

Final project report

Project ID: 2003/11.1
Title: Sustainable food-plant systems for isolated and extreme environments

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Duration: 2 years
Assigned funding: €50.000,00

Activities and results

Since 1998, ENEA (Italian National Agency for New Technology, Energy and the Environment) has been carrying on researches to develop a plant based greenhouse facility for producing plant fresh food at the Italian bases of TNB (Terra Nova Bay) and Dome C (Concordia base) in Antarctica. Accordingly, at the base TNB "Mario Zucchelli" was installed a sustainable closed greenhouse facility PULSA (Plant-based Unit for Life Support in Antarctica). PULSA has been in operation during four campaigns in Antarctica. A brief overview of the main prototypes and software developed with the cooperation of the Universities of Pisa and Palermo in the frame of the research activities in Antarctica and Italy is in the following reported.

- 1) A complete automatic hydroponics system for plant cultivation in artificial environmental (C.H.G.S., Closed Hydroponic Greenhouse System);
2. A closed module PULSA Unit. A prototype greenhouse module has been conceived and designed as a transportable unit made of a standard container, dimensions of 6055 (l)*2435(w)*2585(h) mm. The installed microclimate conditioning unit included an air heater of about 6.0 kW which can also act as inside air cooling as well as dehumidifier for removing the internal humidity (up to 2.5 kg/h of water) by forcing the air into a drying service. An air ventilation device composed of two fans each of 400 W and air capacity exchanging of 1200 m³/h was also installed to keep necessary air exchange and CO₂ concentration.
- 3) A treating and recycling wastes unit for the purification of water and for the recycling of residual biomass wastes from the hydroponic cycles,
- 4) A complete automated and remote-controlling system for the germination and the production of the plantlets (Box-Nursery);
- 5) A simulator for the growth and the yield production of lettuce (SLS) in function of the temperature and the light applied to the crops.

Other prototypes still under developing are: a) the multilevel hydroponics design; b) the solar photovoltaic system of 1.1 kWp, to optimize the yield and the autonomy of the enclosed growing volume using artificial and/or Light Emitting Diodes (LEDs) as light sources for plant crop growth. Considerations and comments are reported on the on-going challenge to use PULSA as scientific platform for implementing activities of research and demonstration on plant growth technologies for Space.

Products

A – papers in scientific magazines

1. Bibbiani C., L. Incrocci, C. Campiotti, R. Balducchi (2004). Realizzazione di un prototipo automatizzato di camera di crescita (box nursery) per la produzione di plantule nella base italiana di "Baia Terra Nova" in Antartide. Riv. di Ing. Agr. 3, 49-55.
2. Campiotti, C., Balducchi, R., Dondi, F., Incrocci, L., Mattiello, S., Pardossi, A., Tognoni, F., (2006). Missione possibile: produrre in Antartide. L'Informatore Agrario, 62 (18).
3. Incrocci L., G. Fila, G. Bellocchi, A. Pardossi, C.A. Campiotti, R. Balducchi. (2006). Soil-less indoor-grown lettuce (*Lactuca sativa* L.): Approaching the modelling task. Environmental Modelling & Software, 17:121-126.

B – book chapters

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Programma Nazionale di Ricerche in Antartide (PNRA)

C - proceedings of international conferences

1. Campiotti C., Roberto Balducchi, Francesca Dondi, Giuseppe Alonzo, Viviana Catanese, Luca Incrocci, Carlo Bibbiani. (2007). The PULSA (Plant-based Unit for Life Support in Antarctica): a sustainable plant food production technology for remote and isolated environments. Acta Hort. 801, 2008.
2. Campiotti C. et al. Photovoltaic as sustainable energy for closed greenhouse system in southern Italy. 2007. Acta Hort. 797, 2008.
3. Incrocci L., Pardossi A., Malorgio F., Maggini R and C, Campiotti (2003). Cascade cropping system for greenhouse soilless culture. Acta Horticulturae 609, May 2003.
4. Integrating closed plant food systems for isolated and extreme environments. 2008. Poster. Abstract Volume XXX SCAR San Pietroburgo 2008.
5. Campiotti C., Rita Di Bonito, Roberto Balducchi, Francesca Dondi, Giuseppe Alonzo, Viviana Catanese, Luca Incrocci, Fabio Piccolo, Valentina Bornisacci. (2006). Integration of Antarctica hydroponics as sustainable option for food plant in Space. International Workshop, Moon Base: "The Precursor Age" . Mosca-Star City 16-17 novembre 2006.

D – proceedings of national meetings and conferences

1. Campiotti C. The developing of a plant-based unit as sustainable plant food support in Antarctica. Meeting Nazionale sulle Tecnologie del PNRA 14-16 maggio 2003.
2. Campiotti C., Roberto Balducchi Giuseppe Alonzo, Francesca Dondi, Luca Incrocci, Stefano Mattiello, Alberto Pardossi, Franco Tognoni. (2005). La coltura fuori suolo per la produzione di piante alimentari in ambienti anomali (Antartide e Spazio). Workshop 21 ottobre 2005, Pisa. CDrom Regione Siciliana.

E – thematic maps

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F – patents, prototypes and data bases

1. A greenhouse closed module for plant food support in extreme environment (PULSA).
2. a prototype of a multilevel hydroponics with a lighting system by LEDs.
3. a prototype treating and recycling wastes unit for the purification of water and for the recycling of residual biomass wastes from the hydroponic cycles.
4. a prototype portable box-nursery system;
5. a prototype of a closed greenhouse photovoltaic system of 1.1 kWp, to optimize the yield and the autonomy of the enclosed growing volume of PULSA.
6. a prototype of simulator for the growth and the yield production of lettuce (SLS) in function of the temperature and the light applied to the crops.

G – exhibits, organization of conferences, editing and similar

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H - formation (PhD thesis, research fellowships, etc.)

1. One thesis in progress.

Research units

1. ENEA Casaccia, BAS BIOTEC SIS

Carlo Alberto Campiotti (tecnologo ENEA), Rita Di Bonito (ricercatrice ENEA), Francesca Dondi (contrattista ENEA).

2. Università di Palermo, Dipartimento ITAF, Cattedra di Chimica Inorganica

Prof. Giuseppe Alonzo, Dr. Piero Aiello, Filippo Saiano.

3. Università di Reggio Calabria

Prof. Sergio Camporeale, Claudio Garesci, Marco Mastrovito

4. Università di Pisa, Dipartimento Biologia Piante Agrarie

Prof. Franco Tognoni, dr. Luca Incrocci, Prof. Alberto Paradossi.

Date: 20/04/2009

Notes

Technical reports

1. Campiotti et al. (2003). Progettazione e realizzazione di un prototipo di riciclo e depurazione per il ricondizionamento delle soluzioni idroponiche. Contratto interno ENEA, Ant. N.1329.
2. Alonzo G.. (2004). La determinazione delle emissioni di composti organici volatili (VOC's) da produzioni in serra a ciclo chiuso. Rapporto tecnico. Università di Palermo.
3. Campiotti C. et al. (2005). Sistema "Substrato" per coltivazioni idroponiche a ciclo chiuso. RT/2008/9/BAS. ENEA. ISSN/0393-3016.
4. Pardossi A., C. Campiotti, Giuseppe Alonzo, Roberto Balducchi, Luca Incrocci. (2007). Principi generali della coltivazione idroponica in NFT. RT/2008/9/BAS ENEA. ISSN/0393-3016.
5. Campiotti C et al. Energia rinnovabile per i sistemi serra. 2007. RT/2007/32/BAS ENEA. ISSN/0393-3016.
6. Carlino M., Giuseppe Alonzo, Carlo Alberto Campiotti, Francesca Dondi. (2007). Accrescimento delle piante con luce LED. Rapporto tecnico ENEA. in Press.
7. Campiotti C. 2008. Componenti di un impianto di fertirrigazione. RT/2008/9 BAS ENEA. ISSN/0393-3016.