Benefits of sustainable strategies on nutrient management in orchards and vineyards

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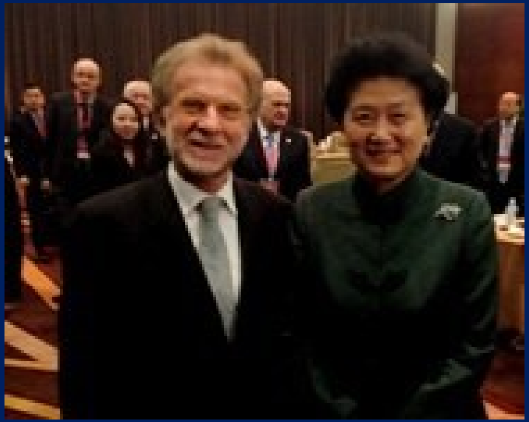
ALMA MATER STUDIORUM
UNIVERSITY OF BOLOGNA

Founded in 1088, the University of Bologna has 920 years of history.

Multicampus Structure (Bologna, Forlì, Cesena, Ravenna, Rimini).

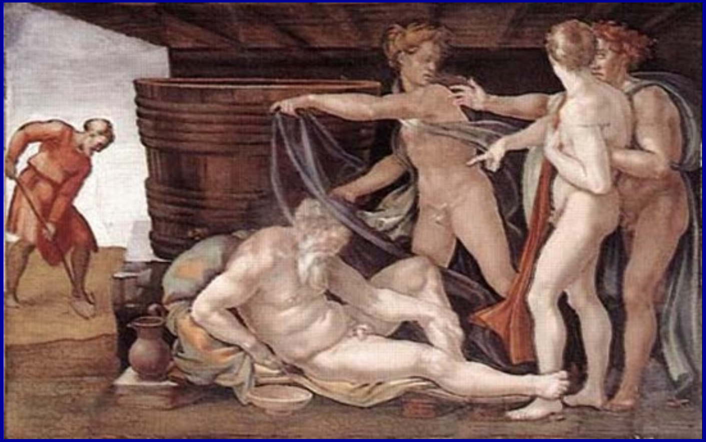


Friendship with China

Department of Agricultural Sciences

BACHELOR COURSE OF VITICULTURE AND ENOLOGY


ABBÉ FETEL



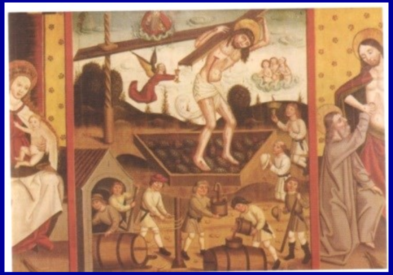
Mar Mediterráneo












OUTLOOK OF THE TALK

1) **Enhancement of NUE**

2) **Fe chlorosis: Intercropping**

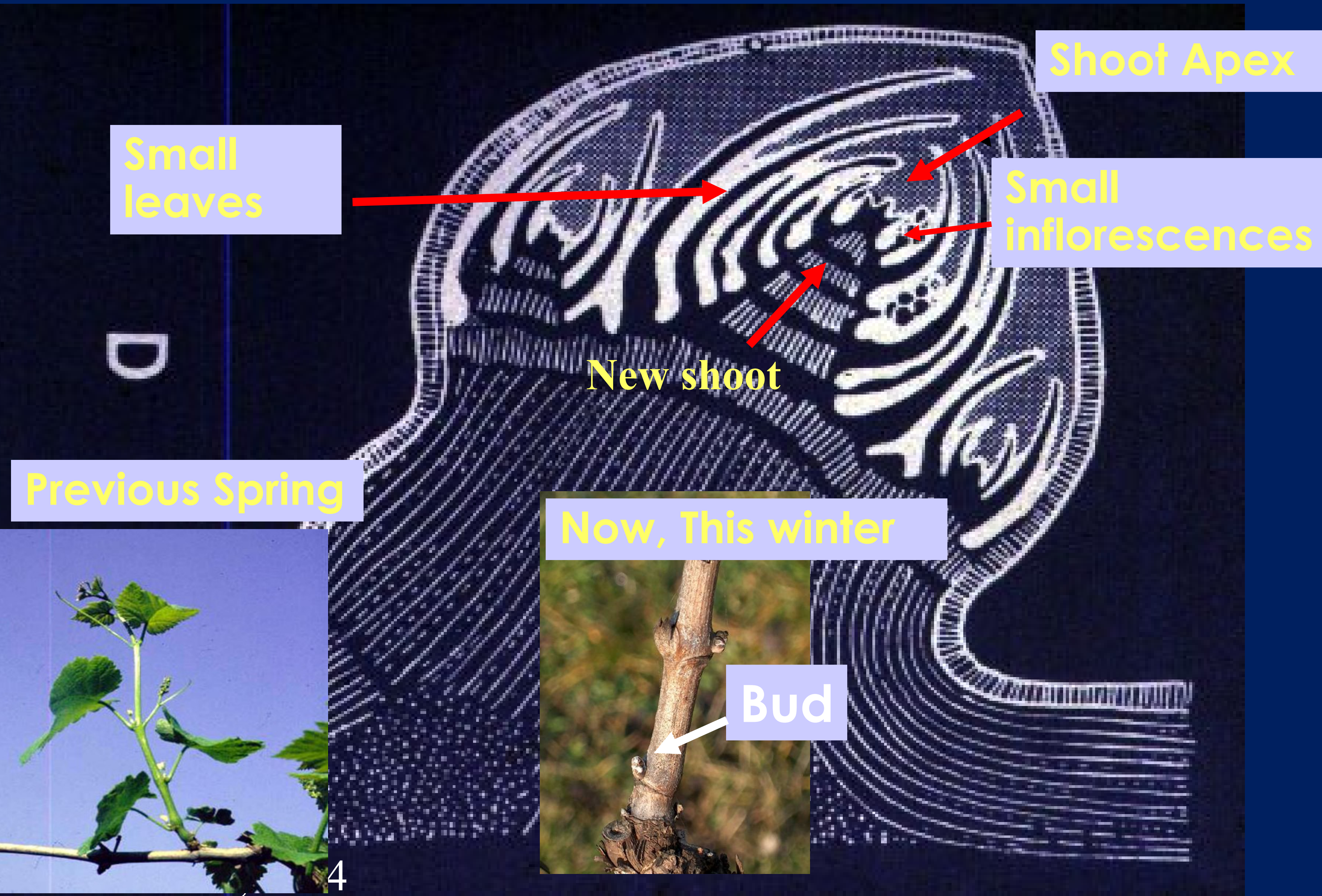
3) **HSAS: Soil Management**

4) **HSAS: Canopy Management**

SUSTAINABILITY

FRUIT TREES

Section of a grapevine bud (during winter)



In Late Summer/Beginning of Autumn:
High Nutrient Efficiency of Leaf-applied N

Storage of N in the permanent organs

Effect of post-harvest N supply on the concentration of N (% M.S.) in perennial organs of peach trees (cv. *Elegant lady* / PS B2)

TREATMENTS	1994			1995		
	branches	*roots*	*buds*	*branches*	*roots*	*buds*
Control	*1.08 a*	*1.40 b*	*2.14 a*	*1.03 b*	*0.98 b*	*1.89 a*
Ammonium nitrate	*1.22 a*	*1.56 ab*	*2.30 a*	*1.17 ab*	*1.14 ab*	*2.03 a*
Foliar –applied Urea (3%)	1.09 a	1.54 ab	2.18 a	1.12 ab	1.08 ab	1.91 a
Fertilzer + Nitrif. inibitor	1.17 a	1.70 a	2.17 a	1.26 a	1.21 a	1.98 a
Slow release fertilizer	1.21 a	1.63 a	2.21 a	1.24 a	1.27 a	2.05 a

Rombolà et al., 1995

Amounts (kg/ha) of nutrients taken up in one year in a mature apple orchard - cv. Mondial Gala (Yield ~ 40 t / ha)

	N	P	K	Mg	Ca
Permanent structure	6	1	4	1	8
Leaves	16	2	27	8	46
Pruning wood	17	3	11	3	19
Fruits	22	5	42	7	3
Total	61	11	84	19	76

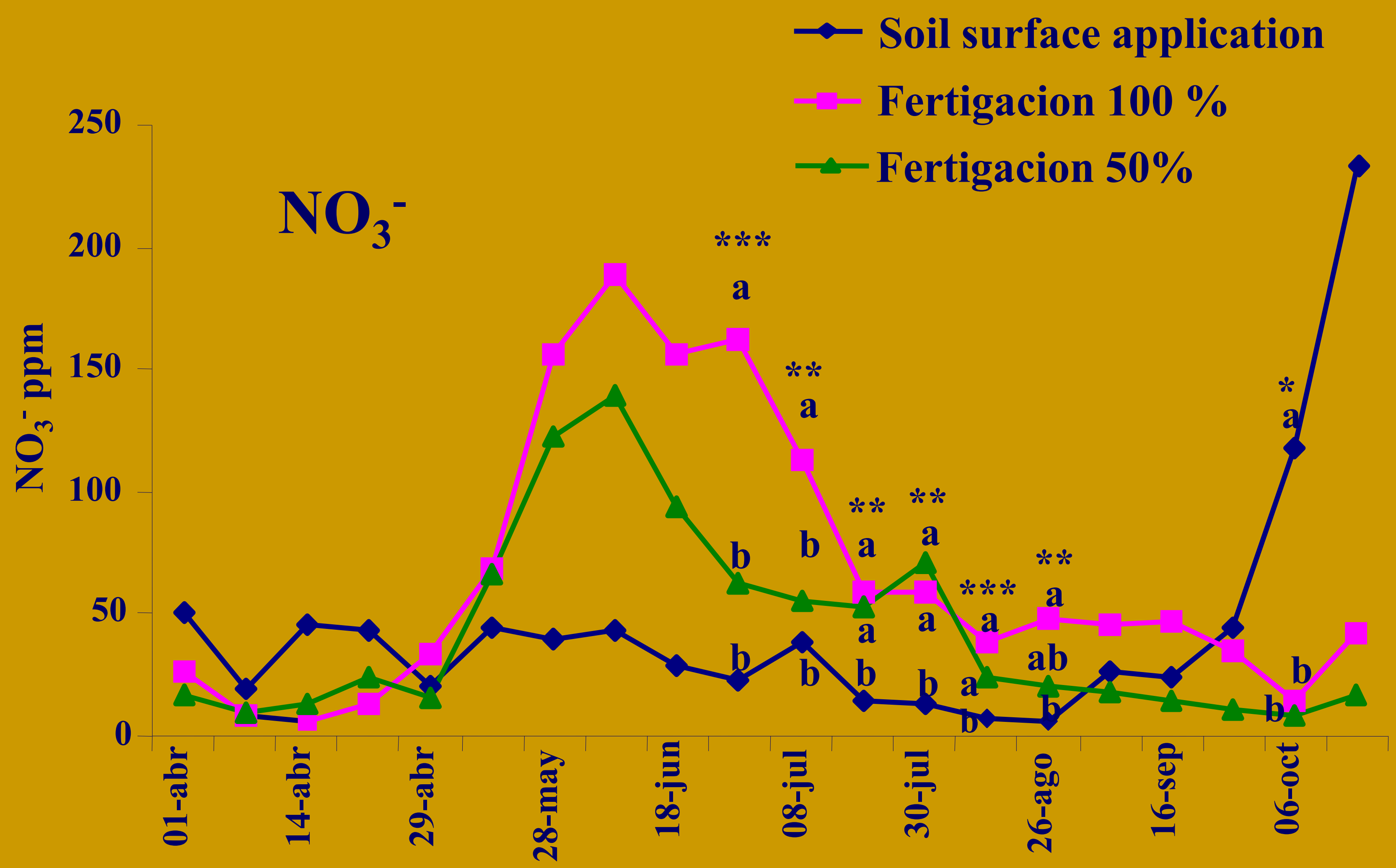
Tagliavini

In adult trees, the amounts of nutrients demanded for the development of perennial organs are relatively small.

Pruning wood and leaves are recycled in the orchard.

Removals are mainly due to fruits.

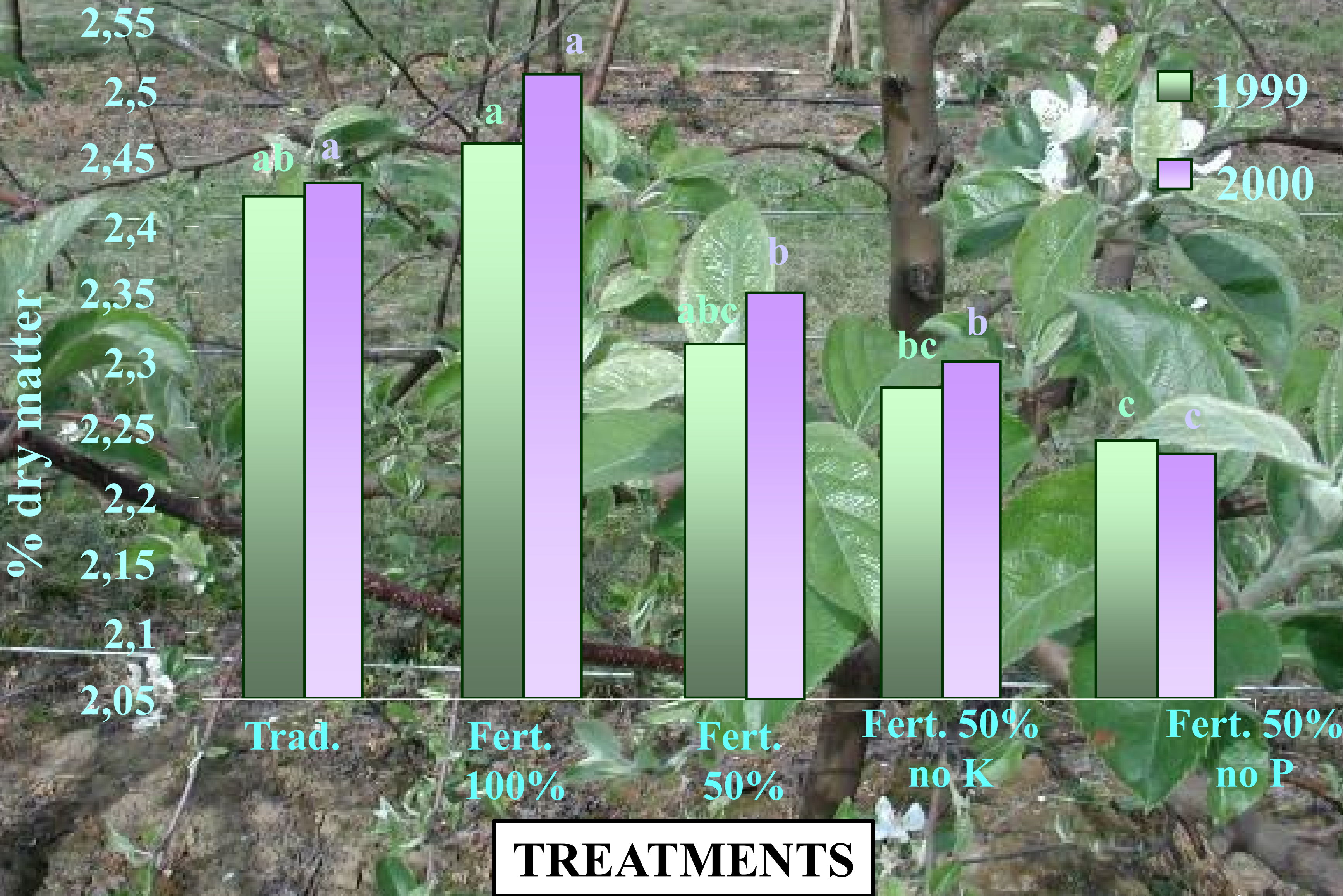
Concentration of nitrate in the soil solution of an apple orchard



Rombolà et al., 2000

ORCHARD MANAGED BY FURROW IRRIGATION

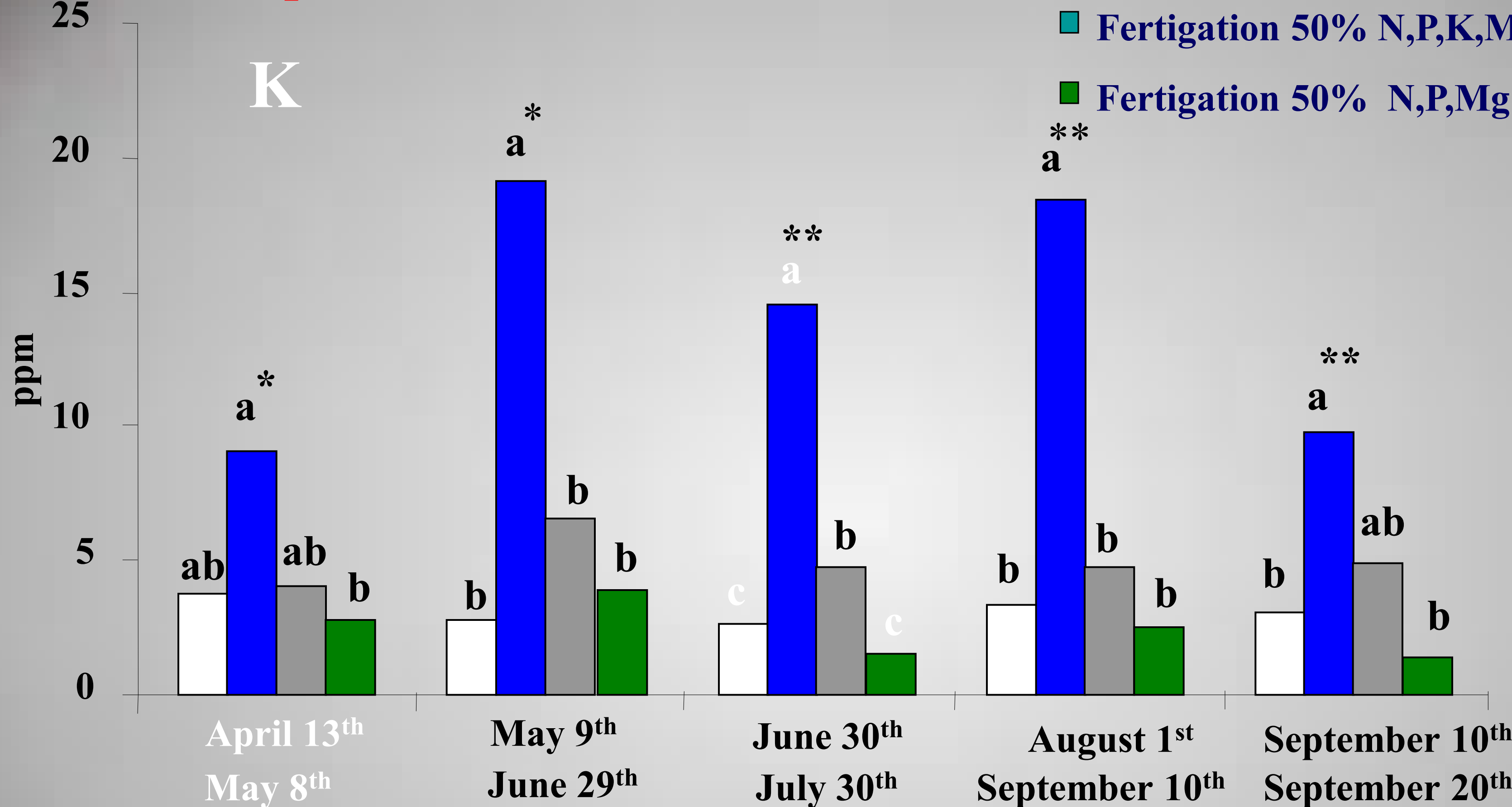
Nitrogen in the leaves (Apple cv. Gala)



Malaguti et al., 2006

DEFICIENCY OF POTASSIUM

Fertigation improve the movement of K in the soil profile



LEAF ANALYSIS

CULTIVAR FUJI

%K/ms	0,86 b	0,95 a	0,94 a	0,83 b	**

Malaguti et al., 2006

Concentration of K in leaves at veraison

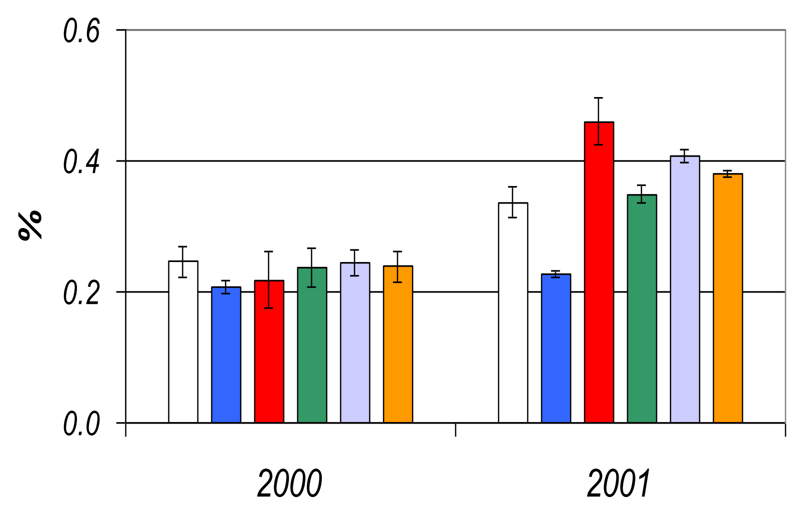
Treatments	Exchangeable K in soil (mg kg soil)		K in leaves at veraison		
	5-30cm	30-60cm	1998	1999	2000
Non-irrigated Control	227b	207b	0.69b	0.71b	0.66
Irrigated-Control	223b	176b	0.82a	0.83a	0.61
K 150 kg/ha	508a	223ab	0.89a	0.82a	0.68
K 300 kg/ha	559a	281a	0.86a	0.83a	0.67
Significance	*	*	***	***	ns

Potassium nutrition in grapevine is improved by irrigation

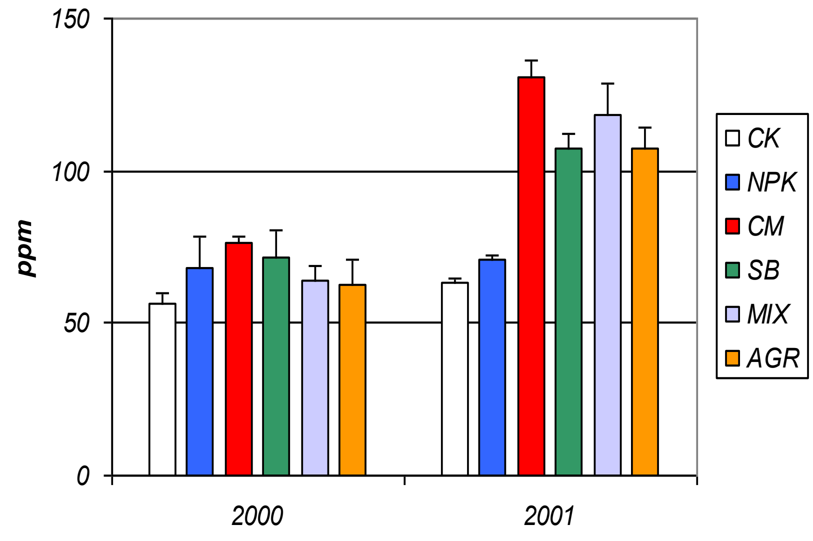
Rombolà et al., 2006

Mg deficiency induced by K fertilization

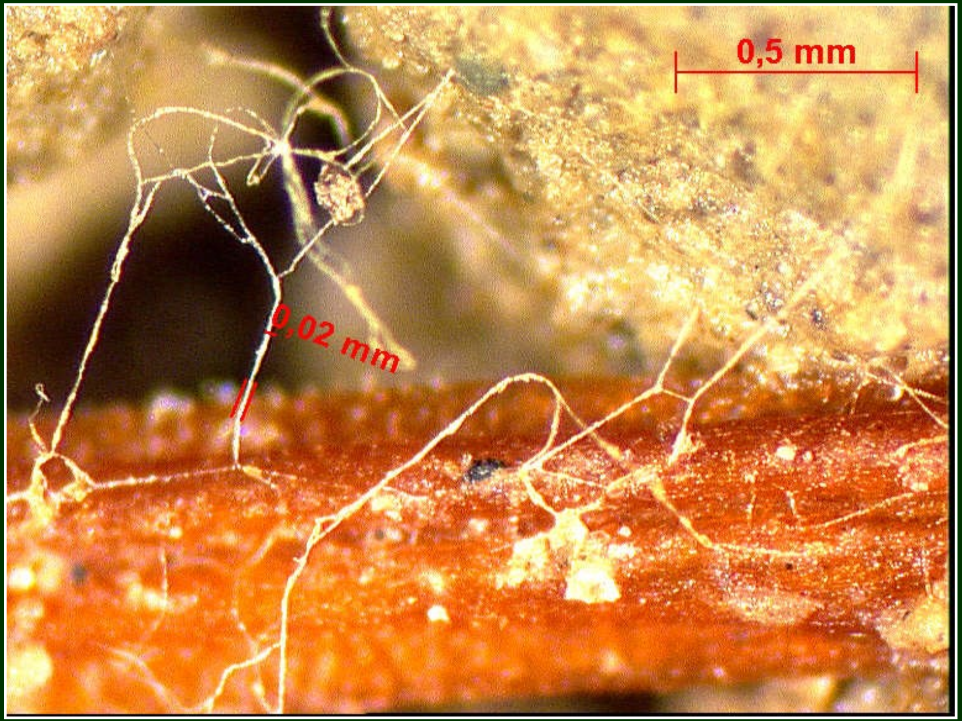
Phosphorous in leaves



Phosphorous in the soil



P availability is mainly enhanced by organic fertilization and the presence of *mycorrhizae*



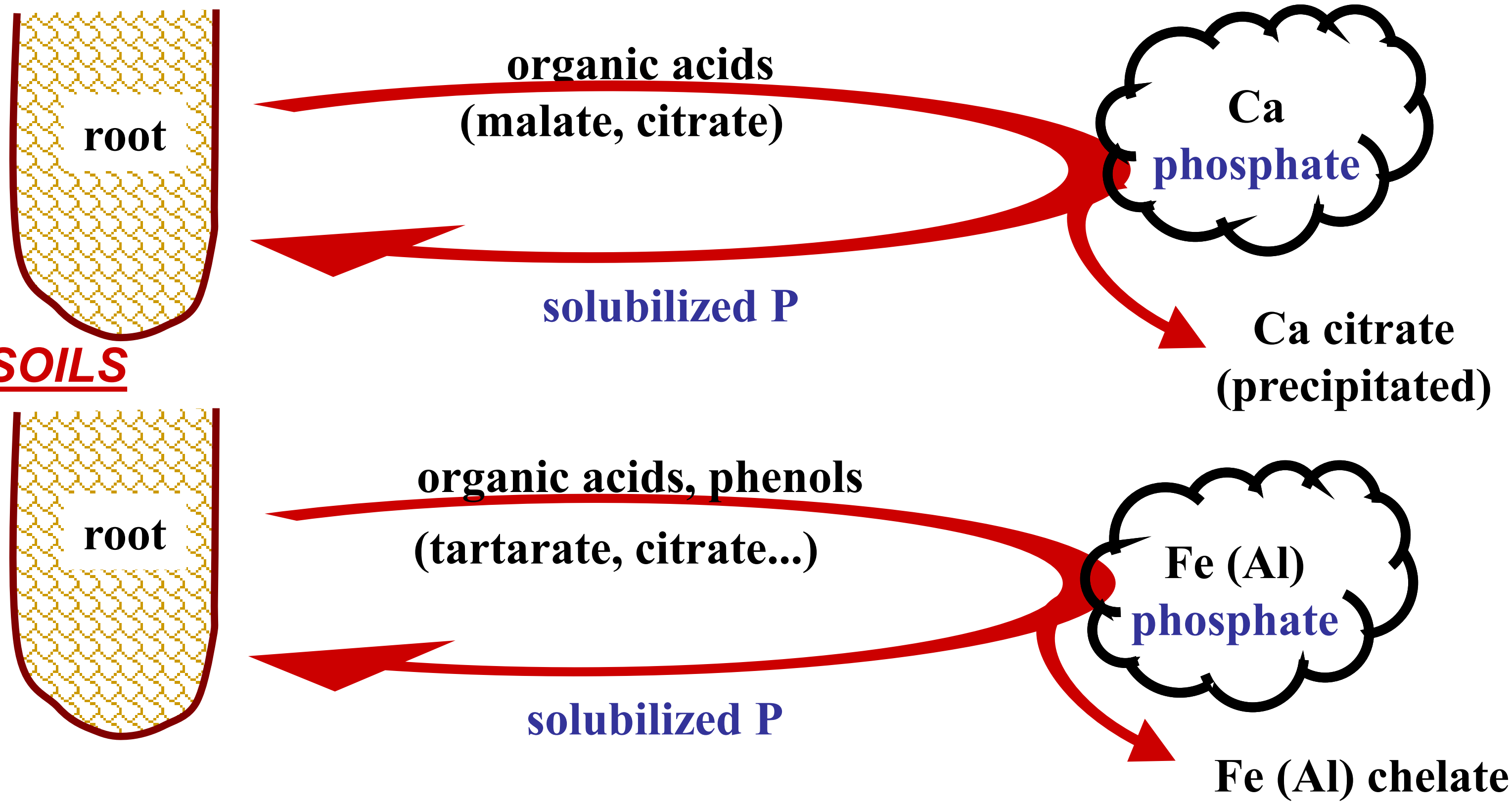
Mazzanti et al., 2001

Lupin (*Lupinus spp.)*

DIPARTIMENTO SCIENZE AGRARIE

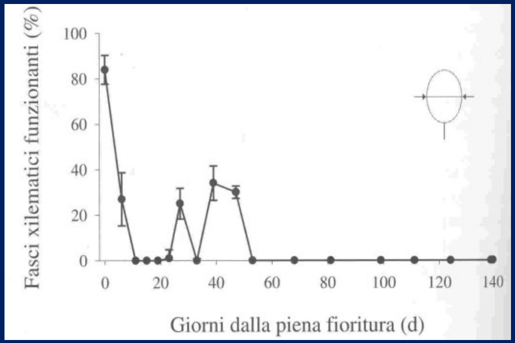
P mobilization in the rhizosphere:
Significance of root exudates

CALCAREOUS SOILS



Organic acids release increases under P deficiency!

CALCIUM



- ***Leaf treatments***
- ***Balance between vegetative growth and productivity***
- ***Reduction of NH_4^+ and K^+ supply in early spring (competicion)***

Reduction of cracking in cherry fruits by canopy applied-silicon

▲ ▶ *Fig. 1 - Lo spacco compromette irrimediabilmente la commerciabilità del prodotto.*

▲ *Fig. 4 - Le infezioni di Monilia sulle ciliegie sono favorite dalla presenza di frutti spaccati. Nella foto, evidenti sintomi di Monilia sui frutti della cv New Star in prossimità della raccolta.*

TAB. 2 - PROVA 1: EFFETTO DEI TRATTAMENTI SULL'INCIDENZA DEI FRUTTI SPACCATI E SULLA TIPOLOGIA DELLO SPACCO (DATI ESPRESSI IN PERCENTUALE).

Trattamento	Incidenza totale dello spacco sui frutti	Spacco apicale	Spacco peduncolare	Spacco dorsale
Controllo	27,9 a	58	36	6
Cloruro di calcio	13,4 b	74	26	0
Silicato di sodio	13,3 b	58	42	0
Significatività	*[1]	*ns*	*ns*	*ns*

[1] * e ns: significativo per $P \leq 0,05$ e non significativo
All'interno di ogni colonna, valori contrassegnati da lettere diverse differiscono statisticamente tra loro.

TAB. 3 - PROVA 1: EFFETTO DEI TRATTAMENTI SUL PESO MEDIO E SULLA DUREZZA DEL FRUTTO PRIVATO O MENO DELLA BUCCIA.

Trattamento	Peso medio del frutto (g)	Durezza del frutto[2] (kg cm^{-2})	
		con buccia	senza buccia
Controllo	10,2 a	0,8	0,45
Cloruro di calcio	9,3 ab	0,9	0,46
Silicato di sodio	9,0 b	0,9	0,49
Significatività	*[1]	*ns*	*ns*

[1] * e ns: significativo per $P \leq 0,05$ e non significativo
All'interno di ogni colonna, valori contrassegnati da lettere diverse differiscono statisticamente tra loro.
[2] Valori determinati mediante l'impiego del penetrometro (Effegi, FT 011, puntale ø 5 mm) utilizzando una scala di 5 e 1 kg cm^{-2} rispettivamente per i frutti con e senza buccia.

Rombolà et al.

FE-CHLOROSIS

SYNTHETIC IRON CHELATES

•Enviromental impact

•Potential hazards for human health

•Possible restrictions in the future

Fe chelates do not represent a sustainable approach!

Fe chelates effectiveness
may be improved

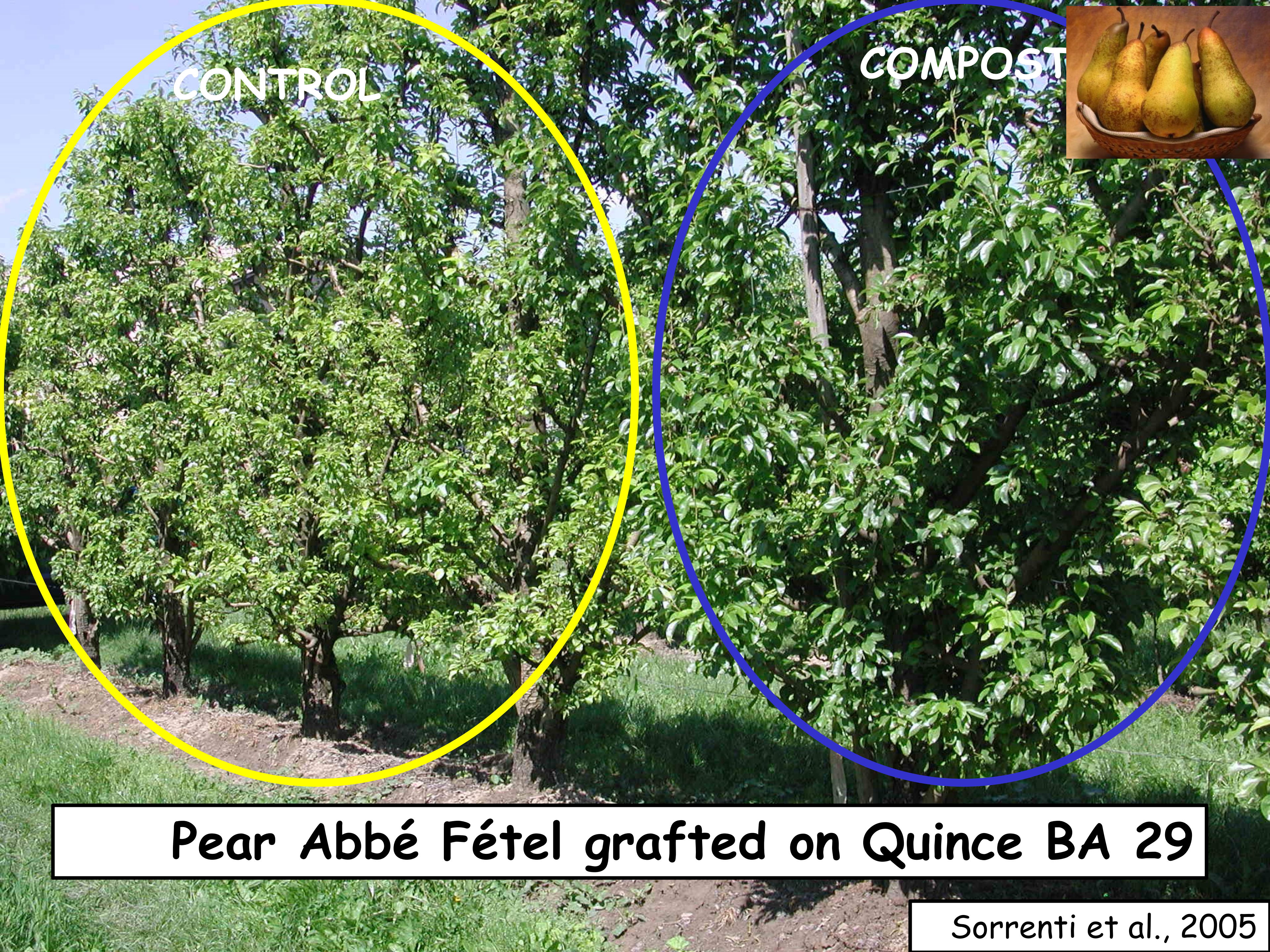
⇓ Optimal timing
of application

⇓ Frequent application of
small rates (fertigation)

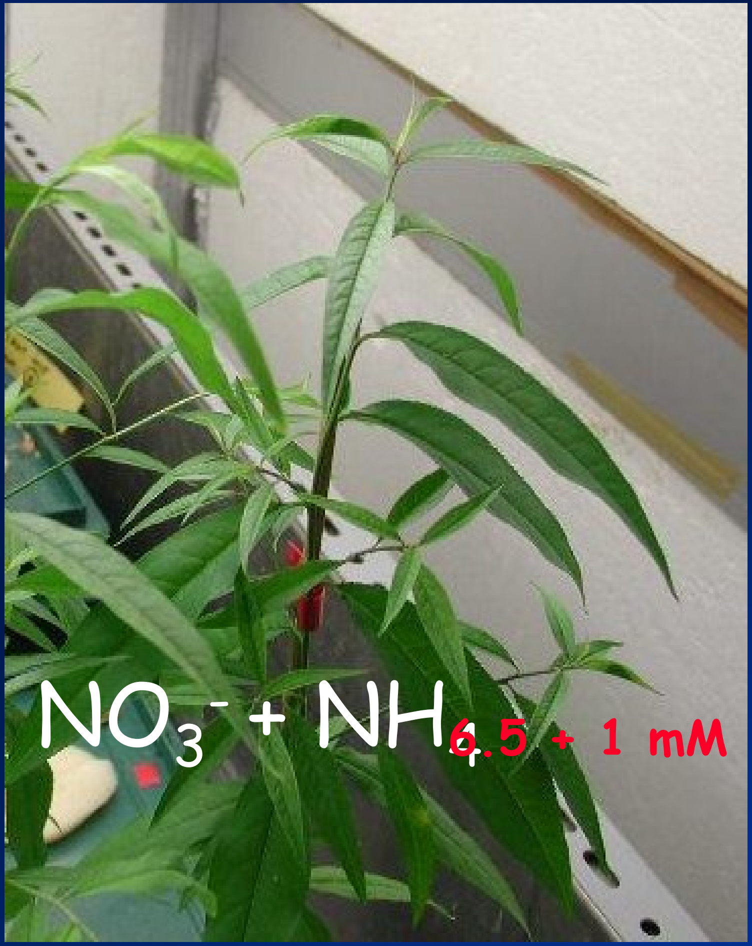

FOLIAR TREATMENTS

LEAF TREATMENTS

Re-greening induced by acidic solutions (e.g. citric, sulphuric, ascorbic acids): are not satisfactory to justify their practical adoption

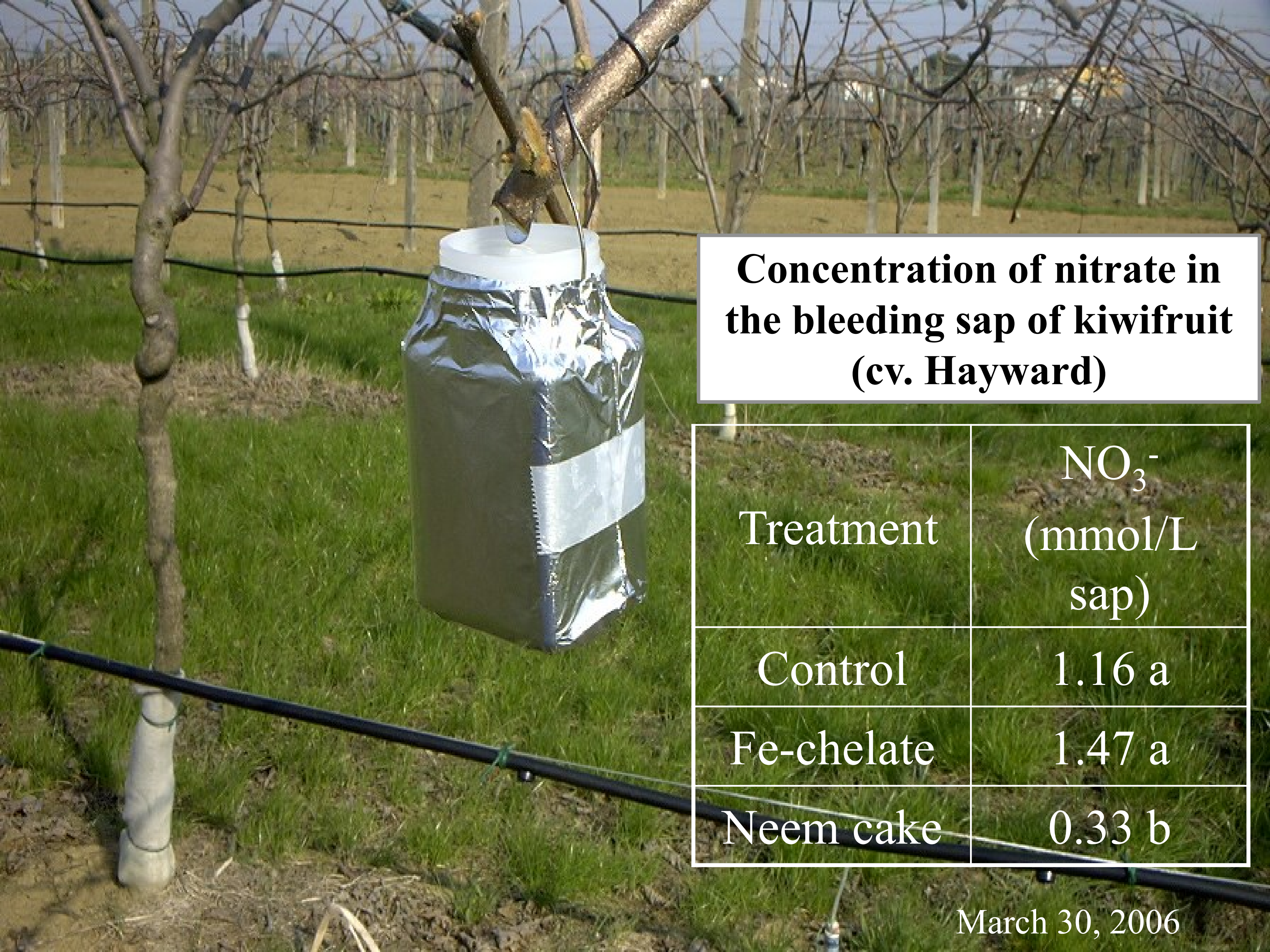

CONTROL
COMPOST
Pear Abbé Fétel grafted on Quince BA 29
Sorrenti et al., 2005

Nitrate-induced Fe deficiency chlorosis



Rationalization of nitrogen nutrition
Possible use of nitrification inhibitors

Kosegarten et al., 2004

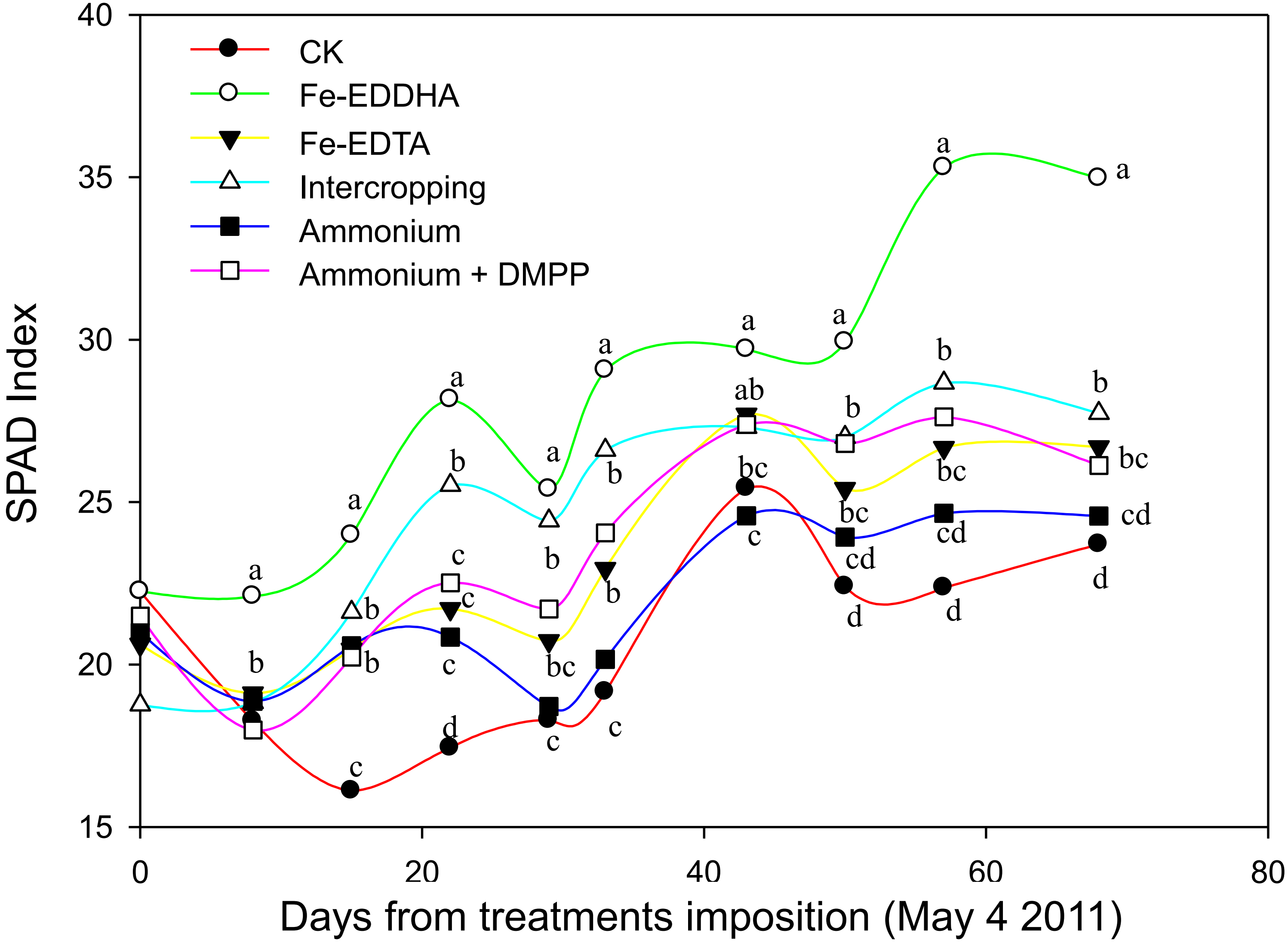


Concentration of nitrate in the bleeding sap of kiwifruit (cv. Hayward)

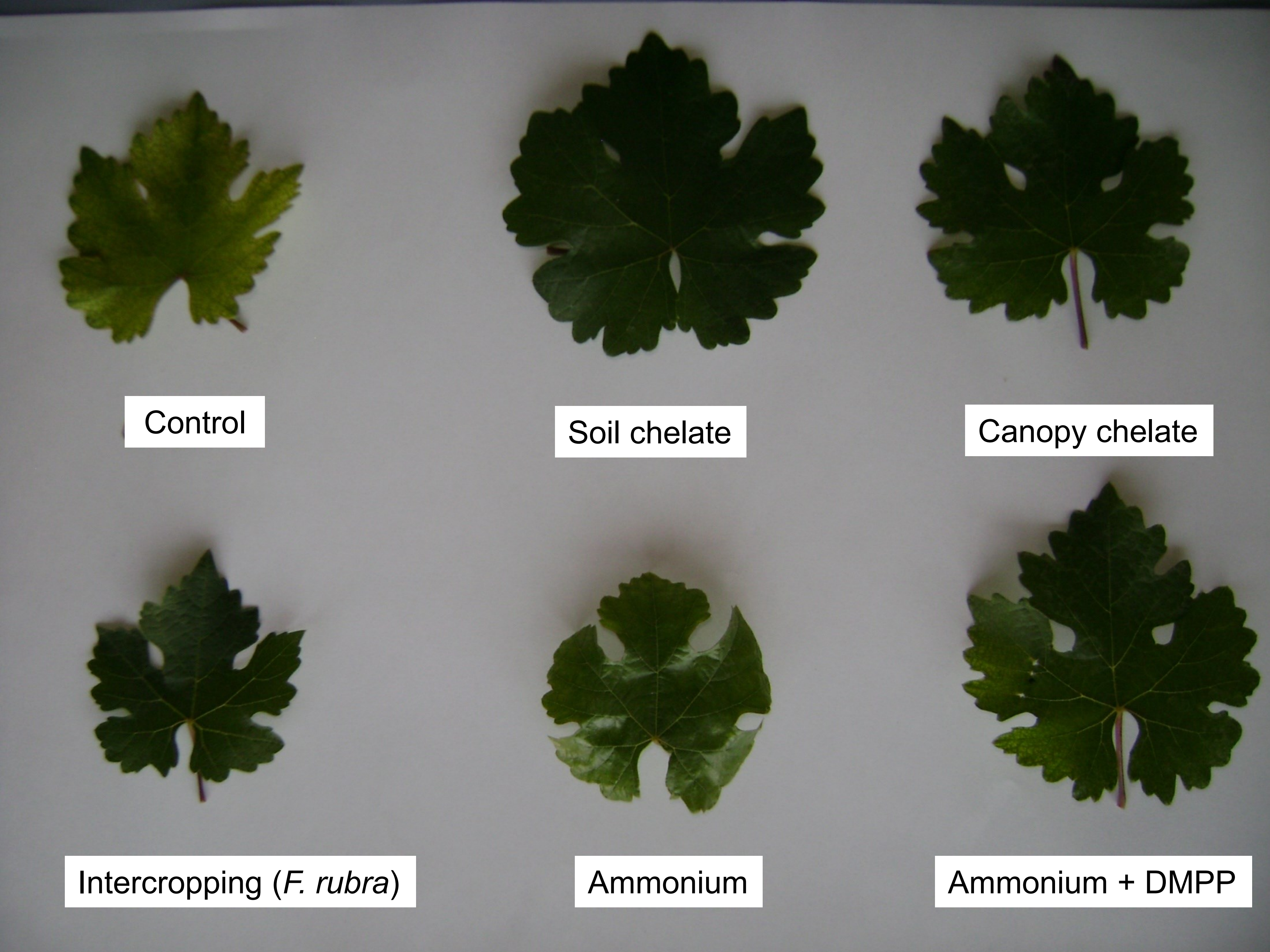
Treatment	NO_3^- (mmol/L sap)
Control	1.16 a
Fe-chelate	1.47 a
Neem cake	0.33 b

March 30, 2006

Effect of a nitrification inhibitor (DMPP) on leaf chlorophyll content (Grapevine, cv. Cabernet Sauvignon)



Covarrubias et al., 2014

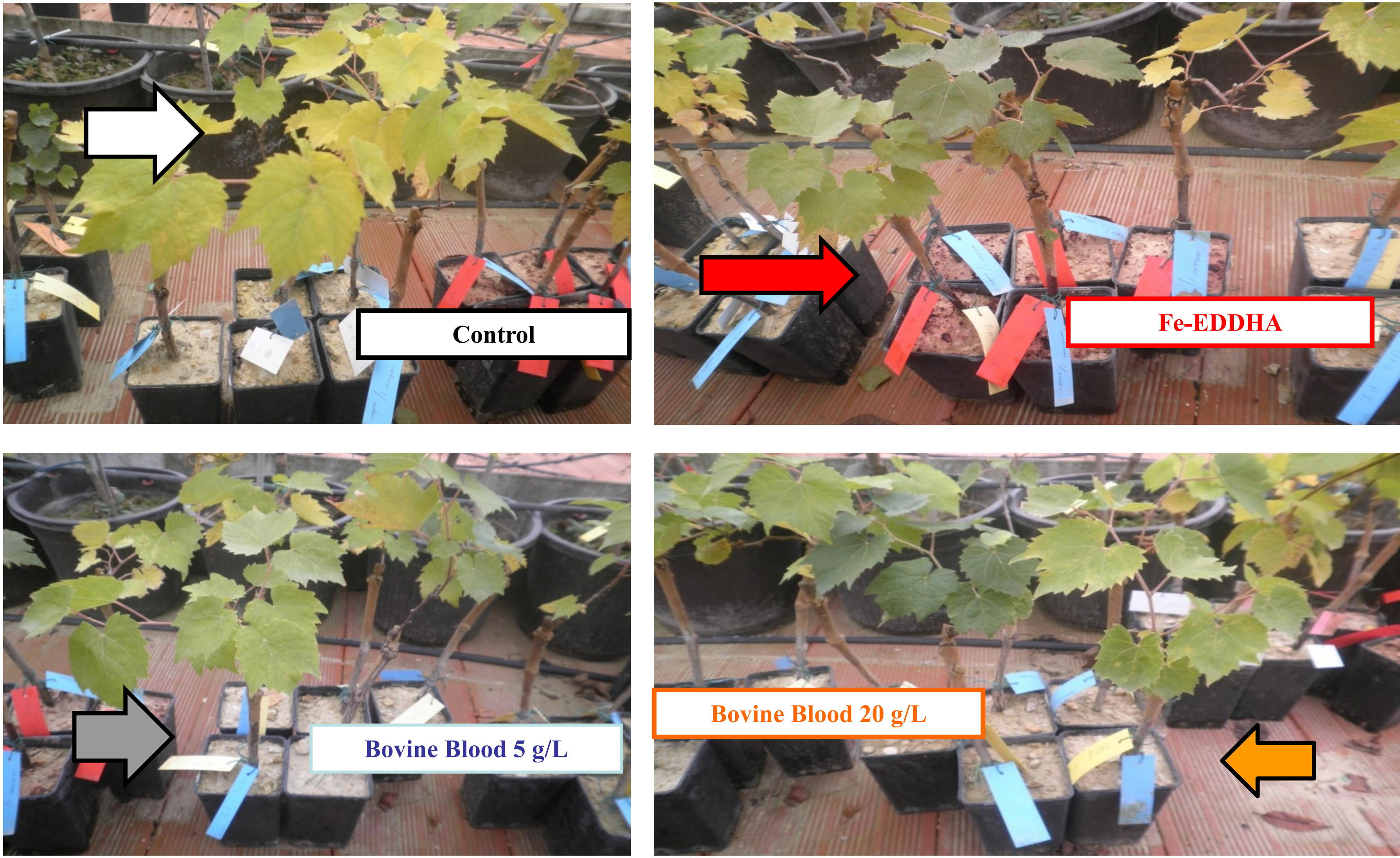

Control
Soil chelate
Canopy chelate
Intercropping (*F. rubra*)
Ammonium
Ammonium + DMPP

RESEARCH ON FE-HEME FERTILIZERS

- Chemical characterization
- Interaction with the soil
- Evaluation of the effectiveness
- Interactions with the roots and the rhizosphere

YUNTA F., DI FOGGIA M., BELLIDO V., MORALES M., TESSARIN P., LÓPEZ-RAYO S., TINTI A., KOVÁCS K., KLENCSÁR Z., FODOR F., **ROMBOLÀ A.D.**, 2013. Blood meal-based compound. Good choice as iron fertilizer for organic farming. **Journal of Agricultural and Food Chemistry** 61: 3995-4003.
LOPEZ-RAYO S., DI FOGGIA M., BOMBAI G., YUNTA F., RODRIGUES MOREIRA E., G. FILIPPINI G., PISI A., **ROMBOLA' A.D.**, 2015. Blood-derived compounds can efficiently prevent iron deficiency in grapevine. **Australian Journal of Grape and Wine Research**, 21: 135-142.
LÓPEZ-RAYO S., DI FOGGIA M., RODRIGUES MOREIRA E., BOMBAI G., PISI A., **ROMBOLÀ A.D.**, 2015. Physiological responses in roots of the grapevine rootstock 140 Ruggeri subjected to Fe deficiency and Fe-heme nutrition. **Journal of Plant Physiology and Biochemistry**, 96:171-179

EFFECTS OF A BOVINE-BLOOD DERIVED COMPOUND ON LEAF CHLOROPHYLL CONTENT



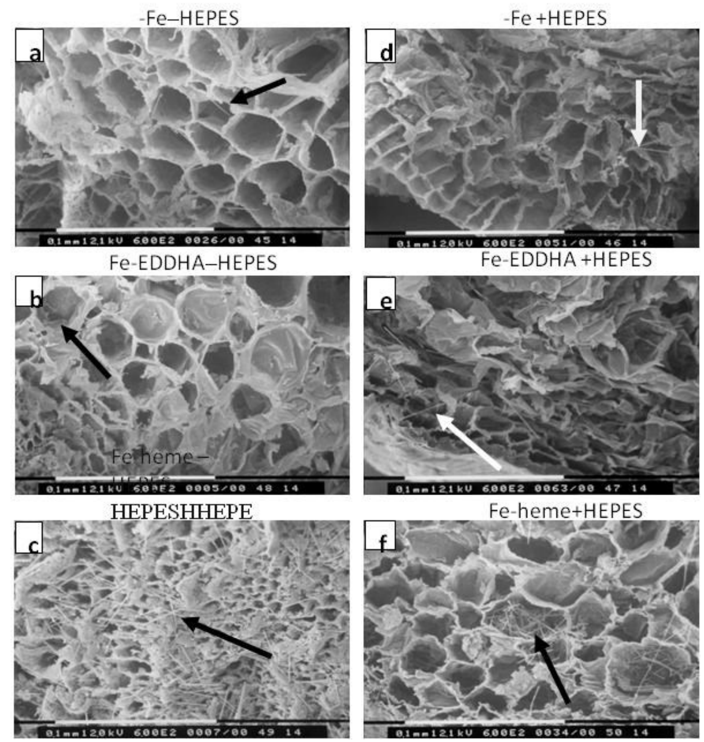
High efficiency of Bovine Blood in preventing Fe chlorosis in grapevine

López-Rayo et al., 2015

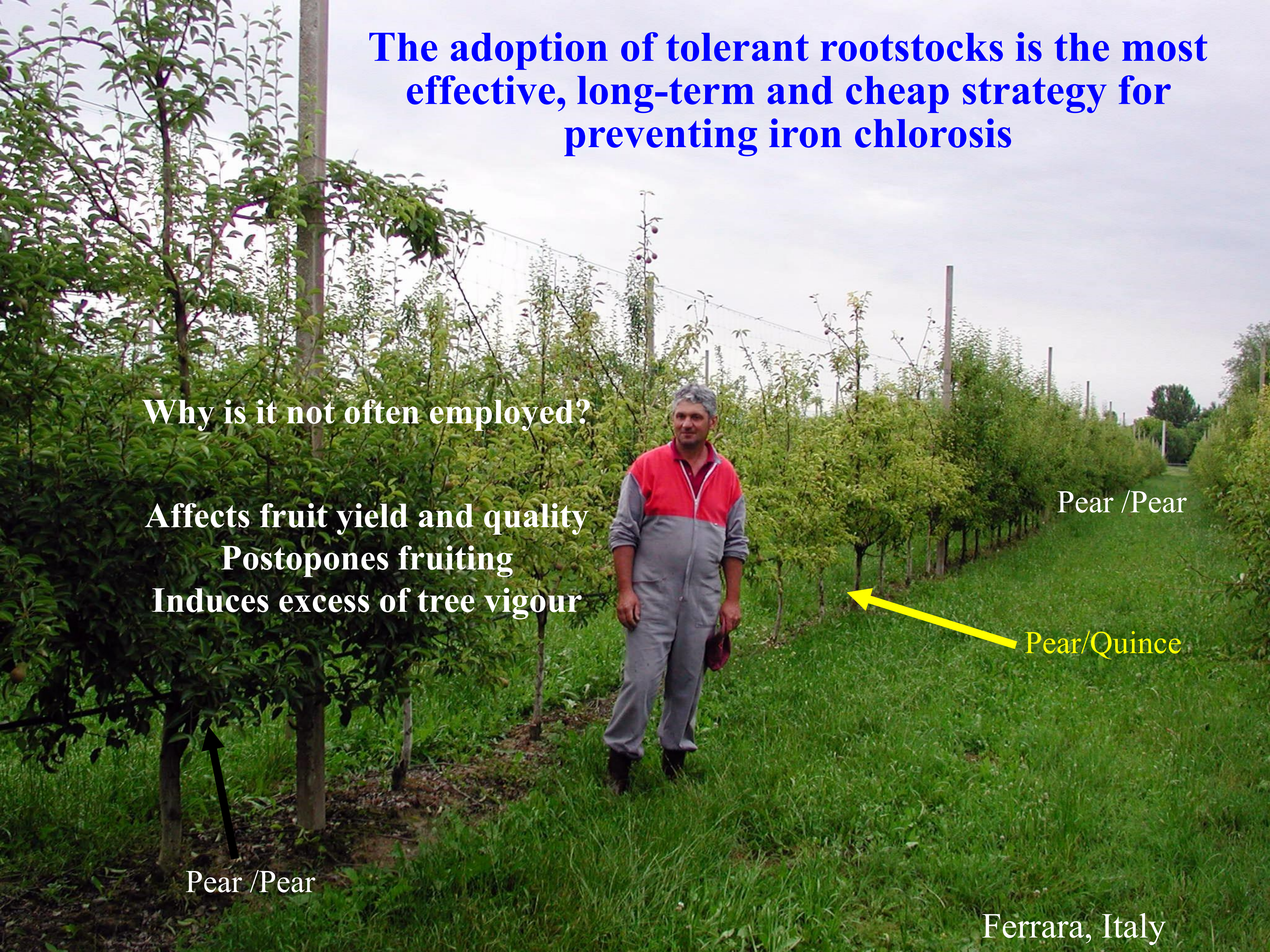
PHYSIOLOGICAL RESPONSES IN ROOTS OF THE GRAPEVINE ROOTSTOCK 140 RUGGERI SUBJECED TO FE-DEFICIENCY AND Fe-HEME NUTRITION

Treatment	Total Fe reduction	Not enzymatic Fe reduction	FCR
–HEPES			
-Fe	1.87 ± 0.26	0.96 ± 0.25	0.91 ± 0.25
FeEDDHA	1.46 ± 0.19	0.76 ± 0.24	0.86 ± 0.18
Fe-heme	3.22 ± 0.49	1.18 ± 0.46	2.05 ± 0.38
+HEPES			
-Fe	1.67 ± 0.35	0.74 ± 0.12	0.93 ± 0.26
FeEDDHA	2.91 ± 0.34	0.92 ± 0.28	2.00 ± 0.22
Fe-heme	2.66 ± 0.63	0.95 ± 0.15	2.31 ± 0.20
Statistics			
+HEPES/–HEPES	ns	ns	*
Fe treatments	*	ns	**
HEPES × Fe	*	ns	ns
SEM[a]	0.282		

Treatment	Oxalic acid	Tartaric acid	Malic acid	Ascorbic acid
–HEPES				
-Fe	2401 ± 592	36.6 ± 9.3	1.07±0.23	2.24±0.49
FeEDDHA	4549 ± 1161	101.5 ± 36.9	0.75±0.19	1.65±0.18
Fe-heme	766 ± 381	27.3 ± 6.2	1.08±0.35	0.86±0.14
+HEPES				
-Fe	4509 ± 1019	66.5 ±18.4	3.27±0.91	4.96±1.22
FeEDDHA	4662 ± 966	101.5 ± 25.7	2.43±0.93	1.86±0.48
Fe-heme	2661 ± 635	76.0 ±31.7	2.59±0.39	0.60±0.12
Statistics				
+HEPES/–HEPES	ns	ns	***	ns
Fe treatments	*	*	ns	*
HEPES× Fe	ns	ns	ns	ns

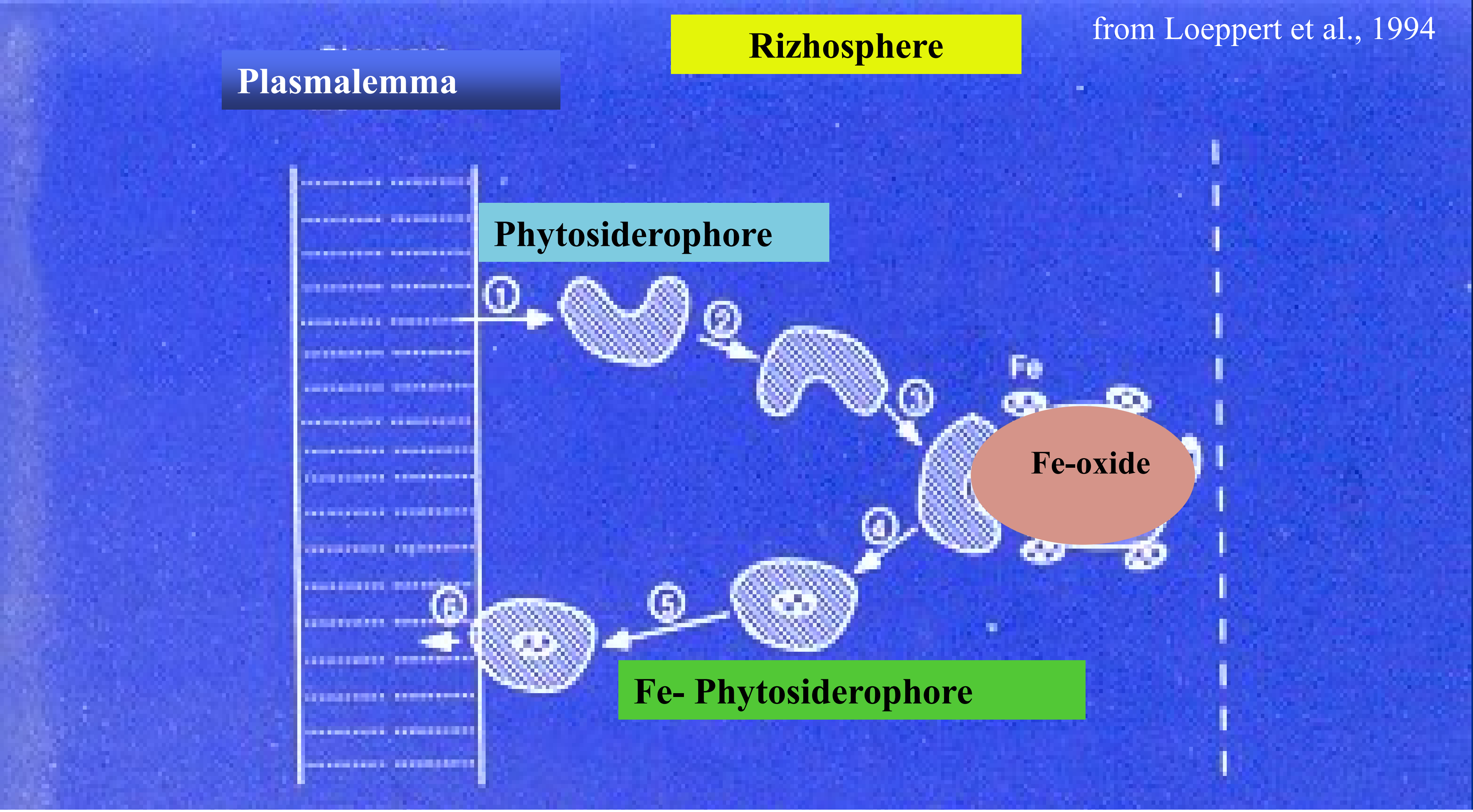


(Lopez-Rajo et al., 2015 PPB)


The adoption of tolerant rootstocks is the most effective, long-term and cheap strategy for preventing iron chlorosis
Why is it not often employed?
Affects fruit yield and quality
Postopones fruiting
Induces excess of tree vigour
Pear /Pear
Pear/Quince
Pear /Pear
Ferrara, Italy

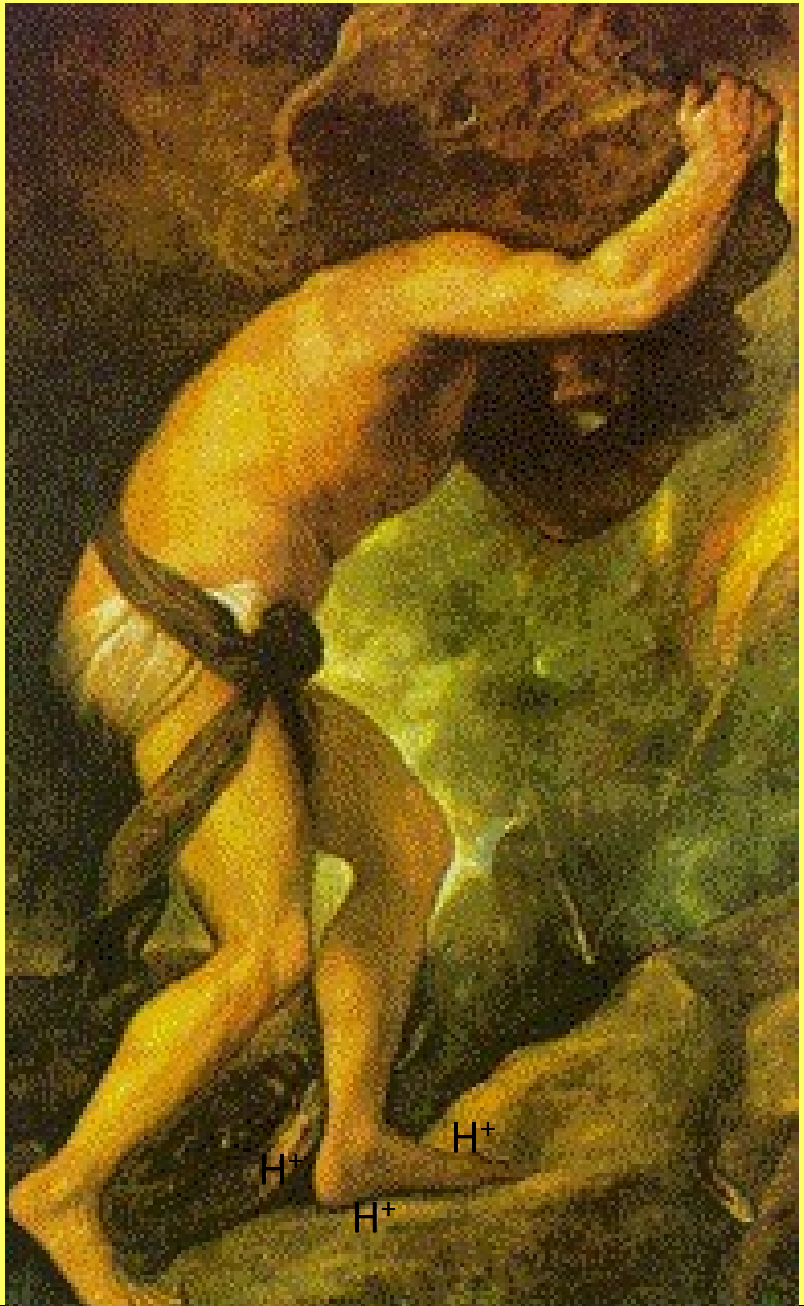
INTERCROPPING WITH PERENNIAL GRASSES


Lolium perenne
Festuca rubra
Poa pratensis


from Loeppert et al., 1994
Rizhosphere
Plasmalemma
Phytosiderophore
1
2
3
Fe
Fe-oxide
4
5
6
Fe- Phytosiderophore

STRATEGY II

STRATEGY I



STRATEGY II

PHYTOSIDEROPHORES

Festuca rubra : DMA

Lolium perenne : DMA, EpiHDMA, HDMA

Poa pratensis : DMA, AVA, HAVA

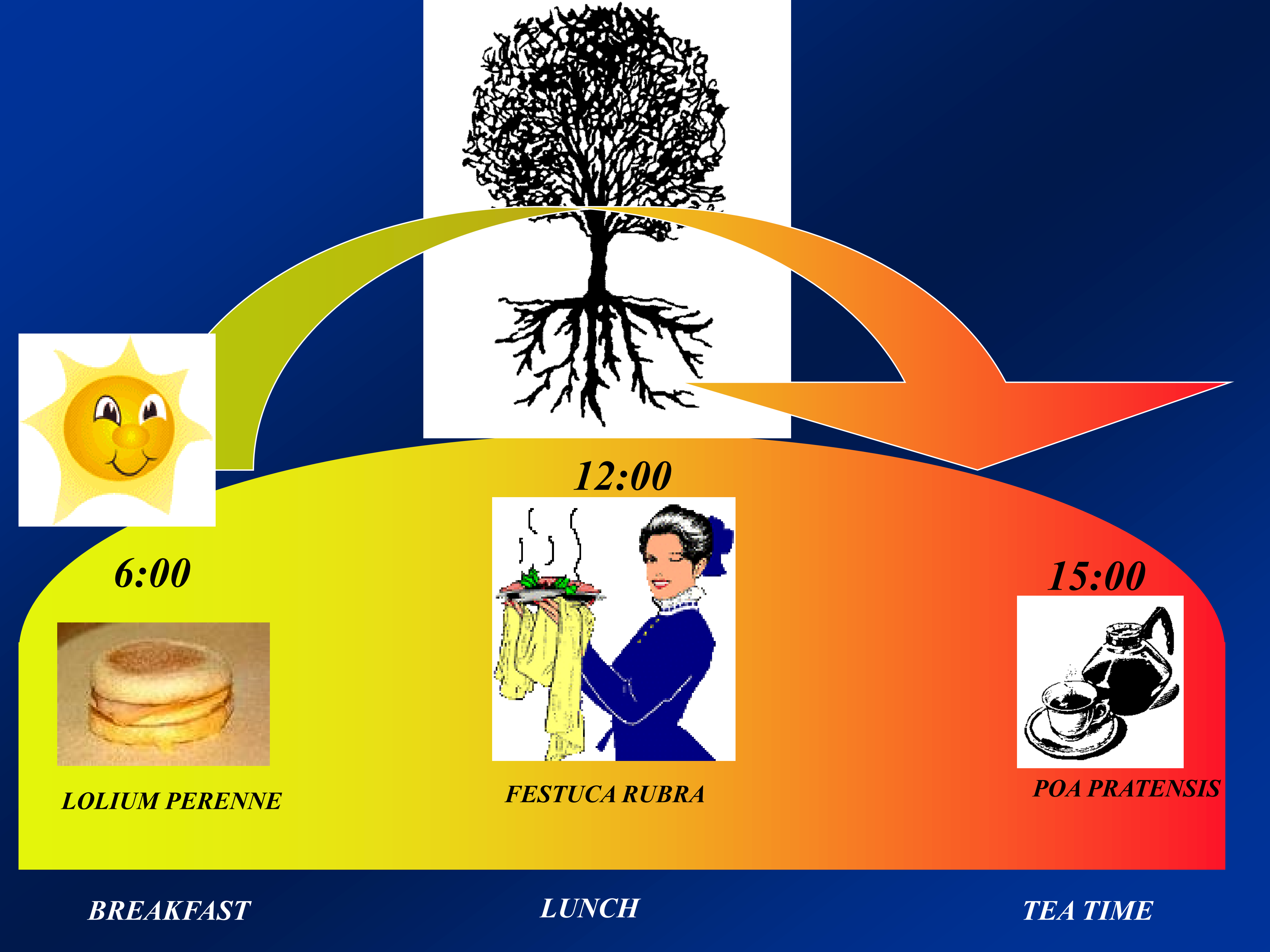
Ma et al., 2003, Ueno et al., 2007

Prevention of Fe chlorosis of kiwifruit by intercropping

TREATMENTS	Leaf Chlorophyll (SPAD units)	Shoot biomass (g)
Control	15.1 ± 1.8 b	17.2 ± 1.5 b
Fe–EDDHA	29.2 ± 0.4 a	26.3 ± 2.3 a
Festuca rubra c.	25.5 ± 1.3 a	21.9 ± 2.4 ab
Lolium perenne	28.3 ± 0.7 a	24.4 ± 1.8 ab
Poa pratensis	25.8 ± 3.3 a	28.2 ± 2.7 a
(Festuca+Lolium+Poa)	27.9 ± 0.6 a	21.7 ± 2.0 ab
Significance	***	*

Rombolà et al., 2003

Orchard floor management

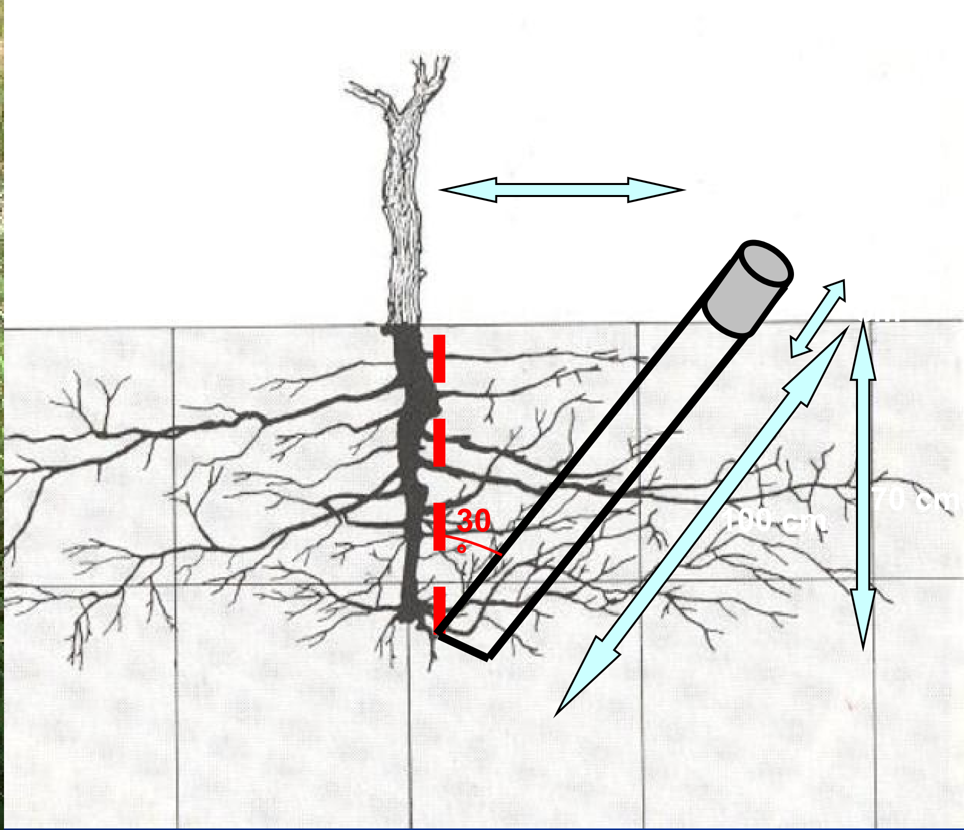

12:00
6:00
15:00
LOLIUM PERENNE
FESTUCA RUBRA
POA PRATENSIS
BREAKFAST
LUNCH
TEA TIME


Neem
Compost
Vivianite
Control
Fe-chelate
Intercropping

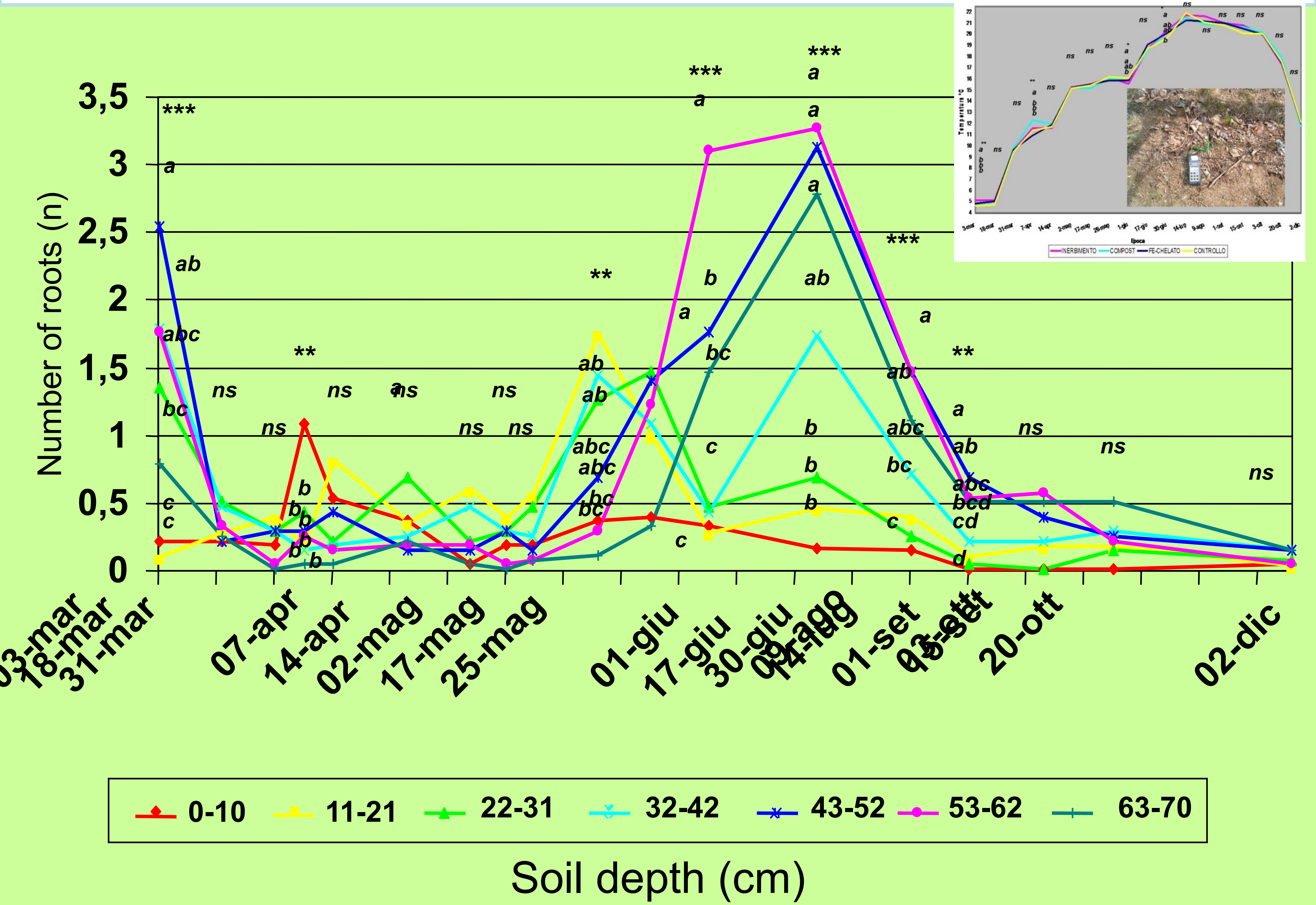
ROOT INTERACTIONS UNDER FIELD CONDITIONS

Faenza, Ravenna, Italy, 2005

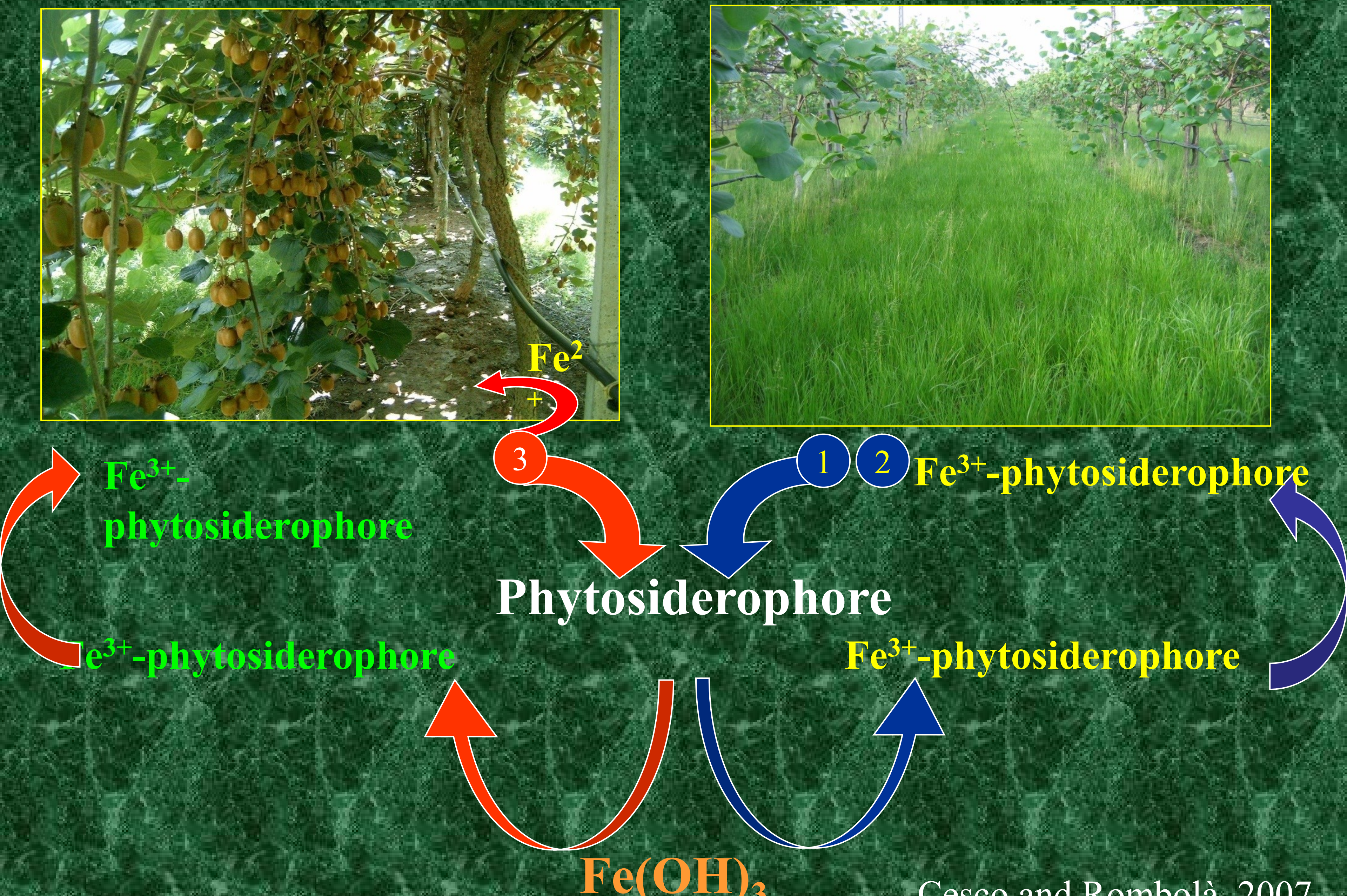
MINIRHIZOTRON



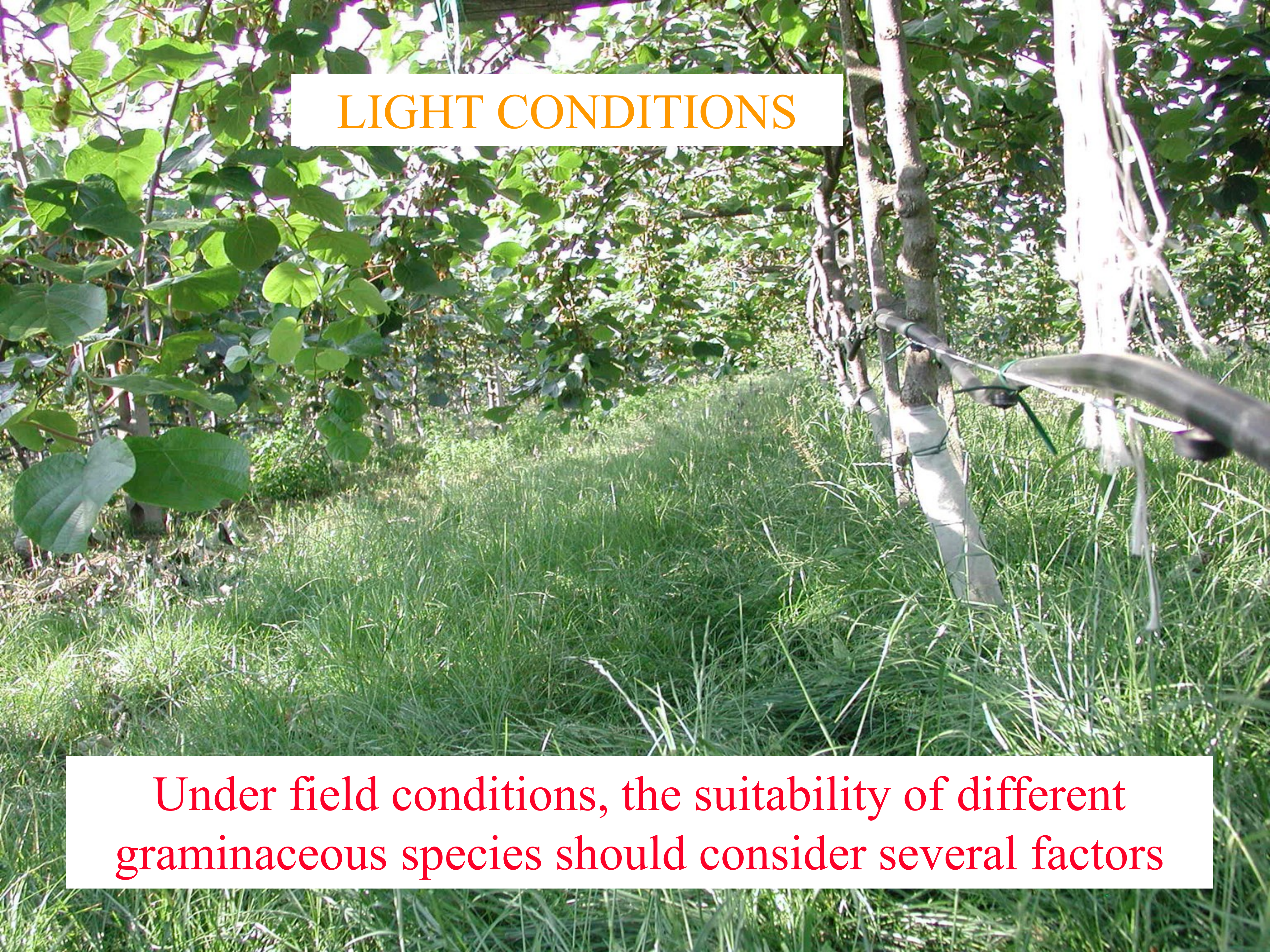
Effect of soil depth on new roots emission



Proposed action of MAs on the nutrition of intercropped plants



Cesco and Rombolà, 2007


LIGHT CONDITIONS
Under field conditions, the suitability of different graminaceous species should consider several factors

Root density of different graminaceous species

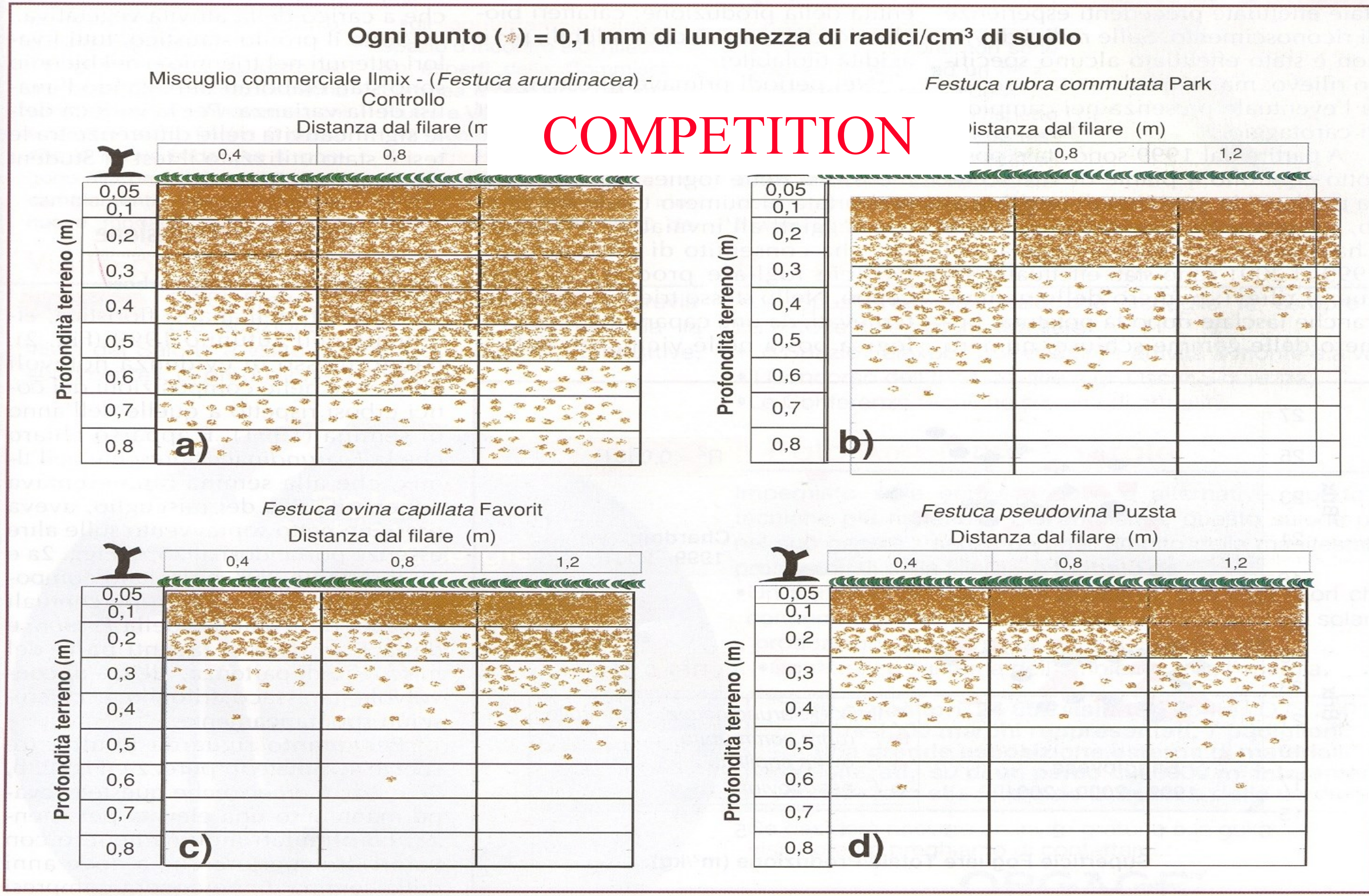


Fig. 4 - Rappresentazione schematica della densità radicale a diverse distanze dal filare e a varie profondità del suolo, rilevata nel 1999 nelle varietà di specie erbacee utilizzate nella prova.

Intrieri et al., 2005

LAWN MANAGEMENT TECHNIQUES


Control
Festuca rubra
Fe-CHELATE
Controllo
Festuca rubra
Fe-chelato
Ammari and Rombolà, 2010

HIGHLY SUSTAINABLE STRATEGIES

HIGHLY SUSTAINABLE

- Integrated systems of agricultural practices having a site-specific application.
- Tangible benefits on environment, soil fertility, biodiversity, resilience, productivity, production capacity, incomes and capability to meet the needs of future generations.
- Efficient use of natural resources, heavy limitation/exclusion of water and fertilizers.

EFFICIENT USE OF NATURAL RESOURCES






INTERCROPPING WITH BARLEY IN VITICULTURAL SYSTEMS

1.5-2.0 t/ha

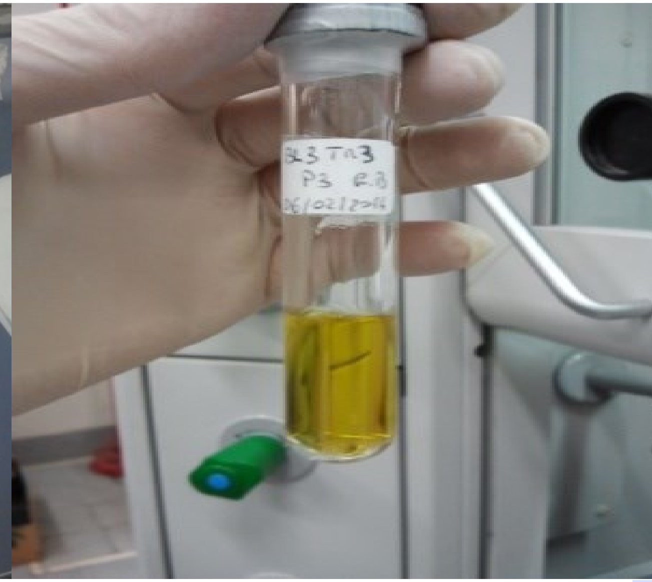
- Control of shoots vigor
- Reduction of evaporation losses
- Additional income

Cultivation of *Trifolium subterraneum* on the row strip




- **Self-reseeding legume**
- **Permanent cover**
- **Provides N without competing for water**

VALORIZATION OF SECONDARY PRODUCTS



GRAPE SEEDS OIL

20 euro/kg

GRAPEVINE LEAVES

1,5 euro/kg

FIELD EXPERIMENT IN SOUTHERN ITALY, CALABRIA

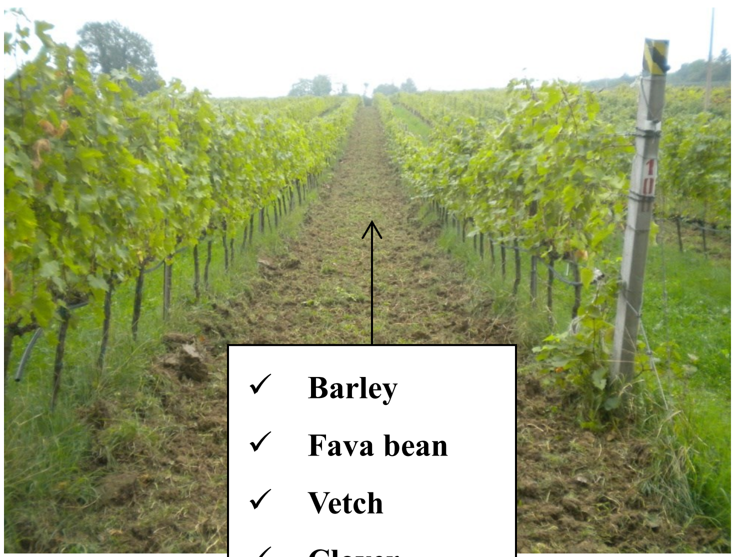
FLOWERS ALONG THE ROW STRIP

INTERCROPPING WITH HERBACEOUS SPECIES

SOWING OF ANNUAL SPECIES

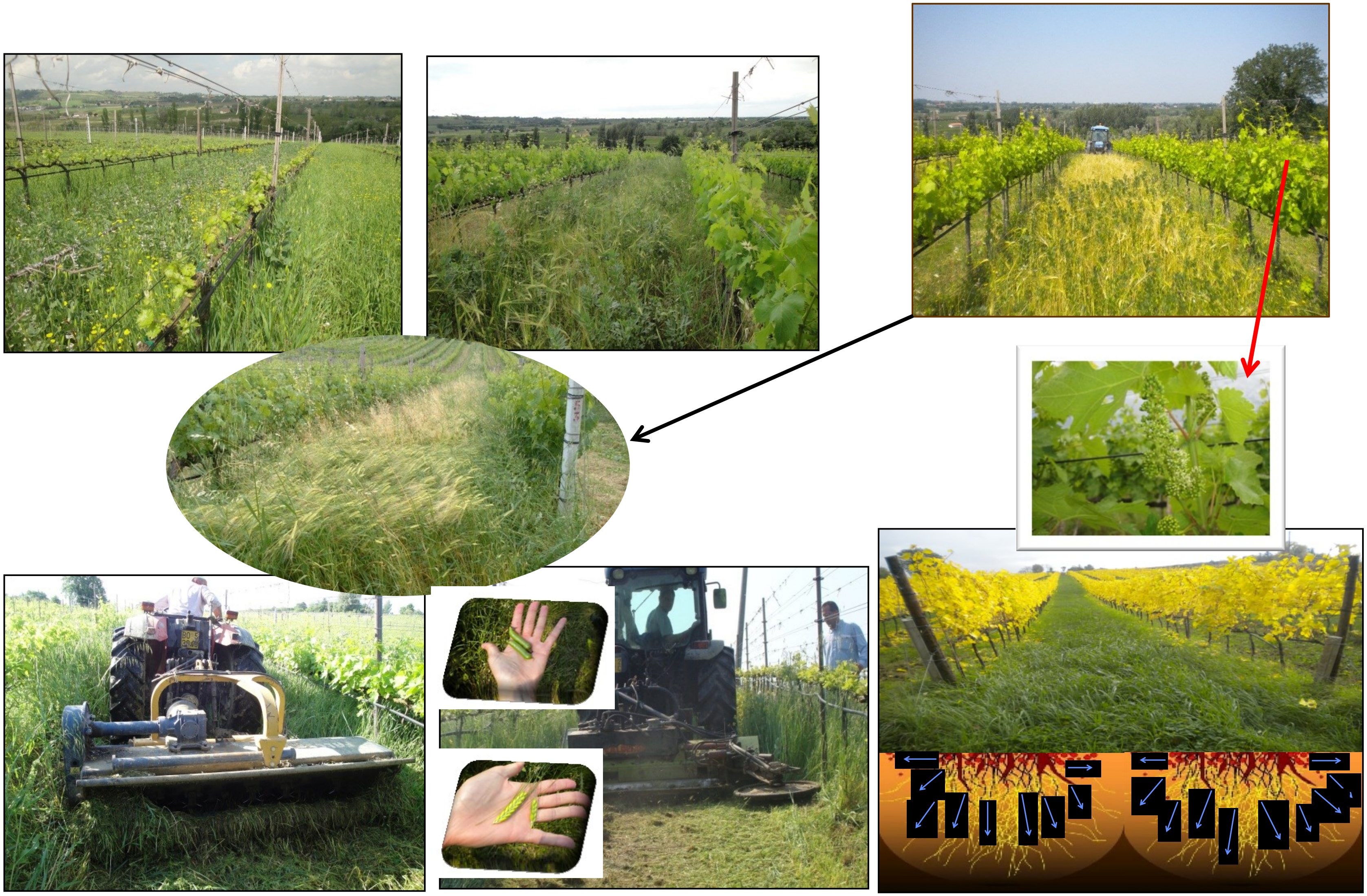
Soil Management

- ✓ Autumn sowing
- ✓ At alternate planting rows
- ✓ Late mowing, in spring



- ✓ Barley
- ✓ Fava bean
- ✓ Vetch
- ✓ Clover

LATE MOWING



SOIL ANALISIS IN A VINEYARD
AFTER 7 YEARS OF ORGANIC MANAGEMENT

PARAMETERS	2008	2015
pH in water	8.14	8.05
Organic matter	1.9%	2.3%
Total carbonates	16.6%	18.0%
Active lime	8.1%	8.5%
Total Nitrogen (N)	1.4%°	1.5%°
Phosphorous assimilable (P)	14.6 ppm	10.3 ppm
Exchangeable potassium (K)	208 ppm	186 ppm
Exchangeable Calcium (Ca)	3,763 ppm	3,591 ppm
Exchangeable Magnesium (Mg)	311 ppm	232 ppm
Exchangeable Sodium (Na)	47 ppm	30.3 ppm
Cation Exchange Capacity	22.1 meq/100 gr	20 meq/100 gr
Assimilable Iron (Fe)	19.5 ppm	24.4 ppm
Assimilable Manganese (Mn)	7,.5 ppm	10.4 ppm
Assimilable Copper (Cu)	13.0 ppm	18.2 ppm
Assimilable Zinc (Zn)	1.92 ppm	1.73 ppm
Assimilable Boron (B)	0.48 ppm	0.39 ppm




CANOPY MANAGEMENT

PLANT PROTECTION IN ORGANIC VITICULTURE

- **Plant protection limited to few active ingredients**
- **Legal limitation concerning the amount of active ingredients (e.g. copper)**
- **Controlled (restricted) use of sulphure**
- **Priority of Agronomic Technique (balanced plants, ventilated bunches).**


温馨提示
Warmhearted Tips
1. 请妥善保管个人财物
Please take care of your valuables
2. 衣冠不整者请勿入内
No admittance for the indecently dressed
3. 请勿携带宠物入内
No admittance with pets
4. 本餐厅谢绝自带酒水
Self supplying beverage & alcohols aren't expected

Late Trimming
POST VERAISON (LT)

BEFORE

2013
Aug-20th (86 DAF)

2014
Aug-22nd (92 DAF)

AFTER

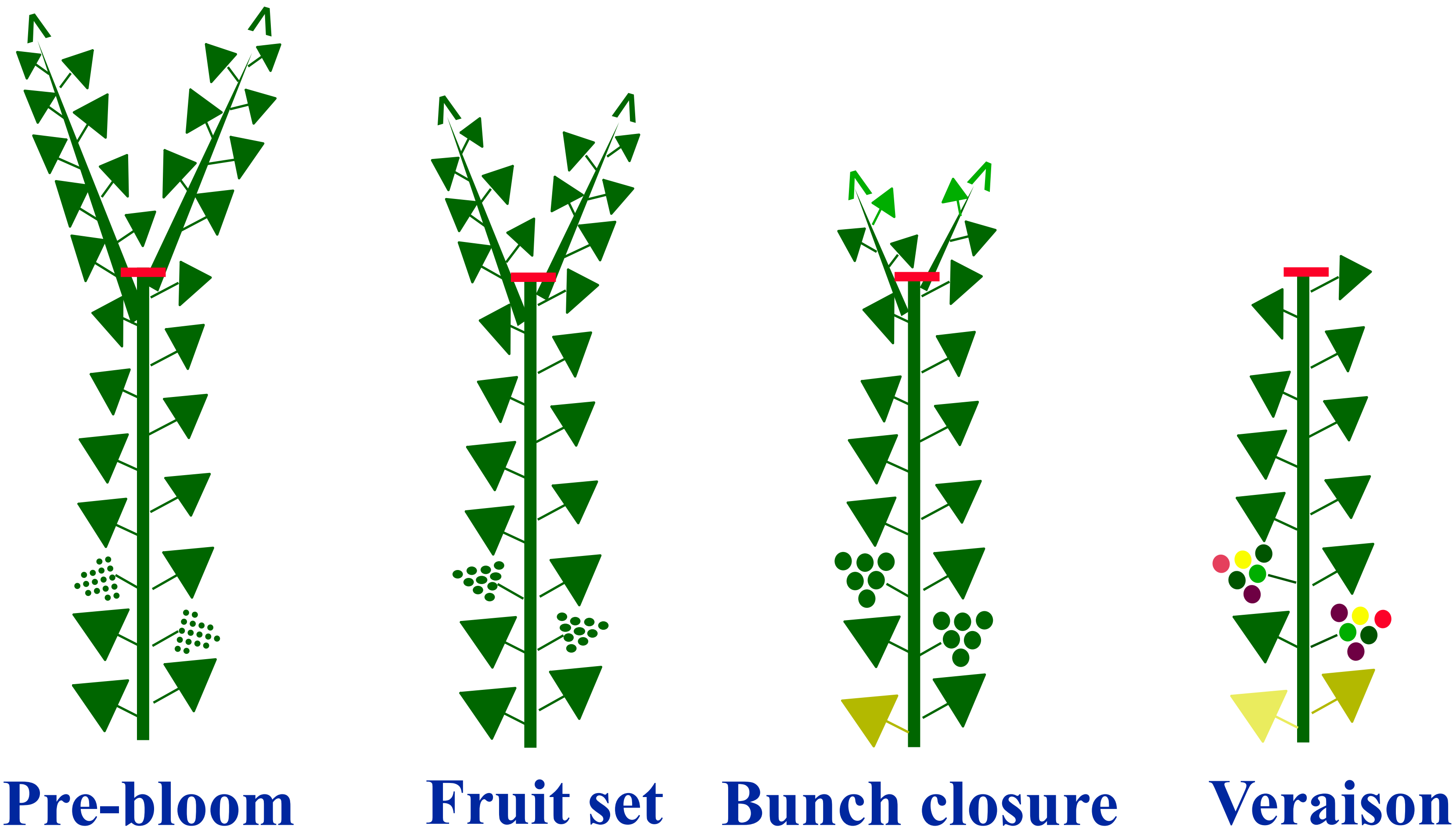
POST VERAISON TRIMMING INCREASED BERRY SKIN ANTHOCYANINS AND TOTAL PHENOLICS CONCENTRATION

(Tessarin et al. 2016, Submitted)

LEAF NUTRITIONAL STATUS

(Tessarin et al. 2016, Submitted)

Emission of laterals after performing shoot Trimming in different phenological phases



Long shoots (24 nodes) + Defoliation

POST-VERAISON DEFOLIATION (DEF I)

BEFORE

2013 Aug-20th (86 DAF)
2014 Aug-22nd (92 DAF)

AFTER

PRE-HARVEST DEFOLIATION (DEF II)

2013 Sep-04th (101 DAF)
2014 Sep-05th (106 DAF)

LATE DEFOLIATIONS INCREASED BERRY SKIN FLAVONOLS CONCENTRATION

(Tessarin et al. 2016, Submitted)

LEAF NUTRITIONAL STATUS (% of dry weight)

(Tessarin et al. 2016, Submitted)

VISIT OF PROF. TONG YANAN (Tebano, RA, Italy, September 2013)


UFRGS

PSP-HSAS - IF PAPERS YEAR 2016

- BOTELHO R., ROBERTI R., TESSARIN P., GARCIA-MINA J.M., **ROMBOLÀ A.D.**, 2016. Physiological responses of grapevines to biodynamic management. **Renewable Agriculture and Food Systems**, 1-12.

- COVARRUBIAS J., RETAMALES C., **ROMBOLÀ A.D.**, PASTENES C., 2016. Time course of physiological responses to iron deficiency in Cabernet Sauvignon grapevines grafted on two rootstocks. **Scientia Horticulturae**, 199:1-8.

- RIBERA A., NOFERINI M., **ROMBOLÀ A.**, 2016. Non-destructive Assessment of Highbush Blueberry Fruit Maturity Parameters and Anthocyanins by Using a Visible/Near Infrared (vis/NIR) Spectroscopy Device: A Preliminary Approach. **Journal of Soil Science and Plant Nutrition.** (In press).

- BONDADA B., COVARRUBIAS J.I., TESSARIN P., BOLIANI A.C., MARODIN G., **ROMBOLÀ A.D**., 2016. Post-veraison shoot trimming reduces bunch compactness without compromising fruit quality attributes in organically-grown Sangiovese grapevines. **Journal of Enology and Viticulture**, 67:2. (In press).

- BOTELHO R., SATO A., MAIA A., MARCHI T., OLIARI C., **ROMBOLÀ A.D.**, 2016. Mineral and vegetable oils as effective dormancy release agents for sustainable viticulture in a sub-tropical region. **Journal of Horticultural Science and Biotechnology.** (In press).

GRAPEVINE AND MALBERRY

PLANT STRESS PHYSIOLOGY – HIGHLY SUSTAINABLE AGRICOLTURAL SYSTEMS (PSP-HSAS)


Tortellini

Mortadella

Lasagne

Tagliatelle al ragù




THANKS FOR YOUR ATTENTION