Rooftop agriculture for food production, social inclusion and ecosystem service provision: a case study from Bologna

Francesco Orsini
Research Centre on the Urban Environment for Agriculture and Biodiversity (RESCUE-AB)
Bologna University, Bologna (Italy)
Urban Agriculture and Food Security

More than half of world population lives in cities (Dubbelling et al., 2010)

More than half of world poor live in cities (Shackleton et al., 2009)

Urban agriculture may enhance food access in cities as well as a range of ecosystem services (Orsini et al., 2013)

Farmers market, Yenanchaung, Myanmar

Therapeutical garden, Venice, Italy
Soilless urban vegetable gardens

In cities, difficult access to available fertile non-contaminated soil (Orsini et al., 2013)

Hydroponics may enable to turn urban concrete into green infrastructures for vegetable cultivation (Orsini et al., 2014)

Soilless system in Abidjan (Ivory Coast) and Simplified Hydroponics in Bologna (Italy)
Vertical vs Rooftop Agriculture

**Vertical farms**
- First green skyscrapers ready after 2020 (Despommier, 2009)
- Cost = 10 to 12.5 Euros kg$^{-1}$ (Schubert, 2012)

**Rooftop gardens**
- Possibility to adapt already existing buildings to vegetable cultivation (Grewal and Grewal, 2011)
- Possibility to use Simplified Hydroponics (Orsini et al, 2014)
- Improve the resource efficiency of the building (heat, cooling, water, etc.) (Specht et al, 2013)

Gotham Green rooftop greenhouse, NYC
Multifunctionality

Rooftop Agriculture

BIODIVERSITY RESERVOIRS, GREEN CORRIDORS, RECYCLING

ENERGETIC EFFICIENCY, FOOD SECURITY AND SAFETY
Biodiversity
Up to 0.67 km km\(^{-2}\) (Orsini et al., 2014)

Cooling
2 to 11 °C (Eumorfopoulou et al., 2009)

Noise absorption
2 to 13 dB (Connelly et al., 2008)

Air depuration
375 g CO\(_2\) m\(^{-2}\)year\(^{-1}\) (Getter et al., 2009)
3.8 g PM\(_{2.5-10}\) m\(^{-2}\) year\(^{-1}\) (Nowak et al., 2006)
7.3 g No\(_x\)/SO\(_x\) m\(^{-2}\) year\(^{-1}\) (Yang et al., 2008)

Thermal insulation
3.4 USD m\(^{-2}\) year\(^{-1}\) (Banting et al., 2005)
Rooftop agriculture for food security

Exploring the production capacity of rooftop gardens (RTGs) in urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna

Francesco Orsini · Daniela Gasperi · Livia Marchetti · Chiara Pisvane · Stefano Draghetti · Solange Ramazzotti · Giovanni Bazzocchi · Giorgio Gianquinto
Urban agriculture for food security

3500 available rooftops
82 ha

34 t d⁻¹
12’495 t y⁻¹

77% of city needs
Water use efficiency in RTGs

10.4 l m⁻² d⁻¹

Lettuce: 2.5 – 25 g l⁻¹
Eggplant: 20 g l⁻¹
Watermelon: 14 g l⁻¹
Melon: 13 g l⁻¹
Tomato: 11 g l⁻¹
Chilli pepper: 6 g l⁻¹

Techniques and crops for efficient rooftop gardens in Bologna, Italy

Esther Sanyé-Mengual¹ • Francesco Orsini² • Jordi Oliver-Sola¹,³ • Joan Rieradevall¹,⁴ • Juan Ignacio Montero¹,⁵ • Giorgio Gianquinto²

Agronomy for Sustainable Development
**Extensive edible GR**

<table>
<thead>
<tr>
<th>ET (%)</th>
<th>Total biomass (g)</th>
<th>Total yield (g/m²)</th>
<th>Edible biomass (g)</th>
<th>Edible yield (g/m²)</th>
<th>WUE_{50} (g l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C. quinoa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>100</td>
<td>172 ±24 b</td>
<td>5166 ±510 ab</td>
<td>36 ±5 bc</td>
<td>1086 ±196 bc</td>
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<td>50</td>
<td>297 ±41 a</td>
<td>8921 ±1621 a</td>
<td>90 ±10 a</td>
<td>2702 ±361 a</td>
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<tr>
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<td>0 ±0</td>
<td>0 ±0</td>
<td>0.0 ±0</td>
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</tr>
<tr>
<td><strong>P. grandiflora</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>159 ±10 bc</td>
<td>4779 ±1097 bc</td>
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<td>1522 ±191 ac</td>
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<tr>
<td>50</td>
<td>161 ±10 bc</td>
<td>4821 ±900 bc</td>
<td>58 ±6 ab</td>
<td>1752 ±569 ab</td>
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</tr>
<tr>
<td>0</td>
<td>92 ±6 bd</td>
<td>2443 ±165 bd</td>
<td>43 ±4 bc</td>
<td>1141 ±19 bc</td>
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<tr>
<td><strong>M. crystallinum</strong></td>
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<tr>
<td>100</td>
<td>7 ±1 d</td>
<td>66 ±15 d</td>
<td>6 ±1 c</td>
<td>55 ±13 c</td>
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<tr>
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<td>6 ±1 d</td>
<td>38 ±0 d</td>
<td>5 ±0 c</td>
<td>30 ±0 c</td>
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<td>0 ±0</td>
<td>0 ±0</td>
<td>0 ±0</td>
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</tr>
<tr>
<td><strong>S. album</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>61 ±4 cd</td>
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<tr>
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<tr>
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<td>33 ±3 d</td>
<td>987 ±173 cd</td>
<td>0 ±0</td>
<td>0 ±0</td>
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</tr>
</tbody>
</table>

Biomass and yield of *C. quinoa*, *S. album*, *P. grandiflora* and *M. crystallinum* at three different irrigation levels (100%, 50% and 0% ET)
Rooftop agriculture for sustainable living

CO₂ production

Kg CO₂ eq / kg tomato

- Rural greenhouse
- Rooftop greenhouse
- Rooftop garden
Rooftop agriculture and Green Corridors

Golena del Lippo, Natura2000

Giardini Margherita, urban park

Parco San Luca, Natura2000

94 km
0.67 km km⁻²

Implementation of green corridors by connecting RTGs within 500 m distance (sufficient for most Apoidea pollinators and beneficial predators) (Gathmann et al. 2002; Osborne et al. 2008; Zurbuchen et al. 2010; Ludgren 2009)
Urban agriculture for social inclusion

... Living the «commons»
Francesco Orsini
Research Centre on the Urban Environment for Agriculture and Biodiversity (RESCUE-AB)
Agricultural Sciences Dept
Bologna University

f.orsini@unibo.it

http://www.unibo.it
http://www.dipsa.unibo.it/
http://www.hortis-europe.net/