



FOLIAR NUTRITION OF CROPS

Nutritional principles and technical aspects

Valagro Marketing Department
Alfredo Daniele Sgrignuoli, PM farm

Strictly Confidential

IFA – FAI NATIONAL SEMINAR
Sustainable Fertilizer Management for Soil health
March 16-17, 2015 - Hotel The Grand
New Delhi - India

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FOLIAR FERTILIZATION

COUNTRY INFORMATION

INDIA: A GIGANT SUBCONTINENT!



Total area: 3.287.263 km²

Population: 1.236.000 b. habitants

AGRICULTURE IS THE BACKBONE OF THE INDIAN ECONOMY

It produces 8% of Global Agricultural GDP on only 9% of the world's arable land

General land data, 2002-2012

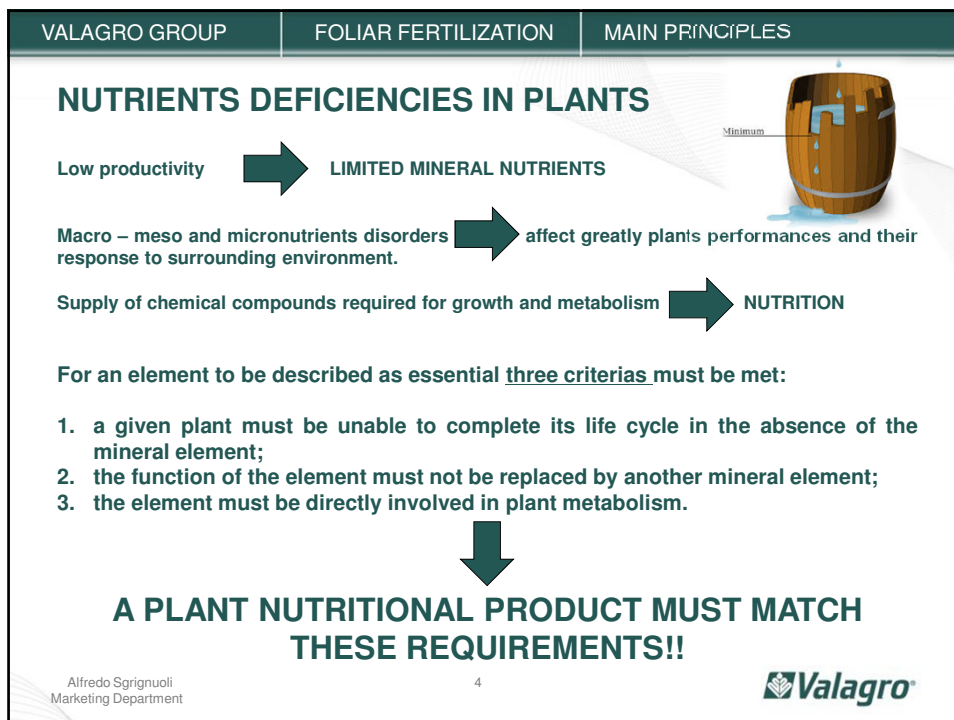
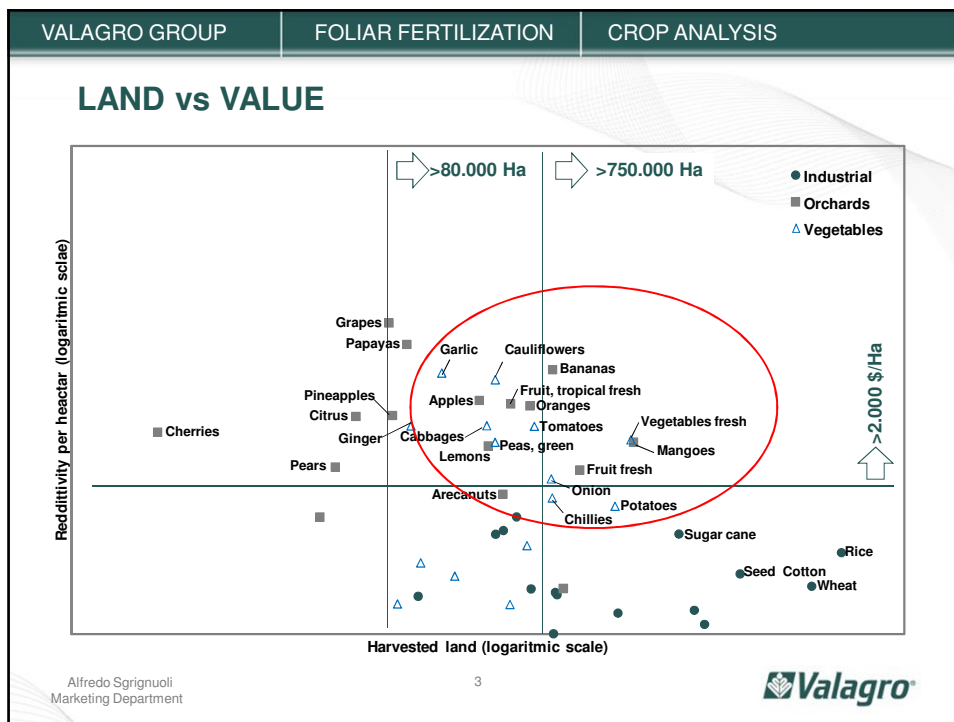
	Total area (1000 ha)	Arable land (1000 ha)	Cultivated area (1000 ha)	Permanent crops (1000 ha)
2002	328,726	159,934	169,534	9,600
2007	328,726	158,104	169,284	11,180
2012	328,726	157,350	169,650	12,300

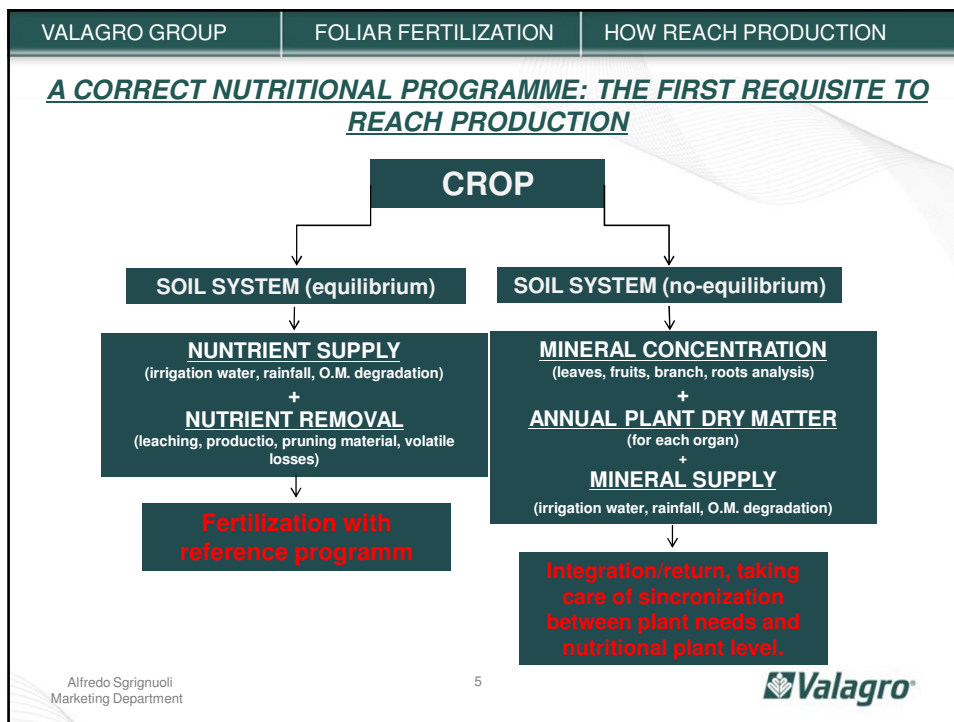
Source FAO, 2014

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VALAGRO GROUP	FOLIAR FERTILIZATION	WHEN APPLY FOLIAR
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WHEN WE SHOULD APPLY FOLIAR APPLICATION PRODUCTS:

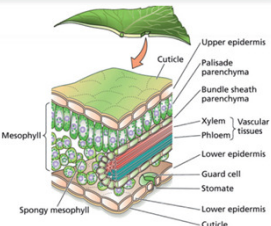
In each of this conditions, the decision to apply foliar fertilizers is determined by:

- the magnitude of the financial risk associated with the failure to correct a deficiency of a nutrient;
- The perceived likelihood of the efficacy of the foliar fertilization.

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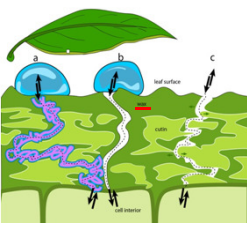
VALAGRO GROUP	FOLIAR FERTILIZATION	TECHNICAL ASPECTS
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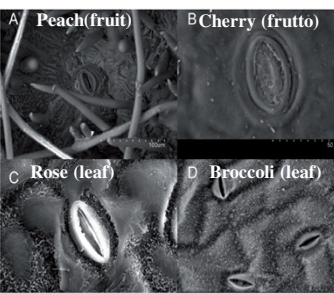
FOLIAR APPLICATION PRODUCTS

- Foliar adsorption;
- Penetration through leaf surface;
- Uptake and adsorption in the cellular compartments of leaf → translocation;
- use

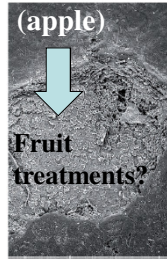
PENETRATION MECHANISMS INSIDE THE LEAVES



Water is the main matrix to dissolve foliar products



(apple)




Fruit treatments?

Cuticles, cuticular ruptures and imperfection, stomata, trichome, lenticels

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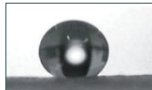


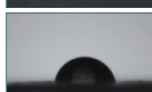
Source: Fernández, Sotiropoulos, Brown - Foliar fertilization: scientific principles and field practices



VALAGRO GROUP	FOLIAR FERTILIZATION	TECHNICAL ASPECTS
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FOLIAR APPLICATION PRODUCTS

Surface differences depending on species, variety, organs influence spray efficacy → needs of adjuvants

PLANT ORGANS AND SPECIES	AVERAGE CONTACT ANGLE WITH PURE WATER (°)	DROP IMAGE
Adaxial side of <i>E. globulus</i>	140	
Adaxial side of <i>Ficus elastica</i> leaf	83	
Calanda peach (<i>P. persica</i>)	130	
Apple (<i>Malus domestica</i>) Fruit surface	84	

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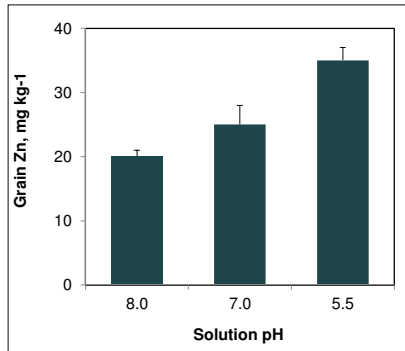


Source: Fernández, Sotiropoulos, Brown - Foliar fertilization: scientific principles and field practices

FOLIAR APPLICATION PRODUCTS

Influence on nutrient penetration:

1. **CONCENTRATION:** The concentration of a nutrient present in a foliar spray will always be significantly higher than the concentration found within the plant organ → kind of nutrient (e.g. macro- or micronutrient), plant species, age, nutritional status and weather conditions and all of these will ultimately be limited by the need to avoid phyto-toxicity.
2. **HIGH SOLUBILITY:** salts, chelates, complexed based products;
3. **pH, HUMIDITY**

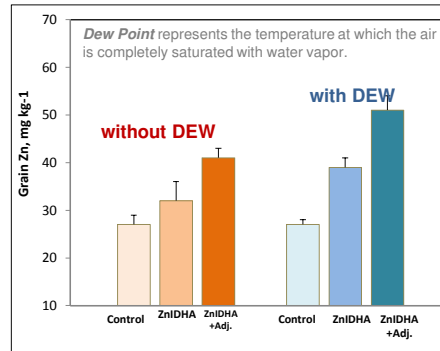


Cakmak et al., 2010

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Source: Fernández, Sotiropoulos, Brown - Foliar fertilization: scientific principles and field practices



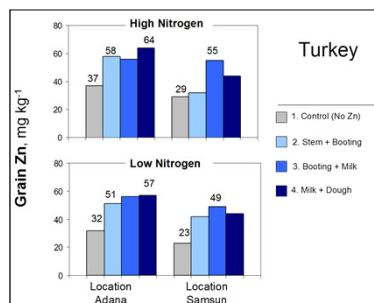
Dew Point represents the temperature at which the air is completely saturated with water vapor.

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FOLIAR APPLICATION PRODUCTS

Influence on nutrient penetration:

4. **MOLECULAR WEIGHT:** The size of the nutrient molecule in solution will affect the rate of penetration of a foliar fertilizer as a consequence of the mechanism of cuticular absorption.
5. **ELECTRIC CHARGE:** element/s – cuticle charges → uncharged or electron-charged compounds and anions can penetrate the leaf and are translocated in the apoplast, easier than positively-charged complexes or cations.
6. **N STATUS IN PLANTS:**



Cakmak et al., 2010, J. Agric Food Chem.

7. OTHER ENVIRONMENTAL FACTORS: temperature, light, rainfall etc.

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Source: Fernández, Sotiropoulos, Brown - Foliar fertilization: scientific principles and field practices

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VALAGRO GROUP	FOLIAR FERTILIZATION	TECHNICAL ASPECTS
FOLIAR APPLICATION PRODUCTS		
THE ADJUVANTS: a lot of efforts to develop adjuvants for herbicides, more focus on foliar fertilizers should be done in the future.		
Adjuvant name on label	Proposed mode of action	
surfactant	lowering surface tension	
wetting agent	equivalent to "surfactant"	
detergent	equivalent to "surfactant"	
spreader	equivalent to "surfactant"	
sticker	increasing solution retention; rainfastness	
retention aid	increasing solution retention; rainfastness	
buffering agent	pH buffering	
neutraliser	pH buffering	
acidifier	lowering pH	
penetrator	increasing the rate of foliar penetration (e.g. by 'solubilizing' cuticular components)	
synergist	increasing the rate of foliar penetration	
activator	increasing the rate of foliar penetration	
compatibility agent	improving formulation compatibility	
humectant	retarding solution drying by lowering the formulation's point of deliquescence (POD) on the leaf	
drift retardant	better spray targeting and deposition on foliage	
bounce and shatter minimizer	better spray targeting and deposition on foliage	

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Source: Fernández, Sotiropoulos, Brown - Foliar fertilization: scientific principles and field practices

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VALAGRO GROUP	FOLIAR FERTILIZATION	Ca UPTAKE
FOLIAR FERTILIZATION: Ca transport to fruits is low, due to the strong impact of transpiration on Ca transport		

Transpiration

Calcium is pulled up by the transpiration stream via xylem vessels

Accumulation in the transpiring tissues, i.e. leaves

Organs of low transpiration, are poor in Ca

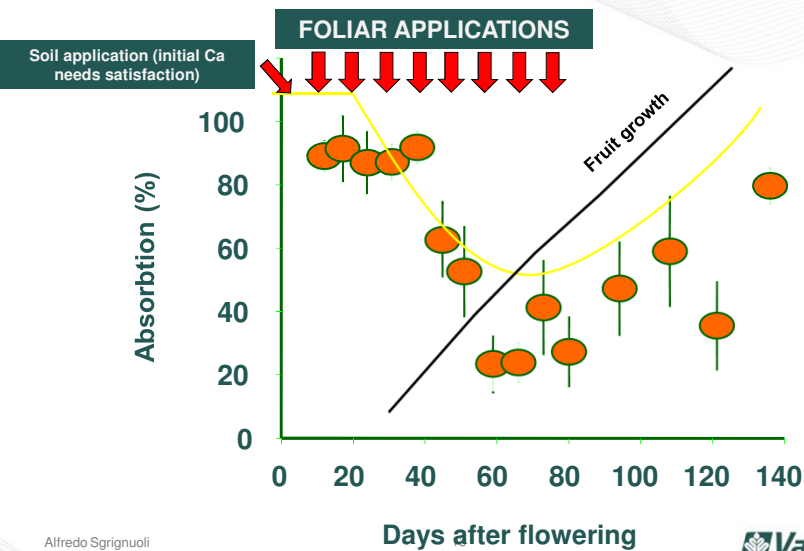
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Calcium uptake in Golden D.

Target: 5 mg Ca /100 g fw at harvest

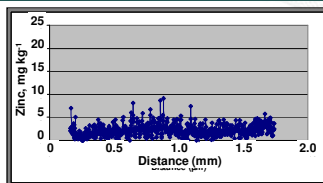
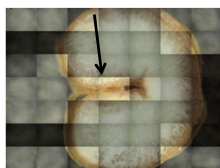


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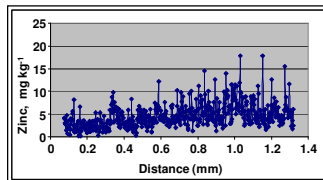
Source: Adapted scheme - Schlegel e Schoenherr, 2002

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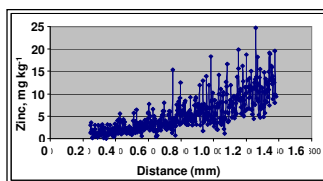
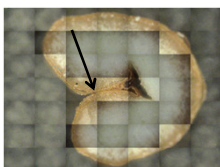
Changes in Zinc Concentrations of Endosperm Depending on Timing of Foliar Zinc Spray (Measurements by LA-ICP-MS)



No Foliar Zn Application



Foliar Zn Spray at Stem Elongation and Booting Stages





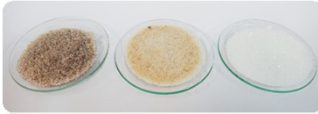



Foliar Zn Spray at Milk and Dough Stages

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Cakmak et al., 2010, J. Agric. Food Chem.


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VALAGRO GROUP	FOLIAR FERTILIZATION	RAW MATERIALS: the quality
<p>THE QUALITY OF A FOLIAR FERTILIZERS DEPENDS ON THE QUALITY OF ITS RAW MATERIAL</p>  <ul style="list-style-type: none"> ✓ Nutrients content (composition and title); ✓ Content ratio between $\text{NO}_3/\text{NH}_4/\text{Urea}$; ✓ Presence or not of chloride; ✓ Specific nutrients in ionic form; ✓ Purity (impurities and unsolved); ✓ Solubility (g / l at 20 ° C); ✓ pH (acidity or alkalinity); ✓ Conductivity (EC mS / cm 1g/la 18-25 ° C); ✓ Miscibility and compatibility with other fertilizers. 		
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VALAGRO GROUP	FOLIAR FERTILIZATION	RAW MATERIALS: the quality
<p>Ammonium Sulphate</p> <div style="display: flex; align-items: center;">   <div style="margin-left: 20px;"> <p><u>LOW SOLUBILITY</u></p> <p><u>TECHNICAL PROBLEMS</u> (nozzle occlusions)</p> </div> </div>		
<p>UREA</p> <div style="display: flex; align-items: center;">  <div style="margin-left: 50px;"> <p><u>SOLUBILITY</u></p> <p><u>TRANSPORT: BAD DISTRIBUTION</u> <u>AMONG NUTRIENTS;</u></p> </div> </div>		
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VALAGRO GROUP	FOLIAR FERTILIZATION	RAW MATERIALS: the quality
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Potassium Sulphate vs Potassium Nitrate




Potassium Sulphate
(K₂SO₄)

Potassium Nitrate
(KNO₃)



Potassium Sulphate
9 g/100 ml




Potassium Nitrate
36 g/100 ml

LOW SOLUBILITY

HIGH SOLUBILITY

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VALAGRO GROUP	FOLIAR FERTILIZATION	CHETALES/COMPLEXING AGENTS
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Tab.1 - General informations

Country	Piacenza - Italy
Crops	<i>Phaseolus vulgaris</i> cv. Linera
Cultivation environment	Potted plants

Chelating or complexing agents (EDTA – LSA etc) can influence the plant uptake and nutritional bioavailability.....

Tab.3 Treatments

Treatment	Dosage (Kg/ha)	N° of application	Date
EDTA - Zn	1	1	A
(Competition)	1	1	A

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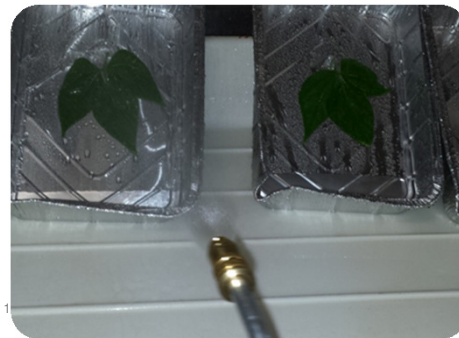




Fig.2 – An homogenous volume of each treatment solution was applied to a leaf per plant (either to older or intermediate leaves, to account for vegetative age);

Fig 3 - AFTER TREATMENTS, RAINFASTNESS (30 mm \pm 2.5 – 15 minutes) WAS SIMULATED BY USING A MANUAL SPRAYING



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RESULTS – KINETICS OF ZINC UPTAKE BY PLANTS USING BREXIL Zn and EDTA-Zn (competitor) AT DIFFERENT SAMPLING AND TIMING

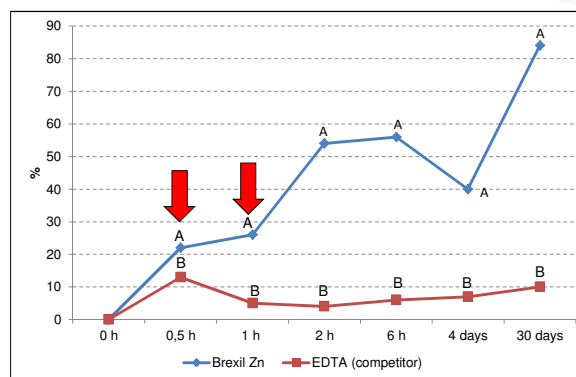



Fig. 7 – Kinetics of Zn uptake by plants
ANOVA, alpha=0.01

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VALAGRO GROUP		FOLIAR FERTILIZATION		CHETALES/COMPLEXING AGENTS	
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Sustainable Cultivation of Durum Wheat


Changes in grain concentrations of Zn and Fe after foliar application of different Zn-containing fertilizers (at 0.1% and 0.3% rates) in wheat grown under greenhouse conditions

Treatment	Product	Spray dose 1	TE concentration (mg/Kg)		Spray dose 2	TE concentration (mg/Kg)	
			Zn	Fe		Zn	Fe
1	Control	-	17 ± 1	29 ± 3	-	17 ± 1	29 ± 3
2	Zn-EDTA	0.1%	23 ± 1	27 ± 2	0.3%	39 ± 3	31 ± 7
3	Brexil (LSA)	0.1%	36 ± 1	28 ± 5	0.3%	53 ± 7	32 ± 4


Source: data extracted from Harvest Zinc Fertilizer project.

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VALAGRO GROUP		FOLIAR FERTILIZATION		BIOSTIMULANTS	
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And BIOSTIMULANTS?
They cannot substitute nutrition but.....

↓


Plant biostimulants contain substance(s) and/or micro-organisms whose function when applied to plants or the rhizosphere is **to stimulate natural processes** to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and crop quality (source: EBIC)

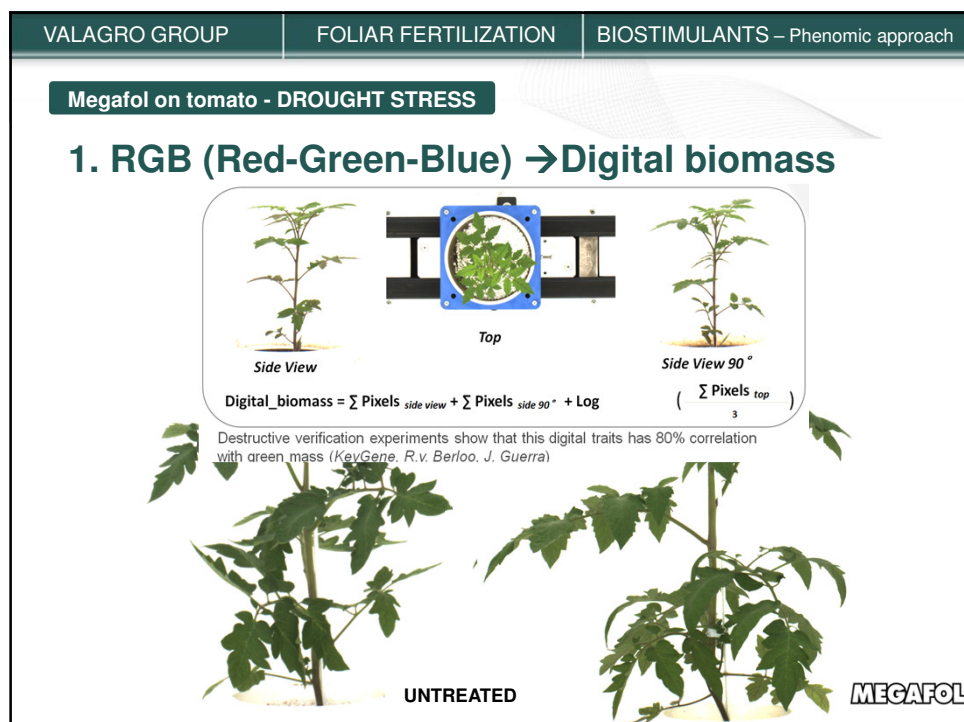
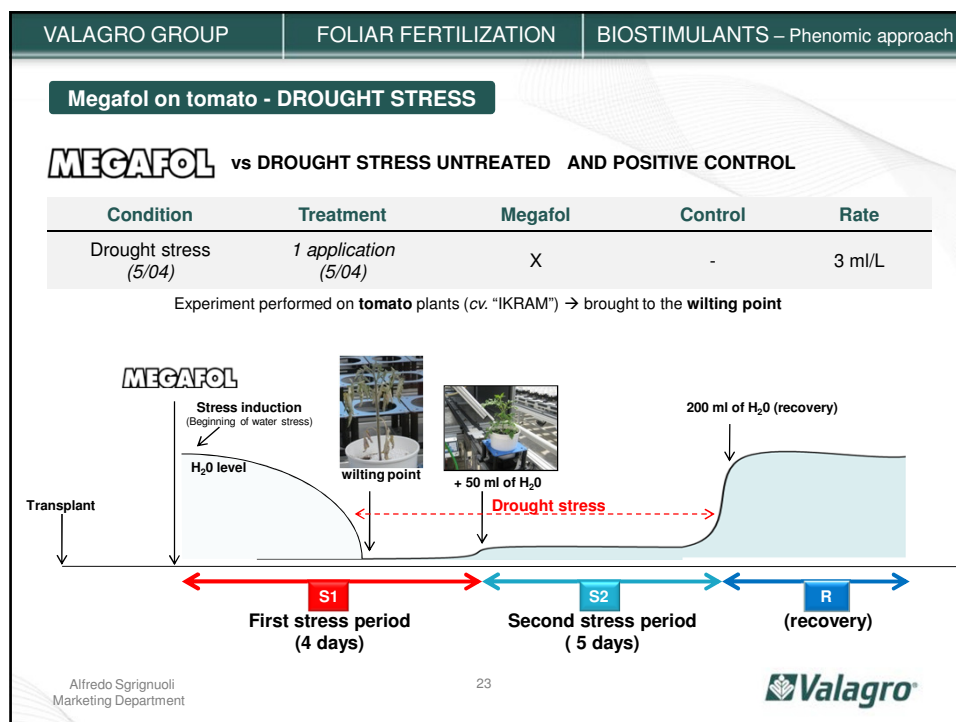
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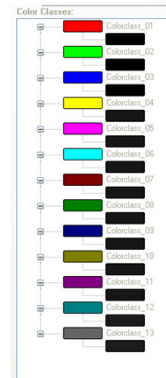
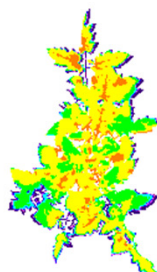
Independently from their nutritional state.....

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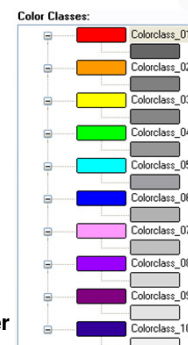


Megafol on tomato - DROUGHT STRESS**2. UV analysis:** high low fluorescence → high fotosynthetic efficiency
Megafol on tomato - DROUGHT STRESS**3. NIR (Near-InfraRed) → water content**

Low water



High water



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