UtiLizzo di microorganism per la difesa delle colture

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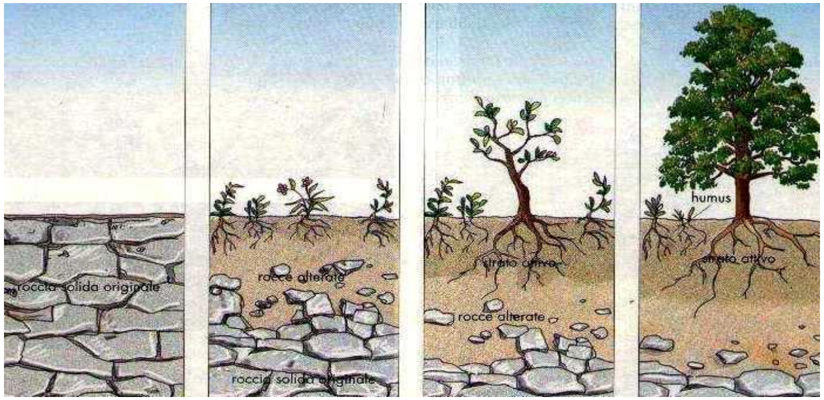
- Perché studiare i microorganismi del suolo?
- Un gruppo di microorganismi speciali, i biostimolanti
- Meccanismi diretti ed indiretti di azione dei biostimolanti microbici
- Evidenze di efficacia dei biostimolanti microbici
- Limiti e potenzialità in agricoltura



Il suolo è un complesso substrato fisico, chimico e biologico che permette la crescita delle piante e, di fatto, la vita stessa sulla terra.

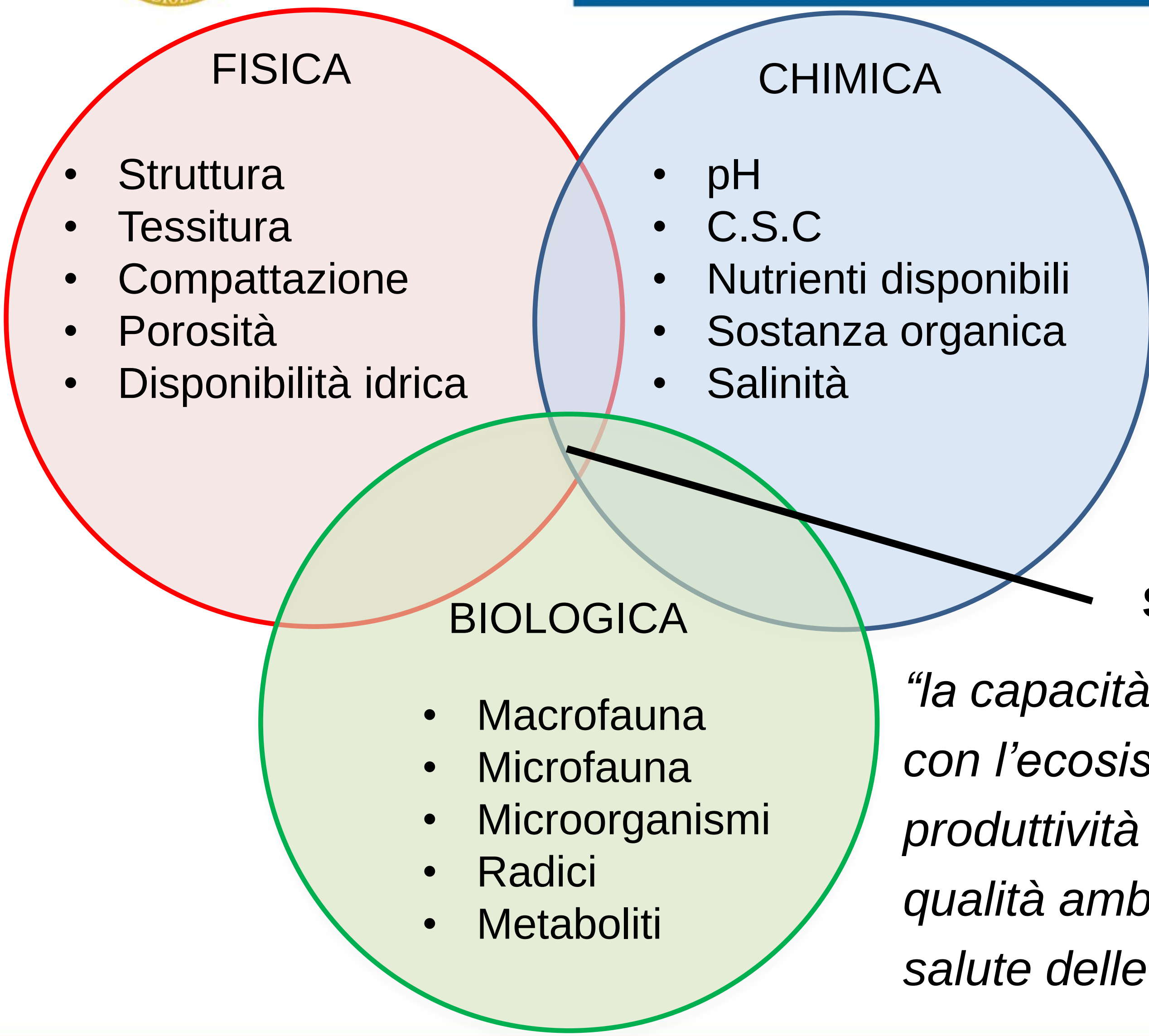
(alcune) funzioni essenziali del suolo:

- Degradazione dei residui organici e riciclo dei nutrienti
- Depurazione delle acque e degradazione di sostanze tossiche
- Riserva di biodiversità
- Sink di CO_2 ed altri gas serra
- Funzioni estetiche e sociali

→ garantire nel tempo un corretto svolgimento di queste funzioni significa garantire la sostenibilità in agricoltura

"The nation that destroys its soil, destroys itself" (Franklin D. Roosvelt, 1937)

LA FERTILITA'/SALUTE DEL SUOLO



SALUTE DEL SUOLO

"la capacità di un suolo di interagire con l'ecosistema per sostenere la produttività biologica, mantenere la qualità ambientale e promuovere la salute delle piante e degli animali"

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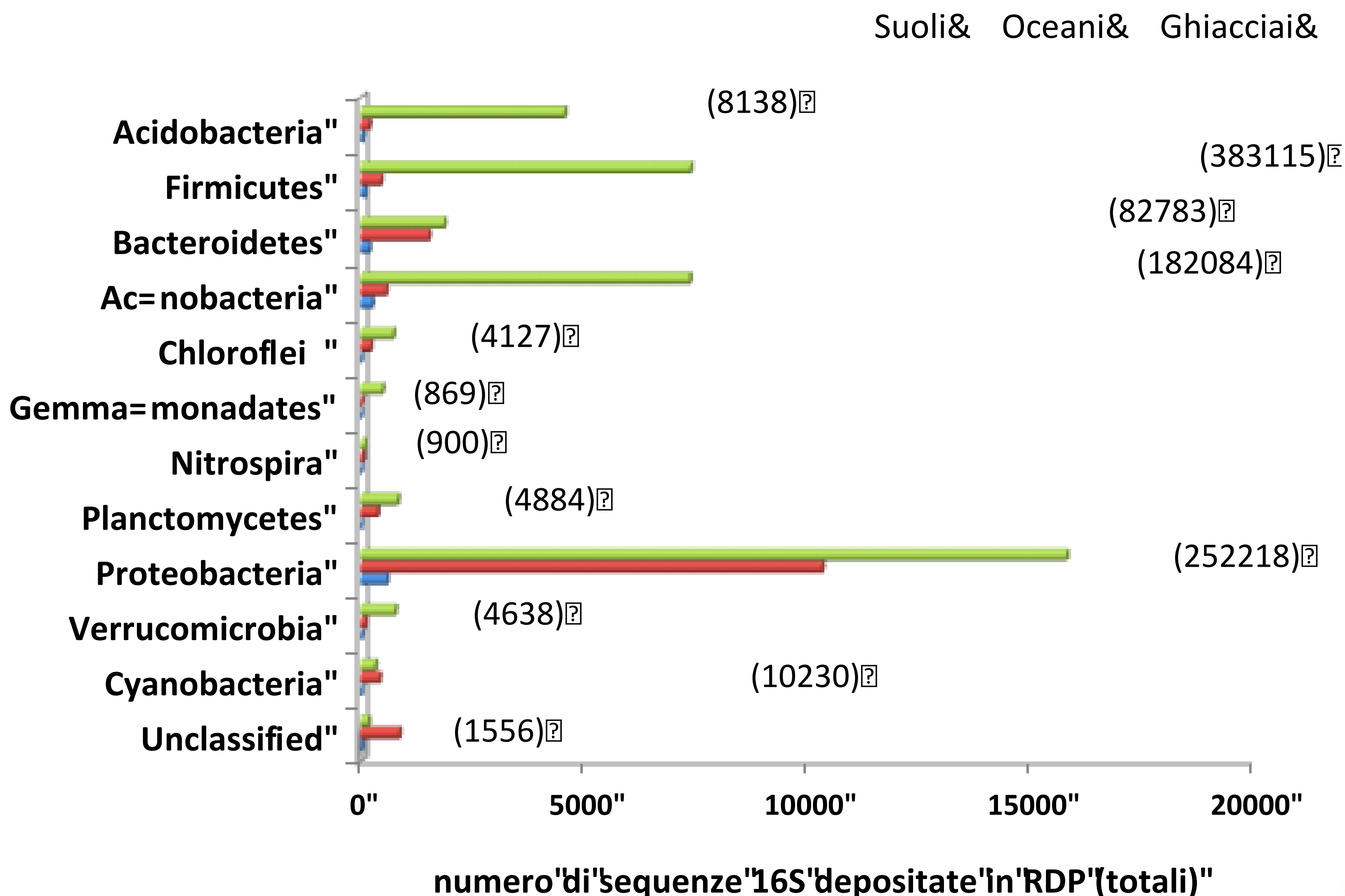
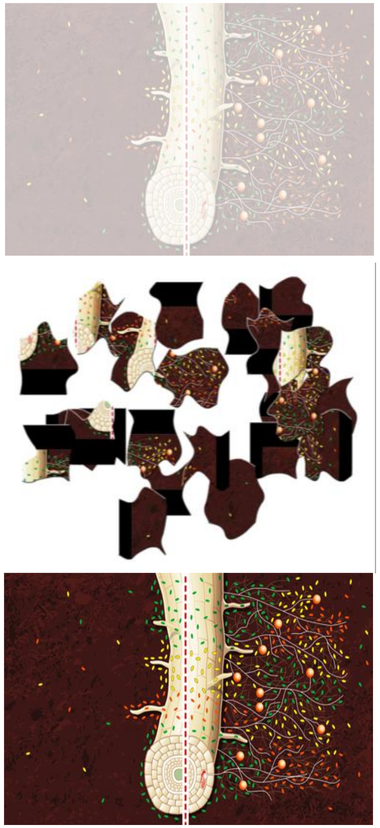
IL SUOLO, L'AMBIENTE CON LA MAGGIORE BIODIVERSITA' MICROBICA AL MONDO



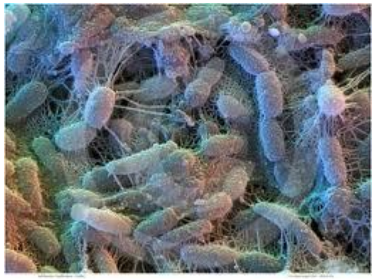
I MICROORGANISMI DEL SUOLO

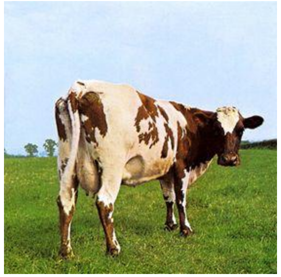
Cosa fanno?

- Decomposizione della sostanza organica
- Ciclo dei nutrienti
- Fissazione dell'N_2
- Soppressione delle malattie delle piante
- Miglioramento della struttura del suolo
- Biodegradazione degli inquinanti
- Emissioni di gas serra



Chi sono? Quanti sono ?



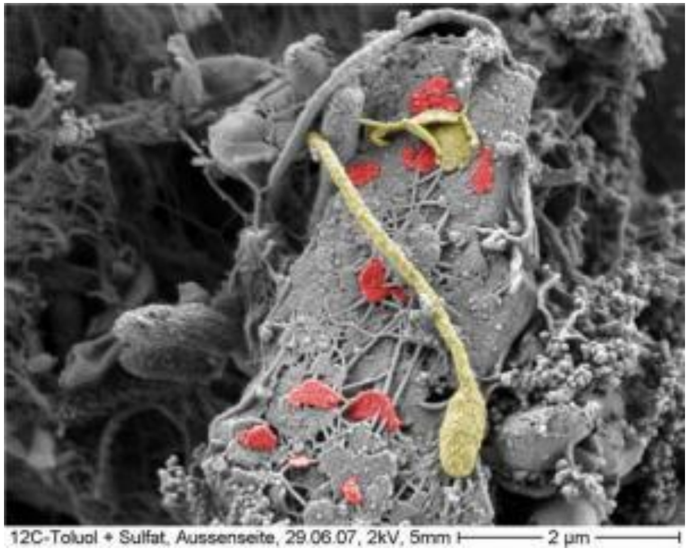


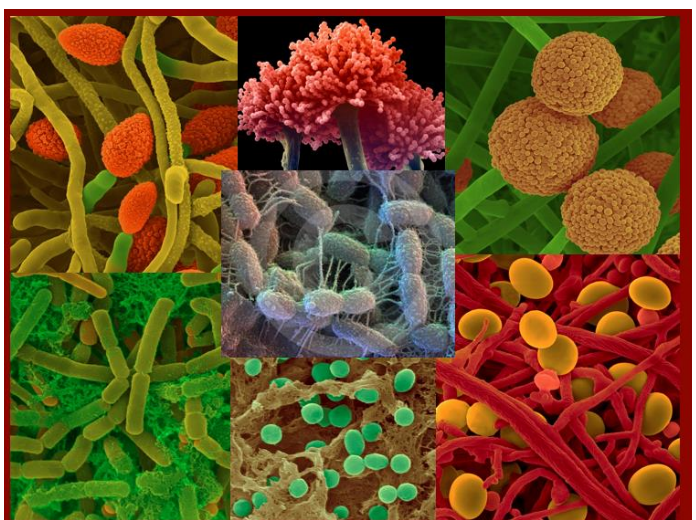
La biomassa microbica in 1 ha di suolo pesa circa come una vacca

Dotazione microbiologica di un g di suolo di buona qualità:

- Oltre 1 miliardo di cellule
- Centinaia di migliaia di specie microbiche

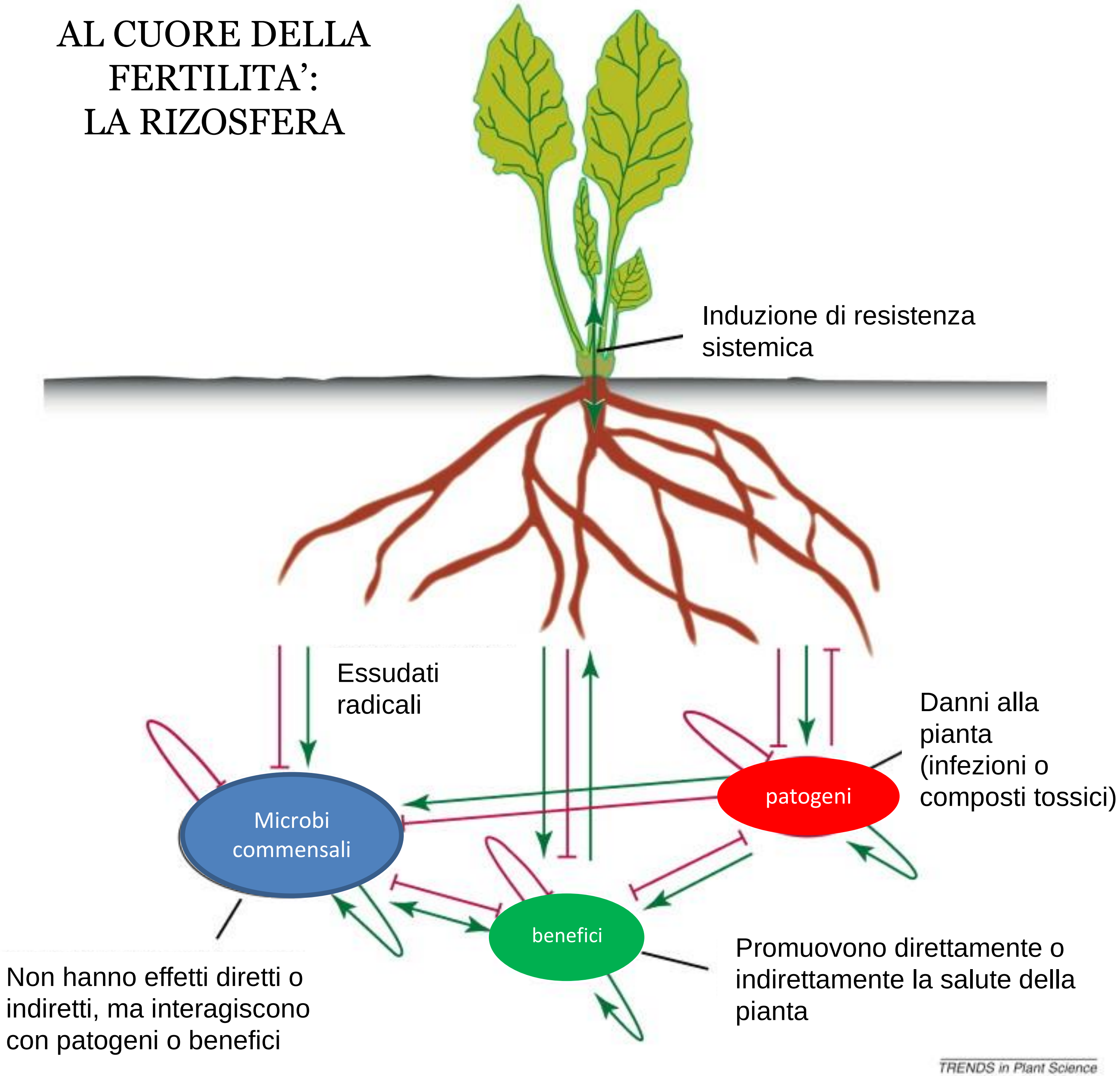
INTERAZIONI BIOLOGICHE: BATTERI, FUNGHI E PIANTE RENDONO Il SUOLO UN AMBIENTE VITALE





Bais et al. (2006) *Annu Rev Plant Biol* **57**:233-66; van West et al. (2002) *Mol Plant-Microbe Interact* **15**:790-98

AL CUORE DELLA FERTILITA':
LA RIZOSFERA



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MICROORGANISMI BIOSTIMOLANTI o PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR)

- Il termine PGPR (**Plant Growth Promoting Rhizobacteria**) è stato coniato nel 1981 (Kloepper and Schroth) per indicare le popolazioni microbiche della rizosfera in grado di promuovere la crescita della pianta
- E' possibile distinguere tra PGPR extracellulari e intracellulari (**ePGPR** e **iPGPR**)
- Du Jardin (2012) definisce i **biostimolanti** come: «Prodotti contenenti sostanze e/o microrganismi che, applicati alla pianta o alla rizosfera, stimolano i processi naturali che migliorano l'efficienza d'assorbimento e d'assimilazione dei nutrienti, la tolleranza a stress abiotici e/o la qualità del prodotto indipendentemente dal loro contenuto in nutrienti".
- Per estensione, i biostimolanti designano anche prodotti commerciali contenenti miscele di tali sostanze e/o microrganismi. Per microrganismi si intende sia **batteri** benefici, PGPB (Plant Growth Promoting Bacteria), che **funghi** benefici

Meccanismi diretti di stimolazione della crescita della pianta (attività biofertilizzante):

- Fissazione dell'azoto atmosferico
- Solubilizzazione del fosforo
- Solubilizzazione del potassio
- Produzione di siderofori
- Produzione di fitoormoni (acido indolacetico, citochinine, etilene)

Meccanismi indiretti di stimolazione della crescita della pianta (attività di biocontrollo):

- Inibizione di funghi patogeni tramite produzione di acido cianidrico e altri metaboliti
- Inibizione di batteri patogeni tramite produzione di batteriocine
- Induzione di resistenza sistemica alla pianta nei confronti di stress abiotici (siccità, salinità) e biotici (resistenza ad insetti fitofagi)

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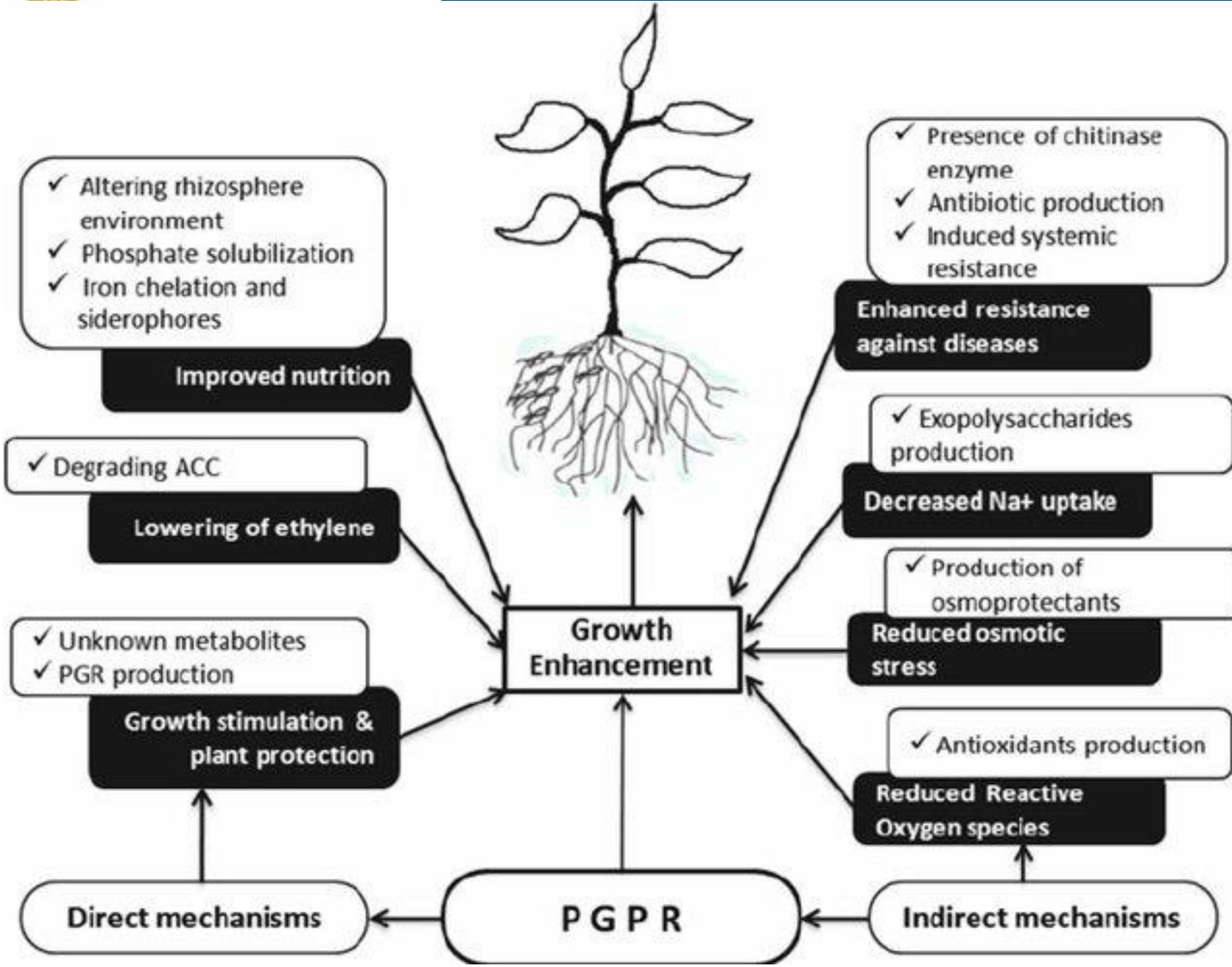
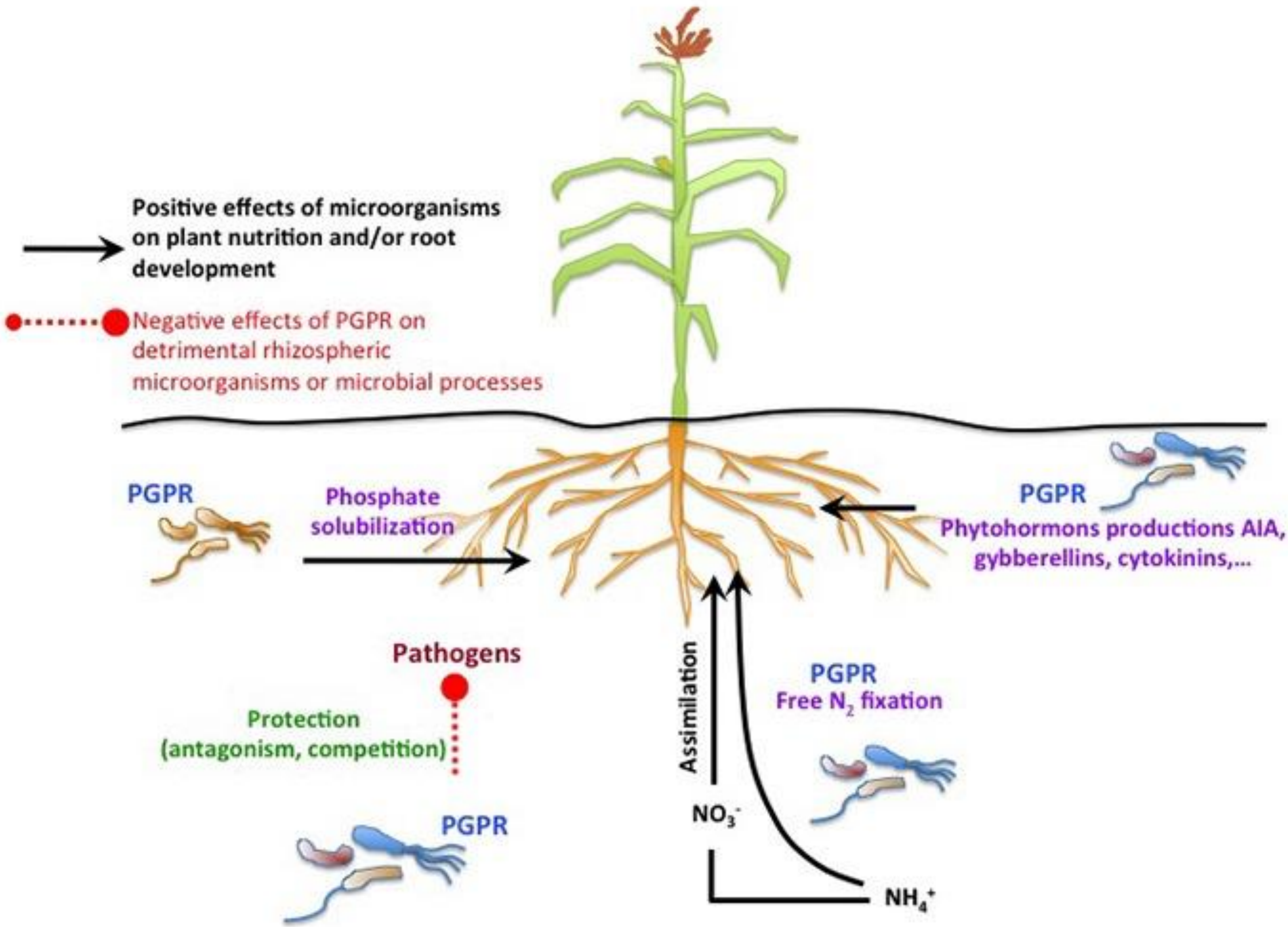
MICROORGANISMI BIOSTIMOLANTI o PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR)



Nadeem et al. (2013) Plant-microbe interactions for sustainable agriculture. DOI: 10.1007/978-81-322-1287-4_2



Positive effects of microorganisms on plant nutrition and/or root development
Negative effects of PGPR on detrimental rhizospheric microorganisms or microbial processes
PGPR
Phosphate solubilization
PGPR
Phytohormons productions AIA, gybberellins, cytokinins,...
Pathogens
Protection (antagonism, competition)
PGPR
Assimilation
PGPR
Free N_2 fixation
NO_3^-
NH_4^+

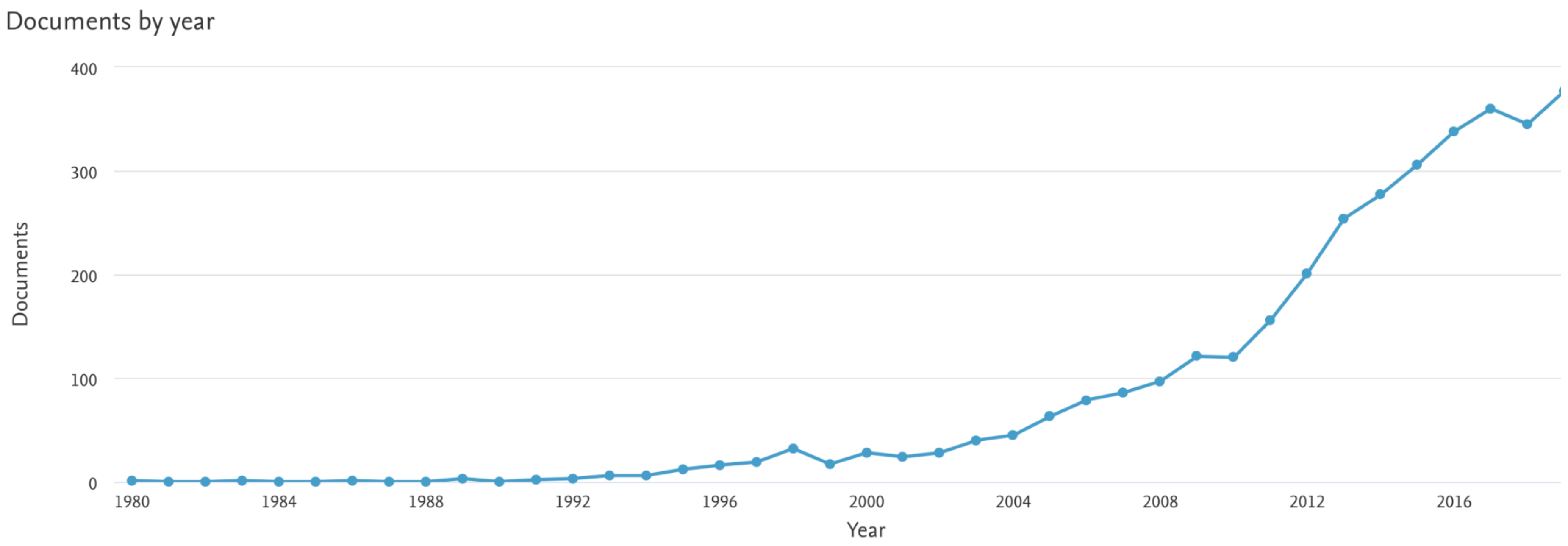
Table 6.1 Direct mechanisms and PGPR used

Mechanism		PGPR	Crops	References
Nitrogen fixation	Symbiotic	*Rhizobium* and allied genera	Legumes, e.g., Soybeans, Peanut, Chickpea etc.	Lucas-Garcia et al. (2004), Vargas et al. (2010), Laranjo et al. (2014), and Abd-Alla et al. (2017)
		Frankia	Higher Agiospermic plants (Actinorhizal plants), e.g., *Alnus, Casurina*	Crannell et al. (1994), Santi et al. (2013), Diagne et al. (2013), and Ballhorn et al. (2017)
	Free-living	Cyanobacteria, *Azotobacter*, *Azospirillum*, *Beijerinckia*	Cereals, e.g., Wheat, Rice, Maize	Steenhoudt and Vanderleyden (2000), Cassán et al. (2009), and Shariatmadari et al. (2013)
Phosphate solubilisation		*Pseudomonas, Bacillus, Rhizobium*	Any crops	Mamta et al. (2010), Schoebitz et al. (2013), and Oteino et al. (2015)
Iron sequestration		*Alcaligenes, Pseudomonas, Bacillus*	Any crops	Gamit and Tank (2014) and Aznar and Dellagi (2015)
Zinc solubilisation		*Burkholderia, Pseudomonas, Bacillus*	Any crops	Goteti et al. (2013), Vaid et al. (2014), and Sunithakumari et al. (2016)
Potassium solubilisation		*Bacillus, Pseudomonas*	Any crops	Bagyalakshmi et al. (2012), Parmar and Sindhu (2013), and Prajapati and Modi (2016)
Phytohormone production		*Bacillus, Rhizobium, Pseudomonas*	Any crops	Khare and Arora (2010), Reetha et al. (2014), and Pandya and Desai (2014)

Table 6.2 Indirect mechanisms and PGPR used

Mechanisms	PGPR	Crops	References
Competition	*Enterobacter, Pseudomonas, Bacillus*	Any crops, e.g., Wheat, Rice, Tomato	Raaijmakers and Weller (2001), Kageyama and Nelson (2003), and Liu et al. (2013)
Enzyme production	*Bacillus, Pseudomonas, Serratia*	Any crops, e.g., Cucumber, Grape, Peanut	Singh et al. (1999), Kishore et al. (2005), Arora et al. (2008), and Kejela et al. (2016)
Antibiotic production	*Pseudomonas, Bacillus, Agrobcaterium, Pantoea*	Any crops, e.g., Tobacco, Cotton, Cabbage, Mung bean	Hill et al. (1994), Mishra and Arora (2012), and Dhanya and Adeline (2014)
HCN production	*Pseudomonas, Bacillus, Burkholderia*	Any crops e. g. Wheat, Barley	Reetha et al. (2014), and Nandi et al. (2015)
Siderophore production	*Rhizobium, Pseudomonas, Bacillus*	Any crops, e.g., Groundnut, Chickpea, Capsicum	Arora et al. (2001), Omidvari et al. (2010), Mishra and Arora (2011), and Rais et al. (2017)
ISR and SAR	*Pseudomonas, Serratia, Bacillus, Rhizobium*	Any crops, e.g., Cucumber, Tobacco Bean, Tomato	Press et al. (1997), Reitz et al. (2002), Meziane et al. (2005), Pal and Gardener (2006), and Tahir et al. (2017)

NUMERO DI ARTICOLI PER ANNO



EVIDENZE - PEPERONE

Table 4. Effect of bacterial inoculums on plant parameters capsicum under field conditions*.

Treatments	Plant height (cm)	Plant biomass (g)	Leaf area index	No. of fruits (no./plant)	Fruit weight (g)	Yield/plant (t ha^{-1})
T_1	60.7^{cdef**}	3918.3^{bc}	2.2^{cd}	10.5^{de}	74.7^{efg}	15.4^{cde}
T_2	71.0^{ab}	4196.7.3^{abc}	2.3^{abc}	12.8^{abc}	90.6^{abc}	19.6^{ab}
T_3	71.7^{ab}	4265.3^{ab}	2.4^{ab}	12.9^{ab}	91.4^{ab}	20.2^{ab}
T_4	73.0^{a}	4277.6^{a}	2.5^{a}	13.2^{a}	93.5^{a}	20.8^{a}
T_5	61.7^{cde}	3874.7^{cdef}	2.1^{cde}	10.7^{de}	75.9^{def}	15.7^{cd}
T_6	62.3^{cd}	3896.6^{cde}	2.2^{cd}	10.9^{de}	77.0^{de}	15.3^{cde}
T_7	64.3^{c}	3910.6^{cd}	2.2^{cd}	11.3^{bcd}	84.1^{bcd}	16.6^{c}
T_8	55.0^{g}	3525.6^{g}	1.8^{f}	9.2^{e}	65.5^{h}	13.2^{f}
T_9	57.3^{defg}	3548.6^{fg}	1.8^{f}	9.8^{de}	69.3^{efgh}	13.7^{f}
T_{10}	58.3^{defg}	3566.1^{df}	1.9^{f}	10.0^{de}	70.8^{efgh}	14.1^{f}
$CD_{0.05}$	5.5	354.1	0.2	1.8	8.5	1.5

T1: 100% dose raccomandata N,P,K (DR)
T2, T3, T4: 100% DR + PGPR
T5, T6, T7: 80% DR + PGPR
T8, T9, T10: 60% DR + PGPR

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EVIDENZE - PEPERONE

Table 5. Effect of bacterial inoculums on soil parameters*.

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1	255.7[bcd]**	43.6[de]	283.8[abcd]	142.4[cd]	13.6[d]	148.1[d]
T_2	272.1[abc]	48.3[abc]	284.2[abc]	158.6[abc]	18.3[abc]	164.4[abc]
T_3	273.9[ab]	48.7[ab]	284.5[ab]	161.9[ab]	19.3[ab]	167.1[ab]
T_4	284.2[a]	50.4[a]	285.8[a]	163.4[a]	19.2[a]	169.0[a]
T_5	222.2[efg]	40.0[defg]	212.4[e]	137.8[de]	12.5[def]	145.7[def]
T_6	223.3[ef]	41.2[def]	212.2[e]	140.3[def]	13.3[de]	147.3[de]
T_7	233.0[de]	43.8[d]	212.1[e]	141.3[cde]	13.6[d]	148.5[d]
T_8	200.2[f]	33.4[h]	199.7[e]	121.8[f]	10.6[h]	132.2[g]
T_9	209.0[ef]	34.8[h]	202.5[e]	123.5[ef]	10.9[gh]	133.2[g]
T_{10}	217.9[ef]	36.3[gh]	201.2[e]	124.1[ef]	11.9[fg]	134.8[g]
$CD_{0.05}$	25.3	4.2	19.4	18.2	1.1	7.9

T1: 100% dose raccomandata N,P,K (DR)
T2, T3, T4: 100% DR + PGPR
T5, T6, T7: 80% DR + PGPR
T8, T9, T10: 60% DR + PGPR

Gupta et al. (2017) *J Plant Nut* **40**:921-927

EVIDENZE – FAGIOLO CONTROLLO DEL MARCIUME BRUNO

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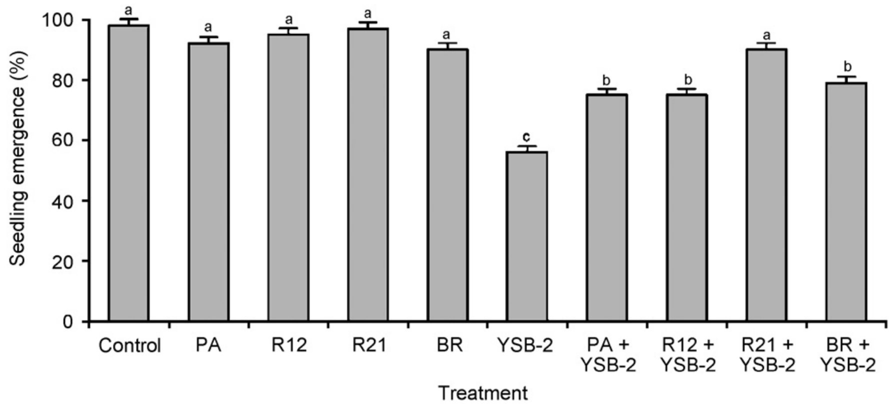


Fig. 2. Effect of seed treatment with *Rhizobium leguminosarum* isolates R12, R21 or BR or *Pantoea agglomerans* (PA) on seedling emergence of navy bean cultivar Morden003 under conditions of artificial infestation with *Curtobacterium flaccumfaciens* pv. *flaccumfaciens* (YSB-2). Plants were 14 d old at time of data collection. Means annotated with the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test).

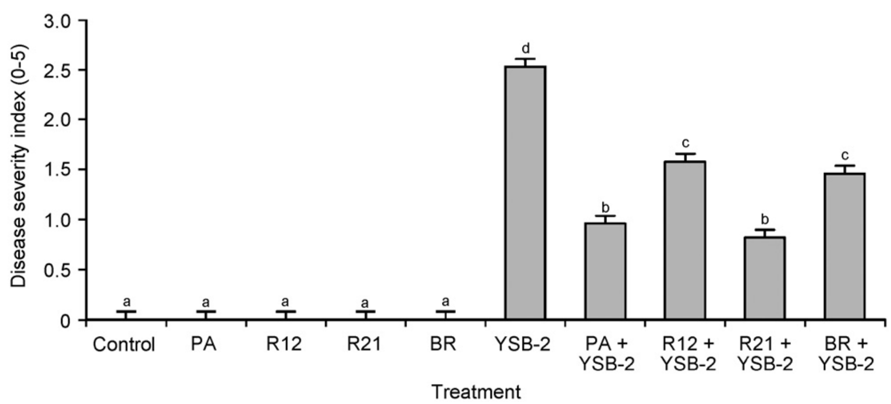


Fig. 3. Effect of seed treatment with *Rhizobium leguminosarum* isolates R12, R21 or BR or *Pantoea agglomerans* (PA) on disease severity index of navy bean cultivar Morden003 under conditions of artificial infestation with *Curtobacterium flaccumfaciens* pv. *flaccumfaciens* (YSB-2). Plants were 14 d old at time of data collection. Means annotated with the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test).

MAIS

Table 1
Effect of inoculation with rhizobacteria containing ACC-deaminase on plant height, root weight and total biomass of maize in pot trial (average of six repeats)

Treatments[a]	Plant height (cm)	Root weight ($g\,pot^{-1}$)	Total biomass ($g\,pot^{-1}$)
Control (uninoculated)	144b[b] (±3.27)[c]	35.2d (±1.03)	516c (±10.7)
Q_7	163a (±2.88)	57.6b (±1.08)	589ab (±13.5)
Q_{14}	153ab (±3.50)	68.6a (±0.94)	602ab (±9.3)
Q_{18}	168a (±2.36)	47.4c (±1.47)	583ab (±5.4)
Q_{30}	146b (±1.23)	37.2d (±1.72)	565bc (±9.0)
Y	143b (±3.65)	40.2cd (±1.38)	552bc (±14.8)
N_3	146b (±2.14)	57.6b (±1.81)	632a (±12.1)

[a]All the treatments received N, P and K at concentrations of 175, 100 and 50 $kg\,ha^{-1}$, respectively.
[b]sharing the same letter(s) in a column do not differ significantly according to Duncan's multiple-range test ($P<0.05$).
[c]Standard error.

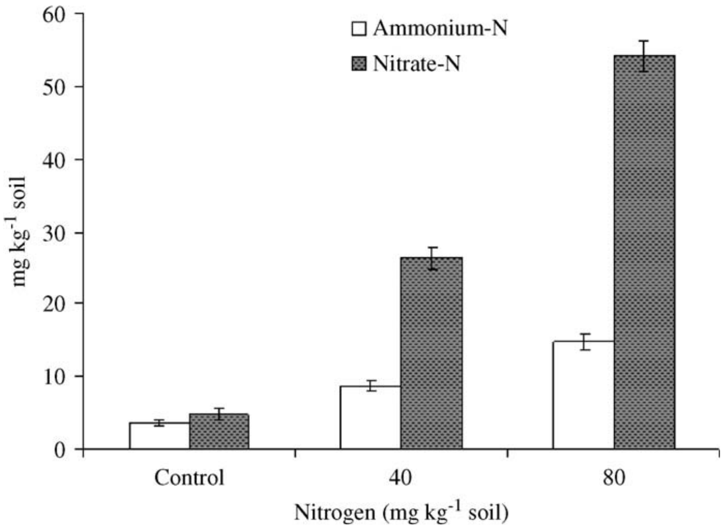


Fig. 1. Concentration of NH_4^+- and NO_3^--N in urea-amended soil after seven days of incubation (average of three repeats).

Table 2
Effect of inoculation with plant-growth-promoting rhizobacteria containing ACC-deaminase on growth and grain yield of maize in the presence and absence of N fertilizer (average of four repeats)

Treatments	Total biomass ($t\,ha^{-1}$)		Cob weight (g)		Cob length (cm)		Grain yield ($t\,ha^{-1}$)	
	Without N fertilizer[a]	With N fertilizer[b]	Without N fertilizer	With N fertilizer	Without N fertilizer	With N fertilizer	Without N fertilizer	With N fertilizer
Uninoculated	17.9d[c] (±0.99)[d]	26.0b (±1.34)	144e (±3.24)	198c (±2.82)	14.4f (±0.68)	17.2cd (±0.98)	4.3f (±0.11)	6.2c (±0.16)
Pseudomonas putida biotype A	18.2d (±1.32)	25.8b (±1.26)	152e (±4.10)	194c (±2.12)	16.5de (±0.74)	17.5bc (±1.00)	4.7ef (±0.0.09)	6.5bc (±0.20)
Pseudomonas fluorescens	18.2d (±1.13)	26.5b (±1.38)	151e (±2.69)	210b (±3.95)	16.3e (±1.01)	18.2b (±1.06)	5.2de (±0.12)	6.8b (±0.10)
Pseudomonas fluorescens biotype G	20.0c (±0.87)	28.4a (±1.07)	166d (±3.96)	237a (±3.21)	17.0cde (±0.98)	19.6a (±1.12)	5.4d (±0.18)	7.4a (±0.22)

[a]The P and K fertilizers were applied at concentrations of 100 and 50 $kg\,ha^{-1}$, respectively, while indigenous N contents were 0.05%.
[b]All the treatments received N, P and K at concentrations of 175, 100 and 50 $kg\,ha^{-1}$, respectively.
[c]sharing the same letter(s) in a column do not differ significantly according to Duncan's multiple-range test ($P<0.05$).
[d]Standard error.

Shaharoona et al. (2006) *Soil Biol Biochem* ***38***:2971-2975

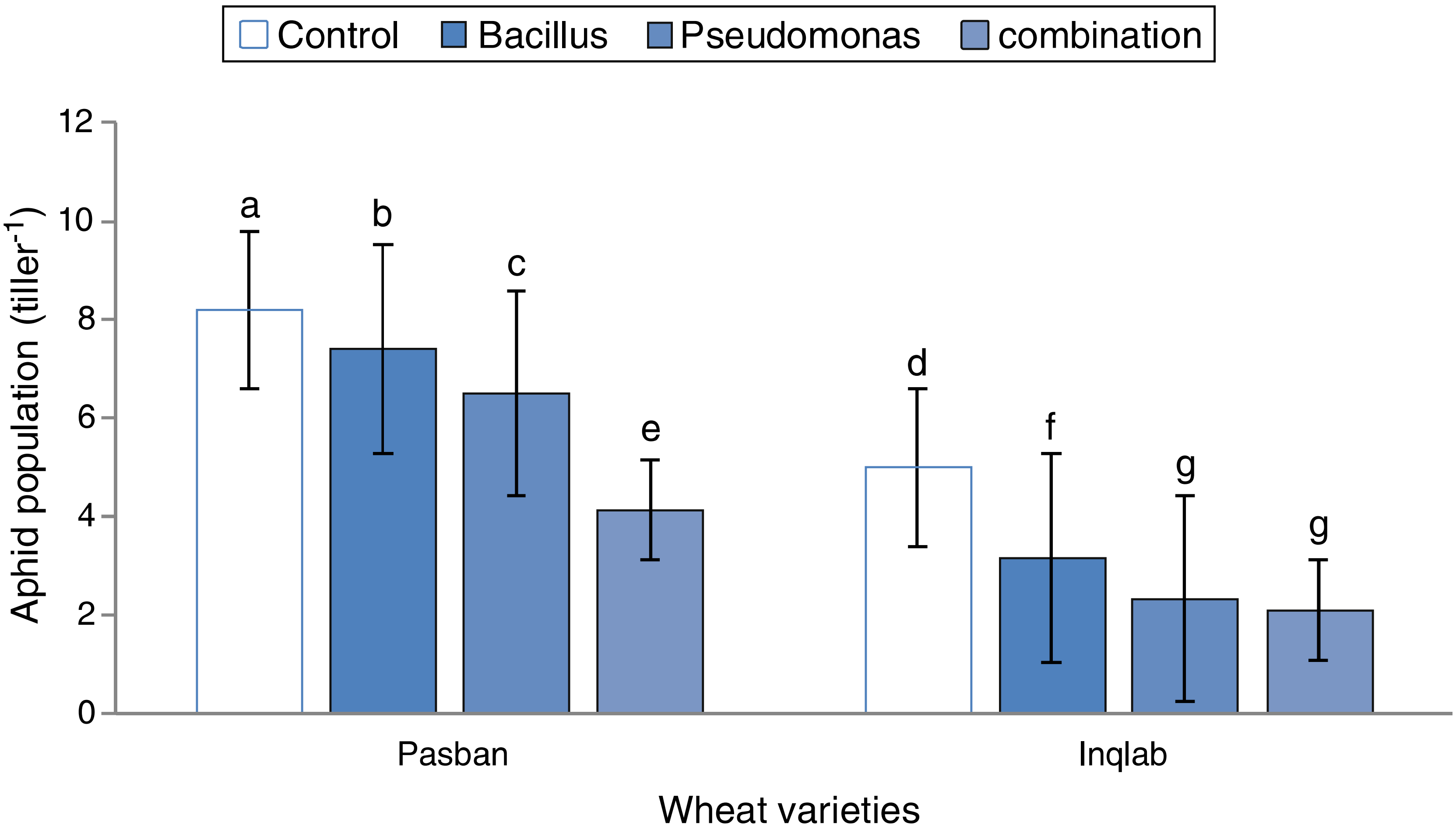
EVIDENZE – MAIS E STRESS IDRICO

Table 4
The effect of inoculation with different strains (P_1, P_3, P_8, P_{14}) of *P. fluorescens* under three watering regimes on root length, root dry weight and root length density.

Bacteria	Watering regime	Root length (cm)		Root dry weight (g)		Root lenght density (cm cm^{-3})	
		2016	2017	2016	2017	2016	2017
	100%	21.87 h	28.32 d	17.51 g	18.53 f	2.8 b	2.65 gh
No Bacteria	80%	20.83 h	25.56 e	15.29 h	17.33 fg	2.59 c	2.75 g
	60%	18.20 j	21.55 fg	13.27 i	15.32 i	2.56 c	2.88 f
	100%	38.62 ab	42.16 a	25.28 a	26.30 a	2.65 bc	2.62 gh
P1	80%	38.65 a	36.80 b	24.87 ab	25.10 a b	2.62 c	2.85 f
	60%	29.61 d	27.67 d	22.05 c	23.10 c	3.01 a	3.47 a b
	100%	29.91 d	34.47 c	20.22 d	21.24 de	2.67 bc	2.61 gh
P3	80%	28.94 de	28.07 d	20.10 de	20.04 e	2.74 b	3.00 e
	60%	23.89 g	22.44 f	16.98 g	18.04 fg	2.81 b	3.36 b c
	100%	35.80 bc	42.30 a	23.15 c	24.17 bc	2.64 c	2.57 gh
P8	80%	36.80 b	34.22 c	22.93 c	24.97 b	2.55 c	3.20 d
	60%	29.72 d	28.80 d	20.91 d	21.96 d	2.87 ab	3.33 c
	100%	25.50 f	29.00 d	19.14 ef	20.16 e	2.75 b	2.69 g
P14	80%	24.53 fg	23.00 f	18.92 f	18.96 f	2.83 ab	3.21 d
	60%	19.59 i	18.40 g	15.90 h	16.95 h	2.99 a	3.59 a

Means within a column followed by the same letter are not significantly different (LSD 5% level).

EVIDENZE – GRANO E AFIDI



Naeem et al. (2018) *Braz J Microbiol gric* ***49***:9-14

EVIDENZE – MAIS E OVODEPOSIZIONE DI LEPIDOTTERI

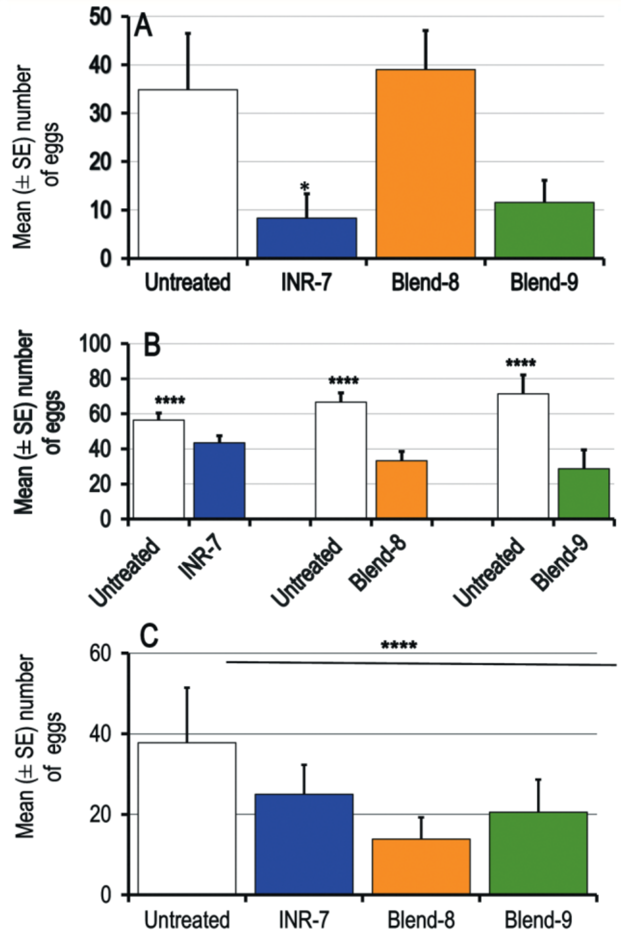


Figure 1 Number of eggs oviposited by *Ostrinia nubilalis* when offered maize plants treated with single PGPR strain (INR-7), mixture of PGPR strains (Blend-8 or Blend-9) or untreated plants. (A) Number of eggs laid overnight (12 h) in no-choice tests by *O. nubilalis* per plant; (B) number of eggs laid overnight (12 h) by *O. nubilalis* when offered a dual-choice between plants treated with PGPR (i.e. INR-7, Blend-8, and Blend-9) and untreated plants; (C) number of eggs laid overnight (12 h) by *O. nubilalis* in four-choice tests comprising plants treated with PGPR (INR-7, Blend-8 and Blend-9) and untreated plants. *indicates significant difference (Wald χ^2; $P \leq 0.05$); **** indicates significant difference (Z; $P \leq 0.0001$).

Disi et al. (2018) *Entomological Science* ***21***:48-58

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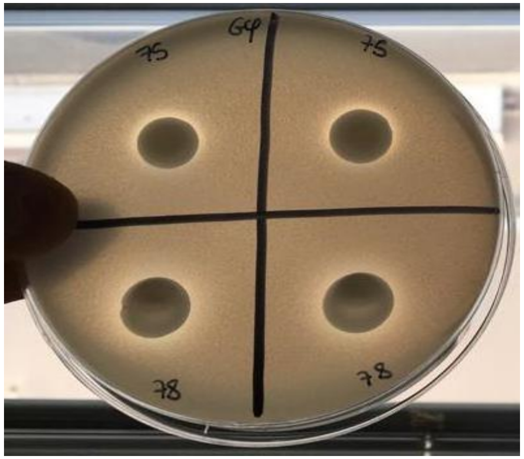
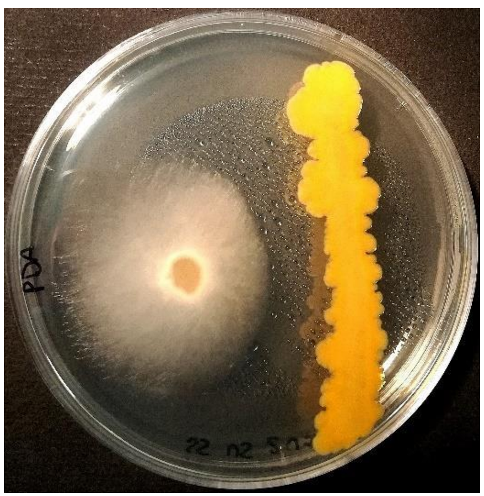
BIOPROSPECTING DI NUOVI CEPPI



Test solubilizzazione del tricalcio fosfato

Test produzione indoli



Test attività di biocontrollo vs *Sclerotinia sclerotiorum*

Test produzione di siderofori

Guerrieri et al. (2020) *Plants* ***9***:668

BIOPROSPECTING DI NUOVI CEPPI

Table 4. Ranking of the rhizobacteria based on their in vitro PGP (plant growth promoting) and antifungal assay.

Code	Identity	*N* Fixation	*P* Solubilization	IAA Production		Antifungal Activity vs. *S. sclerotiorum*	Siderophore	Rank
				w/Try	w/o Try			
UC4094	*Enterobacter tabaci*	1	0.5	0.46	0.42	0.51	0.51	3.41
UC4098	*Stenotrophomonas rhizophila*	1	0.5	0.16	1,00	0.57	0.00	3.22
UC4109	*Enterobacter tabaci*	1	0.5	1.00	0.11	0.38	0.17	3.16
UC4127	*Klebsiella oxytoca*	1	0.5	0.25	0.22	1.00	0.09	3.06
UC4089	*Stenotrophomonas pictorum*	1	0.5	0.25	0.22	1.00	0.09	2.99
UC4105	*Stenotrophomonas pictorum*	1	0.25	0.17	0.03	0.75	0.78	2.98
UC4103	*[Pseudomonas] hibiscicola*	1	0.25	0.04	0.04	0.94	0.68	2.94
UC4123	*Klebsiella oxytoca*	1	0.5	0.25	0.21	0.93	0.02	2.92
UC4099	*Enterobacter tabaci*	1	0.5	0.36	0.09	0.45	0.51	2.90
UC4117	*Pseudomonas taiwanensis*	1	0.75	0.07	0.09	0.59	0.39	2.88
UC4113	*[Pseudomonas] hibiscicola*	1	0.25	0.04	0.03	0.85	0.68	2.86
UC4096	*Stenotrophomonas pavanii*	1	0.25	0.04	0.03	0.76	0.77	2.85
UC4090	*Aeromonas caviae*	1	0.5	0.18	0.12	0.74	0.30	2.84
UC4106	*Enterobacter ludwigii*	1	0.5	0.36	0.26	0.60	0.08	2.80
UC4093	*Stenotrophomonas pictorum*	1	0.25	0.02	0.01	0.60	0.91	2.79
UC4082	*Pseudomonas pseudoalcaligenes*	1	0.25	0.01	0.03	0.90	0.60	2.79
UC4084	*Kosakonia radicincitans*	1	0.5	0.04	0.02	0.65	0.58	2.78
UC4091	*Pseudomonas pseudoalcaligenes*	1	0	0.22	0.05	0.92	0.57	2.76
UC4101	*Klebsiella grimontii*	1	0.5	0.25	0.25	0.61	0.01	2.61
UC4118	*Klebsiella oxytoca*	1	0.5	0.26	0.22	0.43	0.11	2.52
UC4088	*Pseudomonas indoloxydans*	1	0	0.06	0.06	0.86	0.53	2.50
UC4087	*Pseudomonas indoloxydans*	1	0	0.05	0.06	0.82	0.55	2.48
UC4092	*Kosakonia radicincitans*	1	0.5	0.13	0.13	0.66	0.06	2.48
UC4104	*Stenotrophomonas rhizophila*	1	0.25	0.04	0.02	0.56	0.58	2.46
UC4110	*Kosakonia oryzendophytica*	1	0.5	0.06	0.04	0.60	0.18	2.39
UC4126	*Pseudomonas japonica*	1	0.5	0.18	0.13	0.11	0.42	2.33
UC4122	*Pseudomonas taiwanensis*	1	0.75	0.00	0.03	0.20	0.22	2.20
UC4125	*Delftia tsuruhatensis*	1	0	0.01	0.01	0.75	0.28	2.05
UC4102	*Chryseobacterium ureilyticum*	0	0.25	0.04	0.03	0.74	0.98	2.04
UC4120	*Chryseobacterium rhizosphaerae*	0	0	0.18	0.02	0.82	0.97	1.99
UC4086	*Klebsiella oxytoca*	0	0.5	0.54	0.31	0.42	0.19	1.96
UC4112	*Pseudomonas taiwanensis*	1	0.5	0.01	0.03	0.17	0.23	1.95
UC4081	*Chryseobacterium oranimense*	0	0.25	0.04	0.03	0.66	0.91	1.89
UC4083	*Stenotrophomonas acidamiphila*	0	0	0.05	0.04	0.77	0.75	1.61
UC4107	*Sphingobacterium canadense*	0	0	0.06	0.02	0.46	1.00	1.54
UC4108	*Chryseobacterium rhizosphaerae*	0	0	0.04	0.03	0.65	0.81	1.53
UC4080	*Sphingobacterium detergens*	0	0	0.04	0.01	0.45	0.79	1.29
UC4121	*Sphingobacterium siyangense*	0	0	0.00	0.00	0.40	0.87	1.27

w/Try and w/o Try stands for with or without DL-Tryptophan.

CONCLUSIONI E PROSPETTIVE

- Meccanismi di azione dei biostimolanti microbici in larga parte conosciuti (magia → scienza)
- Numerose le evidenze sperimentali di efficacia
- Ampi spazi per la scoperta ed applicazione di nuovi biostimolanti
- Eterogeneità di prodotti attualmente sul mercato (**controlli**)
- Strumenti **complementari** all'utilizzo di fertilizzanti e fitofarmaci
- Ricerca necessaria per calibrare ed ottimizzare modi di produzione ed impiego, dosi di applicazione e co-applicazione con fertilizzanti e fitofarmaci
- Occorre una regolamentazione più ampia, efficace ed al passo con gli avanzamenti scientifici nel settore