Caffè Scientifico – Dipartimento di Agraria
Aula Cinese, 16 gennaio 2019

Le colture fuori suolo: dai giardini di Babilonia alle plant factory

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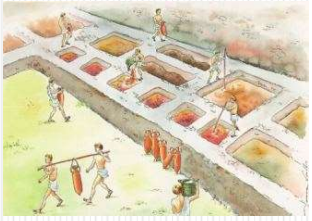
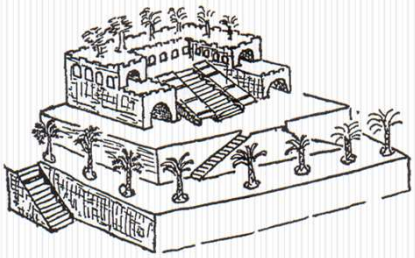
- La storia
- Il glossario
- Suolo vs. fuori suolo

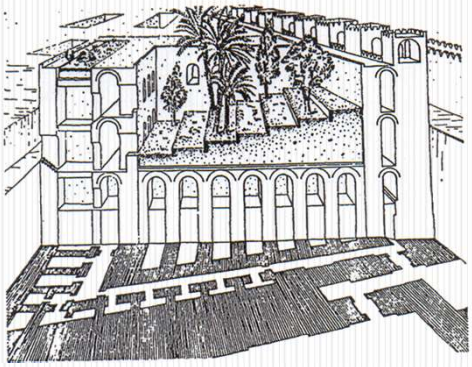
- La ricerca per le colture fuori suolo
- Usi, nuovi usi e ri-usi
- Le colture fuori suolo per la ricerca

- Considerazioni conclusive



La storia





Ricostruzione dei giardini pensili di Babilonia (VI sec. a.C.)

La storia

Zattere galleggianti degli Aztechi (Chinampa, XIV – XVI sec.)

- Età antica:
  - Giardini pensili di Babilonia
  - Zattere galleggianti degli Aztechi
- 1666 - Boyle: coltura delle piante in acqua
- 1699 - Woodward: importanza del fattore terrigeno
- 1803-73 - Justus von Liebig
- 1860 - Sachs e Knop: importanza degli elementi minerali sulla crescita
- 1923 - Gericke: prime applicazioni commerciali (Deep Water Culture)
- 1938 - Hoagland e Arnon: «The Water-Culture Method for Growing Plants without Soil» sulla preparazione della soluzione nutritiva
- 1937 - Shive e Robbins: coltivazioni su substrato (Sand e Gravel Culture)
- 1941-1945 - Guerra del Pacifico: esercito americano utilizza l'idroponica per la produzione di ortaggi freschi in Giappone

…

- Anni '60 - diffusione della plastica in agricoltura
- Anni '70
  - 1965 - Allen Cooper: sistema NFT (Nutrient Film Technique)
  - Impianti in California, Arizona, Abu Dhabi
  - Impianti in Europa Settentrionale

- Anni '80
  - 1976 – Franco Massantini: attività di ricerca presso l'Università di Pisa

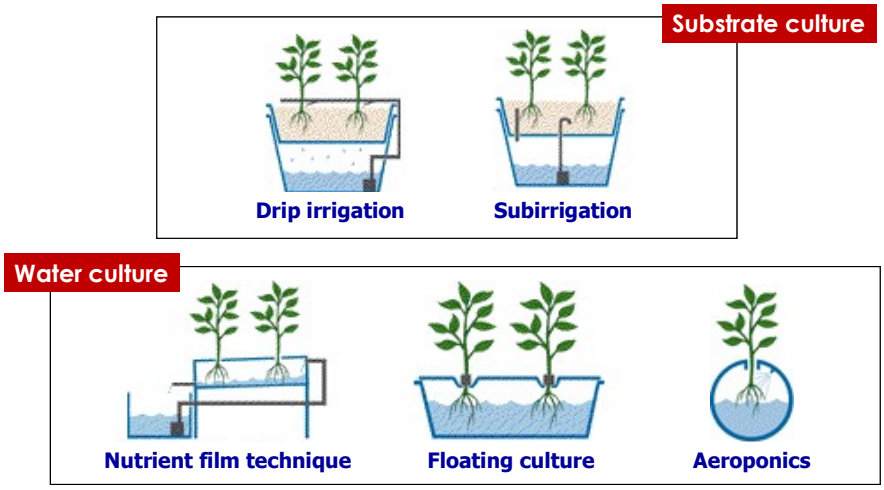
- Anni '90
  - Diffusione nel Bacino del Mediterraneo
  - Primi impianti in Italia (~ 50 ha in Sardegna)
- Oggi
  - 5-10% della superficie a colture protette (~ 40,000 ha)
    - Italia ~ 2500 ha (3% della superficie a serre)

Glossario

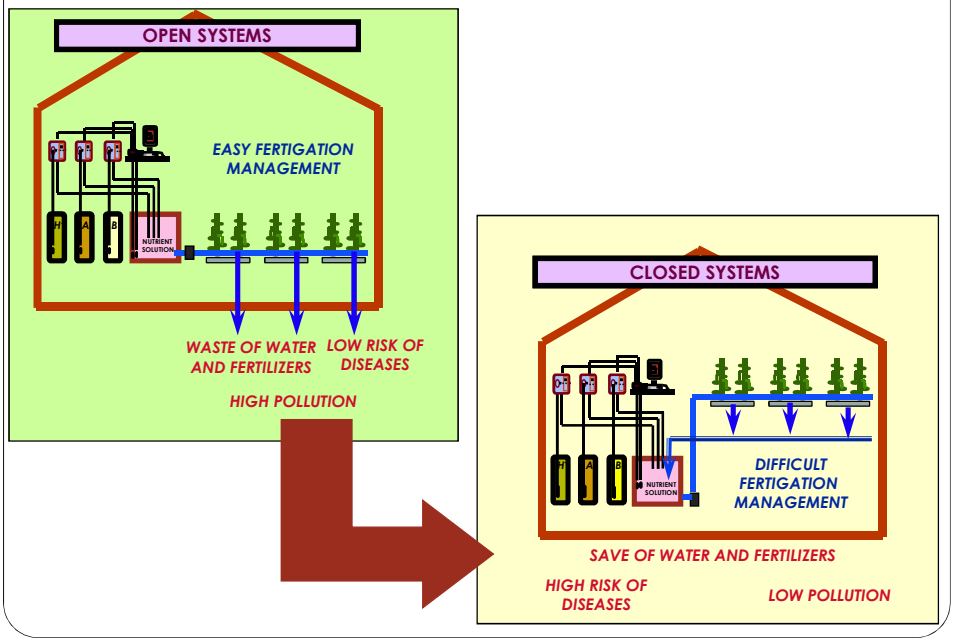
- DEFINIZIONE
  - Coltivazioni condotte in assenza di terreno in cui le piante, opportunamente sorrette in contenitori vuoti o in substrati solidi, sono alimentate con soluzioni nutritive complete in macro- e micro-elementi

- CLASSIFICAZIONE
  - Substrato (SI/NO)
    - Organico vs. Inorganico
    - Drip- vs. sub-irrigation
  - Gestione della soluzione nutritive (open- vs. closed-systems)
  - …

Substrato SI/NO



Gestione della soluzione nutritiva



Suolo vs. fuori suolo

- Potenzialmente «ubiquitaria»
- Difesa fitosanitaria
- Gestione della nutrizione idrica e minerale
- Controllo della crescita
- Impiego di manodopera
- Quantità e qualità della produzione
- Sostenibilità (ciclo chiuso)

- Costi di investimento
- Know-how
- Strutture
- Qualità dell'acqua di irrigazione
- Sostenibilità (ciclo aperto)

La ricerca per le colture fuori suolo

Ottimizzazione del sistema produttivo
Sostenibilità del processo produttivo
Qualità dei prodotti

Water culture - Floating System

Pannelli di polistirolo alveolato
Soluzione nutritiva in vasche
(altezza 20-30 cm, volume 100-300 L m^{-2})
Pompe sommerse per areazione
(concentrazione di O_2 min: 5-6 mg L^{-1})

Pro
- costi bassi
- ciclo chiuso
- semplicità di gestione

Contro
- controllo dell'ossigenazione

Ortaggi da foglia e aromatiche

Journal of Horticultural Science & Biotechnology (2008) **83** (6) 743–748

Sulphur fertilisation affects yield and quality in *friarielli* (*Brassica rapa* L. *subsp. sylvestris* L. Janch. var. *esculenta* Hort.) grown in a floating system

By S. DE PASCALE, A. MAGGIO*, F. ORSINI, A. BOTTINO and G. BARBIERI
Department of Agricultural Engineering and Agronomy, University of Naples Federico II, Via Università 100, 80055 Portici (Naples), Italy

«Friarielli napoletani»

Basilico

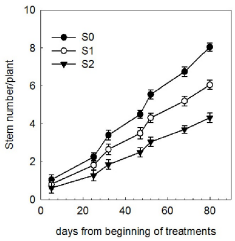
Coltivazione su substrato

«Bulbose»

Closed-Loop Soilless Cultivation System of *Curcuma alismatifolia* under Moderate Saline Stress

G. Raimondi[1], E. Di Stasio[2], C. Cirillo[2,a] and S. De Pascale[2]
[1] Experimental Station Torre Lama, University of Napoli Federico II, Italy
[2] Division of Plant Biology and Crop Science, Department of Agricultural and Food Science, University of Napoli Federico II, Italy

ISHS



S0 0%; S1 0.125% and S2 0.25% NaCl

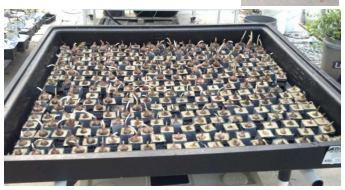
Soilless Cultivation of Saffron in Mediterranean Environment

A. Maggio, G. Raimondi, A. Martino and S. De Pascale
Department of Agricultural Engineering and Agronomy
University of Naples Federico II
Via Università 100, 80055 Portici (Naples)
Italy

ISHS

Table 1. Flowers, replacement corms characteristics and spice yield of saffron in the first experiment (Mean values; ns = not significant; * = significant at P≤0.05; ** = significant at P≤0.01).

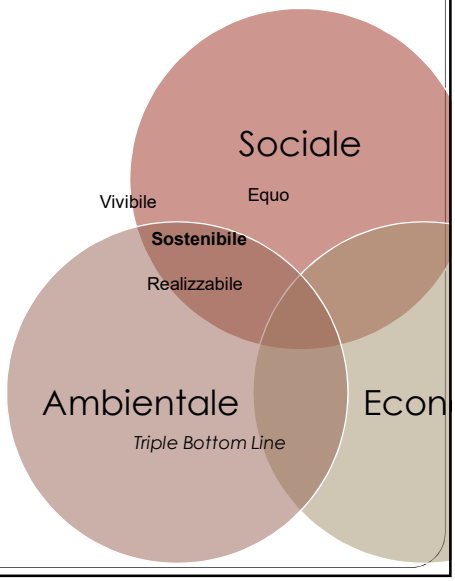
Substrate	Flowers (N. corm^{-1})	Stigma dry weight (mg flower^{-1})	Saffron spice yield (kg ha^{-1})	New corms (N. m^{-2})	Corm weight (g)	Corm diameter (mm)
Perlite	5.2	9.0	23.4	230	11.1	29
Peat+Perlite	3.8	11.0	20.9	150	14.3	33
	*	**	*	**	*	*



Sostenibilità: definizione

- Sostenibile è uno «sviluppo che soddisfa i bisogni delle generazioni presenti, senza compromettere la possibilità che le future generazioni possano soddisfare i propri»

Rapporto Bruntland (Our common future, 1987) – Commissione delle Nazioni Unite – *WCED, World Commission on Environment and Development*



Substrati per il fuori suolo

Minerali
- Sabbia
- Pomice
- Lapillo
- Perlite
- Argilla espansa
- Lana di roccia
- Vermiculite
- Zeoliti

Sintetici
- Polistirolo espanso
- Schiuma di poliuretano

Organici
- Terricci
- Torbe
- Fibra di cocco
- Corteccia
- …

Effects of Coco Fibre Addition to Perlite on Growth and Yield of Cut Gerbera

R. Paradiso and S. De Pascale
Department of Agricultural Engineering and Agronomy
University of Naples Federico II
Portici, Naples
Italy

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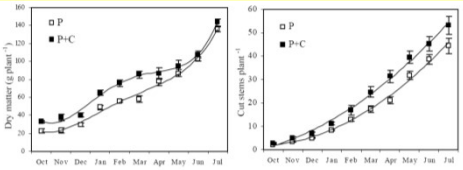


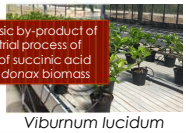
Fig. 4. Effect of growing media on total dry matter and cumulative cut stem production per plant of Gerbera 'Leader' over time (mean ± standard error).

GREEN CITIES 2017
12-15 Settembre 2017
Bologna, Italia
GREENER CITIES
FOR MORE EFFICIENT ECOSYSTEM SERVICES IN A CLIMATE CHANGING WORLD

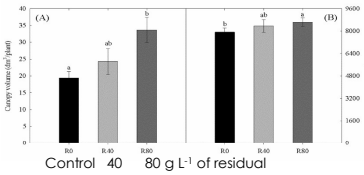
Valorisation of biorefinery by-products in potted ornamental shrub cultivation: effects on growth, water relations and leaf gas exchanges

C. Cirillo*, Y. Rouphael, C. El-Nakhel, A. Pannico, M. Sorrentino, V. Cirillo, R. Caputo and S. De Pascale.
Department of Agricultural Sciences University of Napoli Federico II. Italy.

Lignocellulosic by-product of the industrial process of extraction of succinic acid by *Arundo donax* biomass

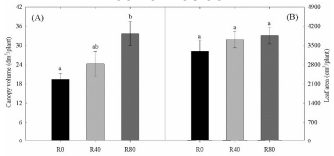


Viburnum lucidum

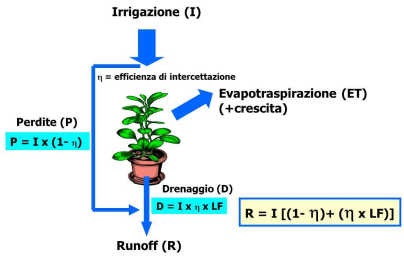


Control 40 80 g L^{-1} of residual

Bougainvillea spectabilis



Acqua e Nutrienti



Fiori recisi, 12 mesi

	Apporti acqua (m^3 ha^{-1})	Consumi acqua (m^3 ha^{-1})	Perdite acqua (m^3 ha^{-1})	Perdite (kg N ha^{-1})
Rosa (ciclo aperto)	19500	10850	8500	1950
Rosa (ciclo chiuso discontinuo)	10790	10160	730	105
Rosa (ciclo chiuso)	10800	10400	-95% 400	-94%125
Crisantemo (ciclo aperto)	9150	7000	2150	350
Crisantemo (ciclo chiuso)	7750	7000	-65%750	-64%125
Cymbidium (ciclo aperto)	34440	21200	13240	250

De Pascale e Barbieri, 2000

HortScience 51(6):684–689. 2016.

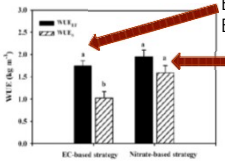
Fertigation Strategies for Improving Water Use Efficiency and Limiting Nutrient Loss in Soilless *Hippeastrum* Production

Youssef Rouphael, Giampaolo Raimondi, Rosanna Caputo, and Stefania De Pascale[1]
Department of Agricultural Sciences, University of Naples Federico II, 80055 Portici, Italy

Table 4. Effect of the nutrient management strategy on the cumulative evapotranspired water (W_{ET}), water loss (W_L), total water use (W_{use}), number of nutrient solution discharges (flushing events), leaching fraction ($LF = W_L/W_{use}$), and loss of nutrient ions (NO_3^-, K^+, and PO_4^{3-}) of *Hippeastrum* grown in semiclosed soilless culture.

Nutrient management strategy	W_{ET} ($m^3 \cdot ha^{-1}$)	W_L ($m^3 \cdot ha^{-1}$)	W_{use} ($m^3 \cdot ha^{-1}$)	Flushing events	LF	NO_3^- ($kg \cdot ha^{-1}$)	PO_4^{3-} ($kg \cdot ha^{-1}$)	K^+ ($kg \cdot ha^{-1}$)
Electrical conductivity-based method	1,647.9	1,159.9	2,807.7	10	0.41	739.0	410.2	163.6
Nitrate-based method	1,417.1	321.2	1,738.3	5	0.18	31.7	91.6	46.8
Significance	NS	***	**	***	***	***	***	**

NS, **, ***Nonsignificant or significant at $P \leq 0.01$ and 0.001, respectively.



EC-based strategy:
EC value = 3.0 dS · m^{-1}

Nitrate-based strategy:
[N-NO$_3^-$] < 1.0 mol·m^{-3}

Fig. 2. Effect of the nutrient management strategy on evapotranspiration water use efficiency (WUE_{ET} = total crop dry weight/cumulative evapotranspired water) and the effective water use efficiency of the system (WUE_S = total crop dry weight/total water use) of *Hippeastrum* grown in semiclosed soilless culture. The values are means of four replicates. Vertical bars indicate ±SE of means. Different letters indicate significant differences according to Duncan's test ($P \leq 0.05$).

Controllo ambientale

Scientia Horticulturae 139 (2012) 102–107
Contents lists available at SciVerse ScienceDirect
Scientia Horticulturae
journal homepage: www.elsevier.com/locate/scihorti

Moderate variations of day/night temperatures affect flower induction and inflorescence development in *Phalaenopsis*

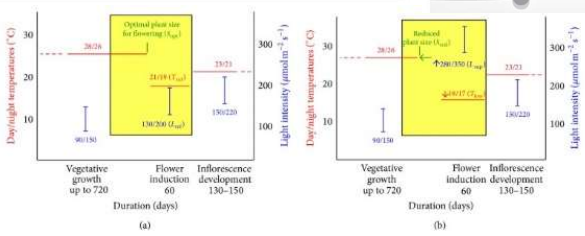
Roberta Paradiso*, Albino Maggio, Stefania De Pascale

Time for flowering of *Phalaenopsis* 'Premium' (days from the beginning of thermal treatment) subjected to different day/night thermal regimes for flower induction: RT (21/19 °C), HT (23/21 °C), and LT (19/17 °C).

	First flower bud appearance	First flower anthesis	Complete anthesis
RT	127.1	160.6	196.5
HT	112.4	138.2	166.5
LT	136.0	168.5	201.5
LSD ($P \leq 0.05$)	10.0	10.3	9.3

Fig. 2. Developmental stages of *Phalaenopsis* 'Premium': emergence of the stem (A), appearance of the first visible flower bud (B), first flower anthesis (C) and detail of flower stem with lateral bracteles (D).

Paradiso R. and De Pascale S.
Effects of plant size, temperature, and light intensity on flowering of Phalaenopsis hybrids in mediterranean greenhouses
Scientific World Journal, 2014, art. no. 420807



Biostimolanti

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Research Paper

Foliar applications of a legume-derived protein hydrolysate elicit dose-dependent increases of growth, leaf mineral composition, yield and fruit quality in two greenhouse tomato cultivars

Youssef Rouphael[a,*], Giuseppe Colla[b], Maria Giordano[a], Christophe El-Nakhel[a]
Marios C. Kyriacou[c], Stefania De Pascale[a]

[a] Department of Agricultural Science, University of Naples Federico II, 80055 Portici, Italy
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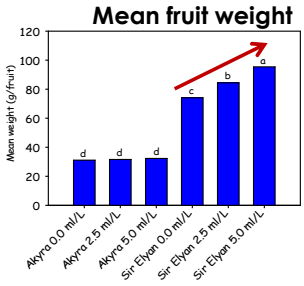
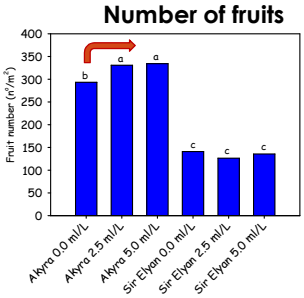
[c] Department of Vegetable Crops, Agricultural Research Institute, 1516 Nicosia, Cyprus

SIR ELYAN





Vegetable crops as functional food

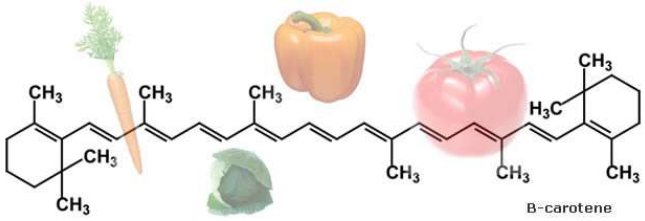
frontiers in Plant Science

OPINION
published: 12 September 2017
doi: 10.3389/fpls.2017.01567

Microgreens as a Component of Space Life Support Systems: A Cornucopia of Functional Food

Marios C. Kyriacou[1], Stefania De Pascale[2], Angelos Kyratzis[1] and Youssef Rouphael[2*]

[1] Department of Vegetable Crops, Agricultural Research Institute, Nicosia, Cyprus, [2] Department of Agricultural Sciences, University of Naples Federico II, Portici, Italy



Food Chemistry 277 (2019) 107–118

Contents lists available at ScienceDirect

Food Chemistry

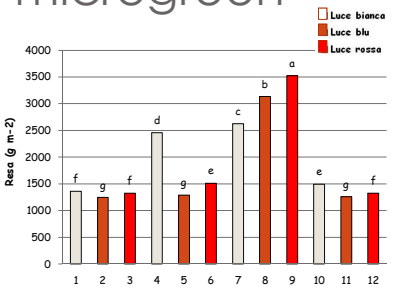
journal homepage: www.elsevier.com/locate/foodchem

Functional quality in novel food sources: Genotypic variation in the nutritive and phytochemical composition of thirteen microgreens species

Marios C. Kyriacou[a], Christophe El-Nakhel[b], Giulia Graziani[c], Antonio Pannico[b], Georgios A. Soteriou[a], Maria Giordano[b], Alberto Ritieni[c], Stefania De Pascale[b], Youssef Rouphael[b,*]

- I micro-ortaggi (o microgreen) sono giovani e tenere piantine di specie orticole, erbacee o aromatiche raccolte generalmente da una a tre settimane dopo la semina
- Sono apprezzati per il loro colore e la capacità di esaltare il sapore delle pietanze, ma soprattutto per il loro valore nutraceutico (functional foods)

Effetto della luce su resa e qualità di microgreen



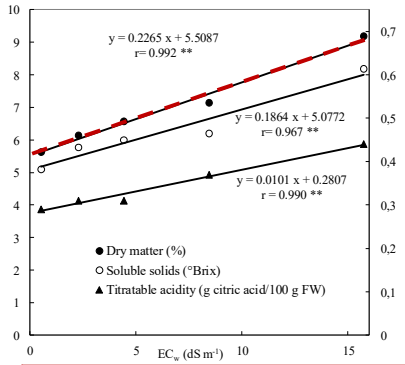
	Clorofilla totale (mg g^{-1} pf)	Vitamina C (mg 100 g^{-1} pf)	Antociani (mg 100 g^{-1} pf)
Specie			
Amaranto	15,8 a	93,3 a	14,6 a
Mizuna	8,1 b	39,3 b	4,2 b
Colore della luce			
Bianca	12,0 b	76,2 a	7,2 c
Blu	12,6 a	66,5 ab	12,0 a
Rossa	11,3 c	52,2 b	9,0 b

Rosso
Blue
Bianco

Journal of Horticultural Science & Biotechnology (2007) **82** (2) 283–289

Comparative analysis of water and salt stress-induced modifications of quality parameters in cherry tomatoes

By S. DE PASCALE*, A. MARTINO, G. RAIMONDI and A. MAGGIO



Relation between dry matter (%), soluble solids concentration (°Brix) and titratable acidity (% citric acid) of the tomato fruits and electrical conductivity of the irrigation water.

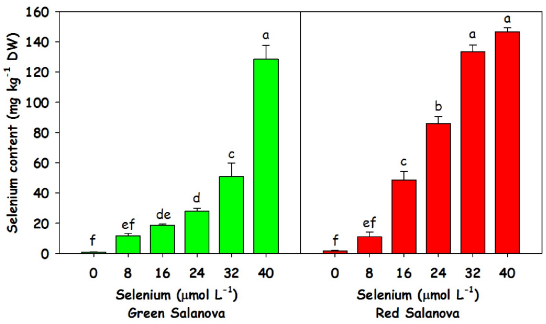
TABLE I

Growth, yield and fruit quality of tomato in response to water or salt stress

Treatment*	Leaf area (dm^2 plant^{-1})	Dry mass (g plant^{-1})	Fruit fresh yield (kg plant^{-1})	Fruits (number plant^{-1})	Mean fruit fresh weight (g)	TSS (°Brix)	Titratable acidity (g citric acid 100 g^{-1} FM)
NSC	42.2 a†	82.1 a	2.03 a	140 a	14.5 b	4.87 b	0.49 b
SST	34.5 b	74.5 a	1.48 b	105 b	14.1 b	5.92 a	0.59 a
WST	25.4 c	54.7 b	1.16 b	76 c	15.3 a	5.97 a	0.52 b

*NSC, non-stressed control; WST, water stress treatment; SST, salt stress treatment.
†Mean values in each column followed by different lower-case letters are significantly different at $P \leq 0.05$.

Se-enriched leafy vegetables



Nitrati negli ortaggi da foglia

Nitrate (NO_3)

↓

Nitrite (NO_2)

↓

N-nitroso compounds

Effects on human health
Methaemoglobinaemia
Fertility problems (?)
Cancer (?)
Hypertrophy of the thyroid (?)
Hypertension (?)
Diabetes (?)

Nitrate and nitrite contents (on a fresh weight basis) of two ecotypes of friarielli *in response to S availability*

Nutrient Code	Nitrate (mg NO_3^- kg^{-1} FW)	Nitrite (mg NO_2^- kg^{-1}FW)
$N_{26}S_2$	3,128 a†	3.6 a
$N_{26}S_4$	2,625 b	2.8 a
$N_{26}S_8$	2,367 b	2.4 a
Ecotype		
LC	3,034‡	2.4
Sn	2,380	3.5
Significance	*	n.s.

†Mean values (n = 40) in each column followed by a different lower-case letter indicate significant difference by the LSD test at $P \leq 0.05$.
‡Mean values (n = 120).
LC = 'Lingua di Cane'; Sn = 'Sessantino'; ns, not significant; *significant at $P \leq 0.05$.

De Pascale *et al.*, 2008

Plant factories

Pharmaceutical sector

Soilless cultivation

Cultivation in BLSS for Extra-terrestrial environments

Hydroponic systems for urban areas

PRIN 2017

GRIN-REVOLUTION

I giardini pensili di Babilonia?

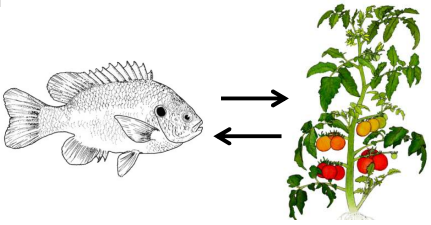
Ameliorating a complex urban ecosystem through instrumental use of softscape buffers: proposal for a green infrastructure network in the metropolitan area of Naples

Coppola E., Rouphael Y., De Pascale S., Moccia F.D., Cirillo C.

frontiers in Plant Science

Research topic: Innovative Growing Solutions for Plant Cultivation in the Urban Environment

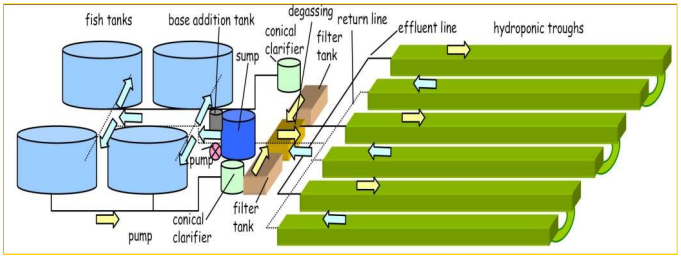
Integrated systems: hydroponic with aquaculture



FOOD systems in European Cities (FoodE)

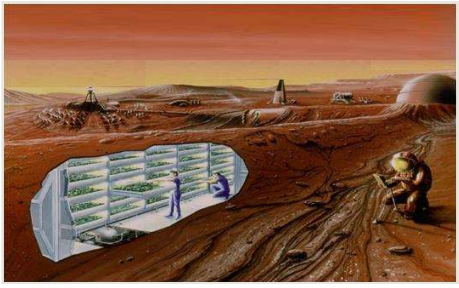
FOOD·E

H2020



Hydroponic systems for Space Farming






"Salad machine"

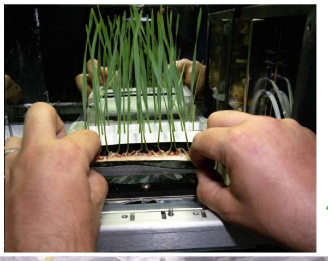

NASA's rack-sized "Salad Machine" system


Cosmonaut Gennady Padalka - Lada Chamber

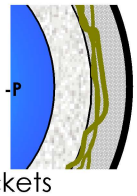

Prototype of NASA's Advanced Plant Habitat

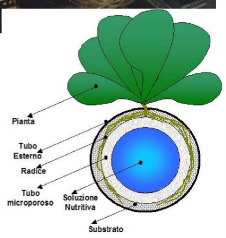

BPSe or VEGGIE Chamber by Orbitec

Le sfide: irrigare in μ-gravità



Use of porous tubes or membranes for watering plants in Space





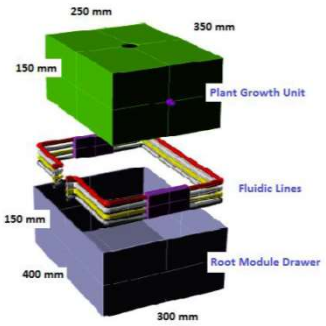
Direct Contact with Contained Root Packets

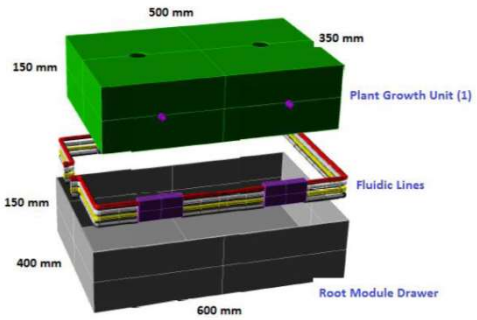
Precursor Food Production Unit – PFPU

2015-2017/2018-…

Flight experiment preparation:

To design a prototype of a modular food production unit for cultivation of potato plants in micro-gravity





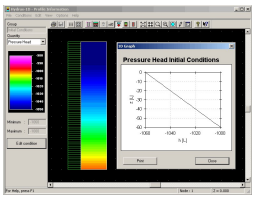
Selezione e caratterizzazione dei substrati

Synthetic Substrates
Capillary Mat (polyester)
Oasis (Horticubes)
Organic Substrates
Natural sponge (cellulose) + Cotton

Capillary Mat + Cotton

Oasis + Cotton

Natural sponge + Cotton

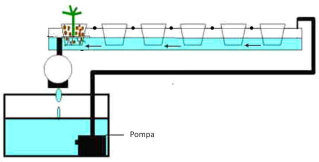


HYDRUS-1D model
to evaluate water status in root environment even in μ-g

Water retention curves
Richard's pressure plate method

Hydraulic conductivity
Falling-head permeability method

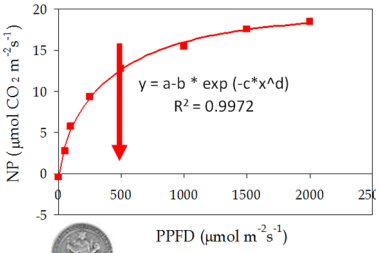
Verso le colonie spaziali: Nutrient Film Tecnique (NFT)



Canaline in plastica (pendenza 1%, larghezza 15-30 cm, altezza 8-10 cm, lunghezza massima 20 m)
Soluzione nutritiva in film sottile (2-3 mm)

La soia

Camera di crescita walk-in del Dipartimento di Agraria dell'Università degli Studi di Napoli Federico II

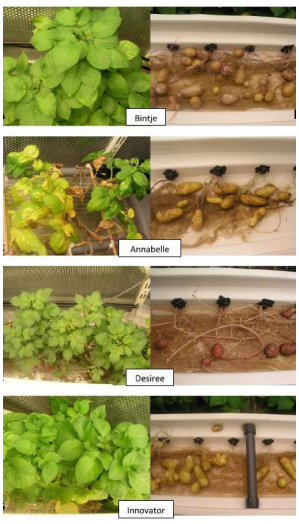


Caratterizzazione delle colture

Bread wheat

Soybean

Potato

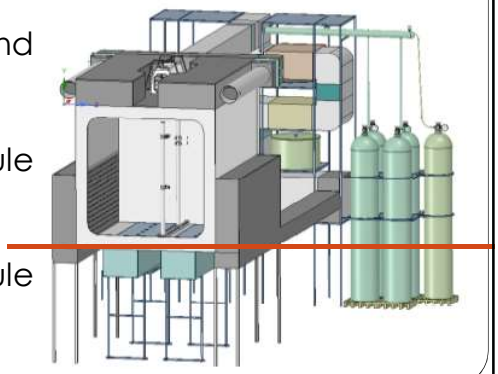


Durum wheat

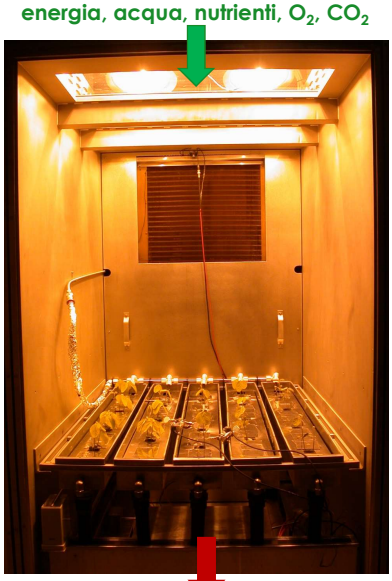
PaCMan

- PlAnt Characterization unit for closed life support system – engineering, MANufacturing & testing

- Real-time monitoring and control of:
- Atmospheric module (plant aerial part)
- Hydroponic module (plant root zone)



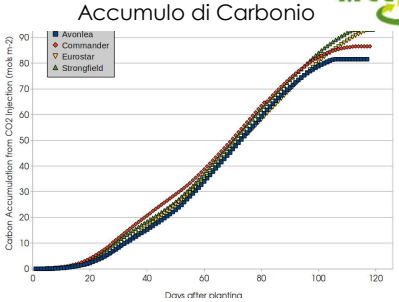
INPUT:
energia, acqua, nutrienti, O_2, CO_2



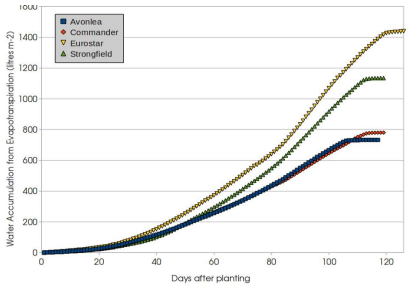
OUTPUT:
acqua, nutrienti, O_2, CO_2

Grano Duro

Accumulo di Carbonio



Recupero acqua



In situ Resource Utilisation

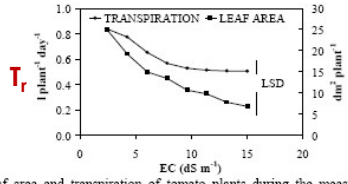
Mojave Mars Simulant 1 (MMS-1, NASA®)

28 m² walk-in plant growth chamber (7.0m x 2.1m x 4.0m, WxHxD)

BANDO DI RICERCA PER MISSIONI FUTURE DI ESPLORAZIONE UMANA DELLO SPAZIO
Area tematica Sistemi Biorigenerativi
***In-situ* REsource Bio-Utilization per il supporto alla vita nello Spazio (ReBUS)**
***In-situ* REsource Bio-Utilization for life Support system (ReBUS)**

Le colture fuori suolo per la ricerca

Biologia funzionale
- adattamento a stress abiotici



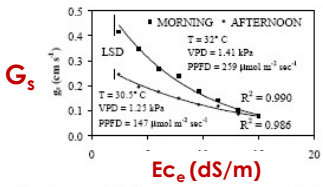
Leaf area and transpiration of tomato plants during the measurements day in response to increasing EC of the nutrient solution (LSD at $p \leq 0.05$).

Water Relations and Abscissic Acid Content in Tomato as Affected by Osmotic Stress

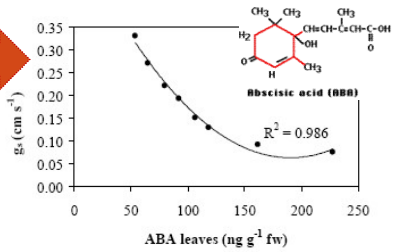
S. De Pascale, G. Raimondi, A. Martino and G. Barbieri
Department of Agricultural engineering and Agronomy
University of Naples Federico II
Portici (NA), Italy

Proc. IS on Greenhouse Salinity
Eds: A. Pardossi et al.
Acta Hort 609, ISHS 2003

Stress salino



Stomatal conductance (g_s) of tomato plants in response to the EC of the nutrient solution during the measurements day (LSD at $p \leq 0.05$).



Relationship between stomatal conductance (g_s) and leaf ABA content of tomato plants grown at increasing osmotic stress level.

A salt-induced increase of the free ABA in tomato leaves was associated with reduced stomatal conductance

Contrasting Effects of GA_3 Treatments on Tomato Plants Exposed to Increasing Salinity

Albino Maggio · Giancarlo Barbieri · Giampaolo Raimondi · Stefania De Pascale

J Plant Growth Regul (2010) 29:63–72
DOI 10.1007/s00344-009-9114-7

THE JOURNAL OF HORTICULTURAL SCIENCE AND BIOTECHNOLOGY, 2016
VOL. 91, NO. 1, 14–22
http://dx.doi.org/10.1080/14620316.2015.1110988

Taylor & Francis

Effects of high salinity and the exogenous application of an osmolyte on growth, photosynthesis, and mineral composition in two ornamental shrubs

C. Cirillo, Y. Rouphael, R. Caputo, G. Raimondi, M. I. Sifola and S. De Pascale

Department of Agricultural Sciences, University of Naples Federico II, Via Università 100, 80055 Portici, Italy

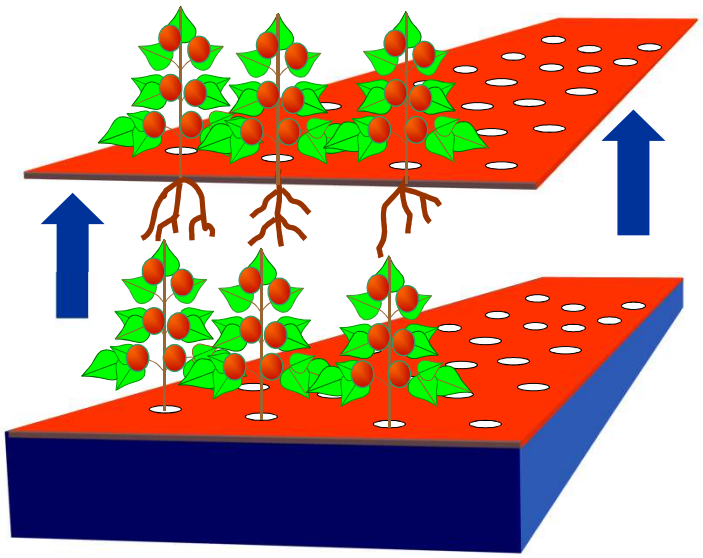
[2.5 mM glycine betaine (GB) or 5.0 mM proline (Pro)]

- Exogenous application of GB reduced the deleterious effects of salt stress (nutrient solution containing 200 mM NaCl) on arrow-wood
- The improved performance was attributed to partial suppression of Na uptake, higher chlorophyll concentrations, and the better nutritional status (higher K) of shoots

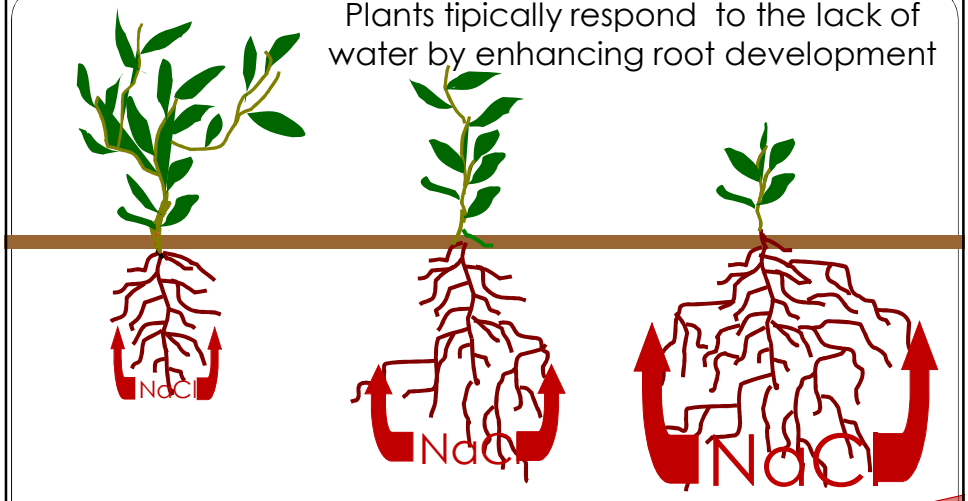
Viburnum lucidum L. (arrow-wood)

Callistemon citrinus (Curtis) Stapf. (red bottlebrush)

Hydroponics to study root development



Plants tipically respond to the lack of water by enhancing root development

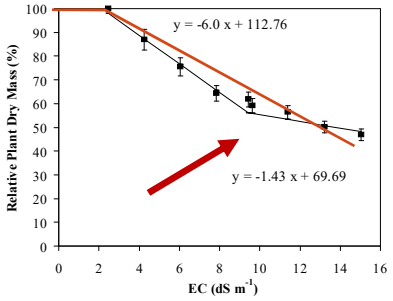


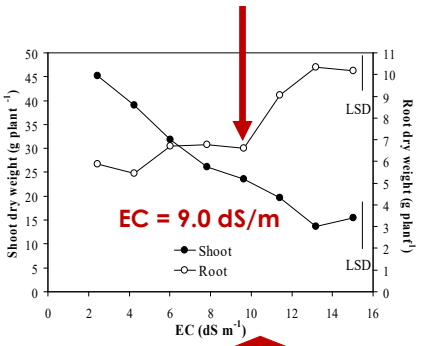
Salinity Stress Index = $\frac{\textit{moles solute to shoot}}{\textit{shoot biomass}}$

Drought stress
Salt stress

Salt stress response in tomato beyond the salinity tolerance threshold

Maggio *et al.* 2007. Environ. Exp. Bot. 59: 276-282





Root/Shoot

(1) increase of ABA levels; (2) decrease of sensitivity of stomata to ABA; (3) increase of compartmentalization of Na^+ ions in mature leaves (4) increase of the root-to-shoot ratio

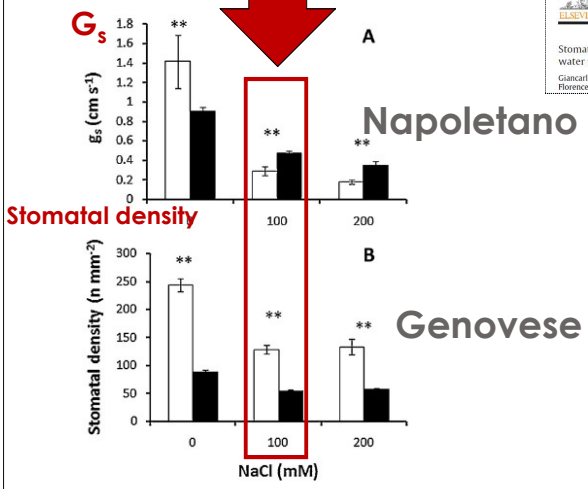
Reduced stomatal density of Genovese contributes to improve stress tolerance and was associated also with lower levels of ABA

ano and Genovese)
spond to salt stress


Journal of Plant Physiology

Stomatal density and metabolic determinants mediate salt stress adaptation and water use efficiency in basil (*Ocimum basilicum* L.)

Giancarlo Barbieri[a], Simona Vallone[b], Francesco Orsini[c], Roberta Paradiso[a], Stefania De Pascale[a], Florence Negre-Zakharov[d], Albino Maggio[a,*]



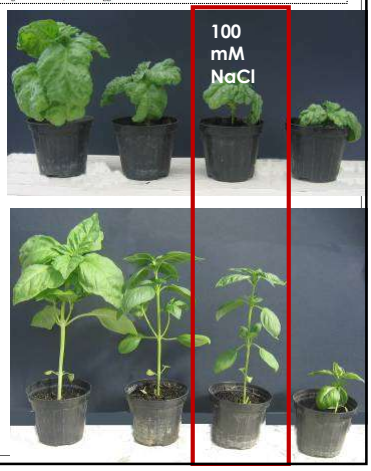
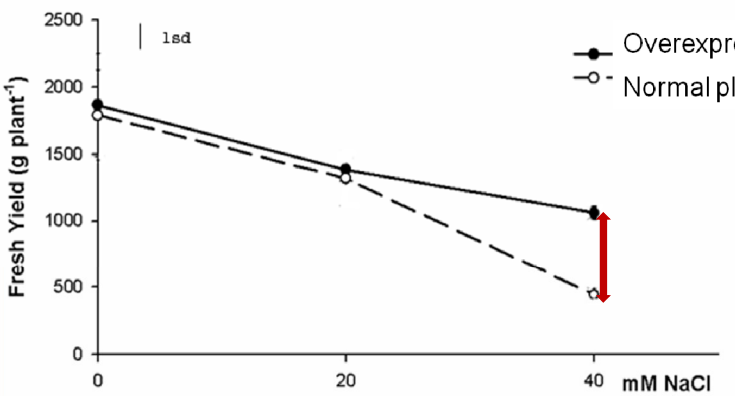
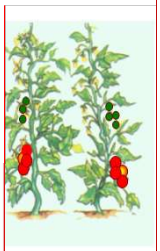


Fig. 2. Stomatal conductance, g_s (A) and density (B) in two sweet basil cultivars (Napoletano, white bars, and Genovese, black bars) as affected by salt stress (0, 100 and 200 mM NaCl). For each salinity level, **significant differences between the

Cross tolerance in tomato





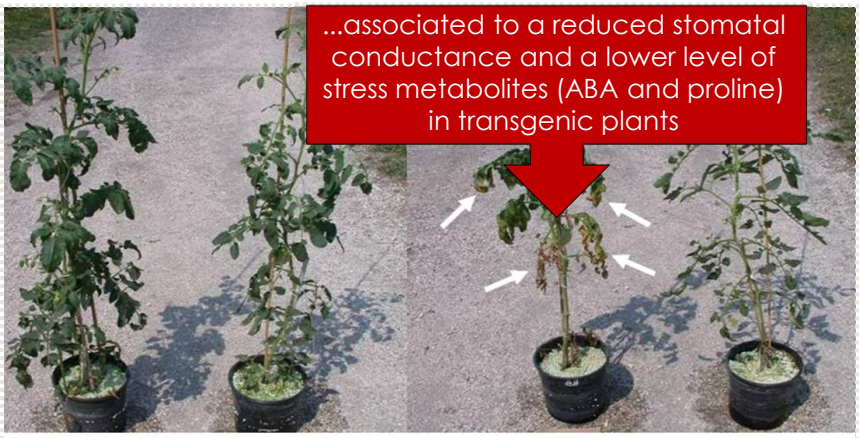
Plants overexpressing systemin are more tolerant to salinity

Physiologia Plantarum 138: 10–21. 2010

Systemin-dependent salinity tolerance in tomato: evidence of specific convergence of abiotic and biotic stress responses

Francesco Orsini[a,†], Pasquale Cascone[b], Stefania De Pascale[a], Giancarlo Barbieri[a], Giandomenico Corrado[b], Rosa Rao[b] and Albino Maggio[a,*]

Overproduction of systemin enhance salt tolerance in tomato



Prosystemin over-expressing (BBS) and untransformed control (BB) tomato plants irrigated with nutrient solution containing 0 (control) or 40 mM NaCl.
White arrows = advanced wilting of older leaves in BB plants 20 days after salinization.

Conclusioni

- Sono passati circa 50 anni dalle prime colture fuori suolo su scala commerciale che rappresentano una percentuale ridottissima della superficie destinata a colture ortoflorovivaistiche
- Dilemma: come trasformare un formidabile strumento per la ricerca nel campo della fisiologia vegetale in un sistema di coltivazione su scala commerciale tecnicamente affidabile ed economicamente conveniente?

TRADE-OFF SUOLO VS. FUORI SUOLO?

- CONTRO: piccole dimensioni aziendali, attuale scenario socio-economico internazionale (continui fenomeni di recessione e crescente competizione da paesi emergenti con conseguente diminuzione dei prezzi)

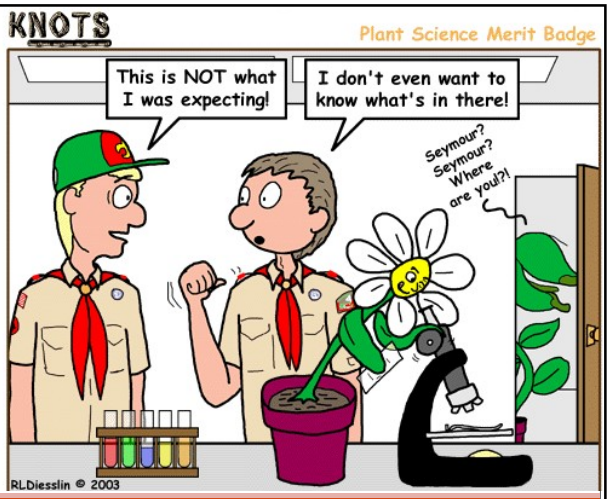
  → ELEVATO RISCHIO DEGLI INVESTIMENTI IN KNOW-HOW E INNOVAZIONE
- PRO: limitazioni nella disinfezione dei suolo, diminuzione in quantità e qualità delle risorse idriche, politiche di stampo ambientalista dei governi centrali e locali

NUOVE OPPORTUNITÀ!!!

Il team

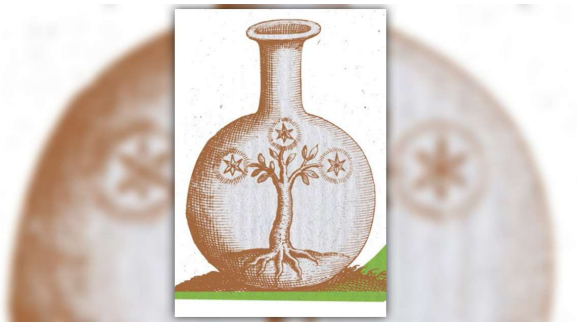
- Giancarlo Barbieri

- Albino Maggio
- Youssef Rouphael
- Roberta Paradiso
- Giovanna Aronne
- Veronica De Micco
- Chiara Cirillo
- Rosanna Caputo
- Giampaolo Raimondi
- Antonio Pannico
- Dottorandi e tesisti
- Colleghi e amici



You never Know What You'll Discover

GRAZIE PER L'ATTENZIONE



13 Febbraio 2019

MARTINO FIORINO

Alla ricerca dell'elisir di lunga vita dell'uomo e…
del vino!