

- **Organic cultivation** and conservation agriculture are the partner elected for the drip irrigation
- Research continue to **demonstrate** that is the right way
THANK YOU

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Italian experience 2010-16

Modern Technologies of Rice Growing
Global Food and Environmental Safety
August 9-12/08/2016

Alberto Vezio Puggioni
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