THE HEBREW UNIVERSITY OF JERUSALEM

המכון למדעי הצמח וגנטיקה בחקלאות ע"ש רוברט ה. סמית
The Robert H. Smith Institute for Plant Sciences & Genetics in Agriculture

Screening for biostimulants effect on drought response using an high-throughput functional-phenotyping system

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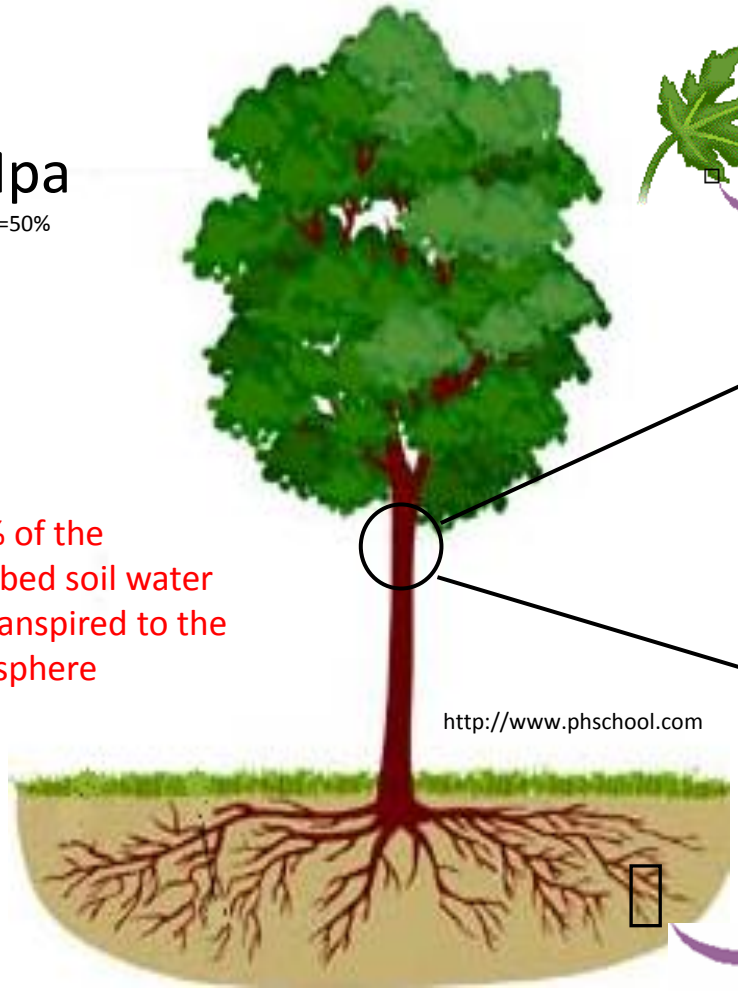
Plant water relations

Plant Water Use Efficiency (WUE)

Ψ_w= -95 Mpa

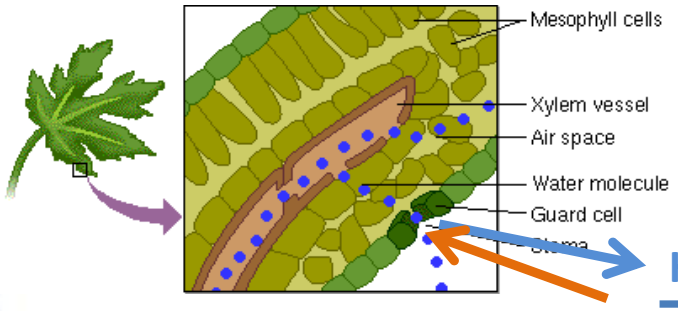
at RH =50%

Driving Force

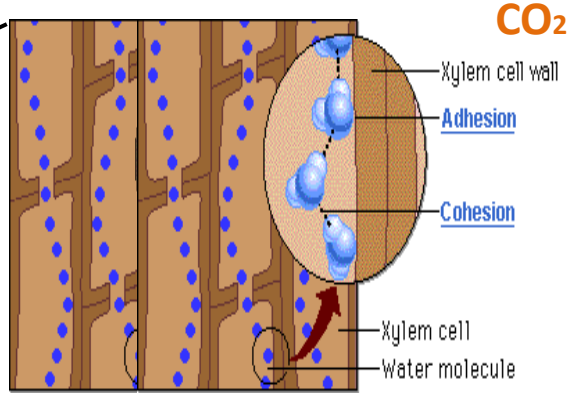


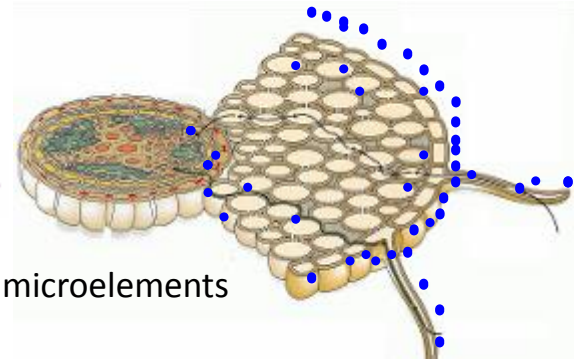
> 95% of the absorbed soil water are transpired to the atmosphere

http://www.phschool.com



$\frac{H_2O}{CO_2} = \frac{500}{1}$





N, P, K and all other macro and microelements

Ψ_w= -0.3 MPa

Plant Water Use Efficiency (WUE)

=

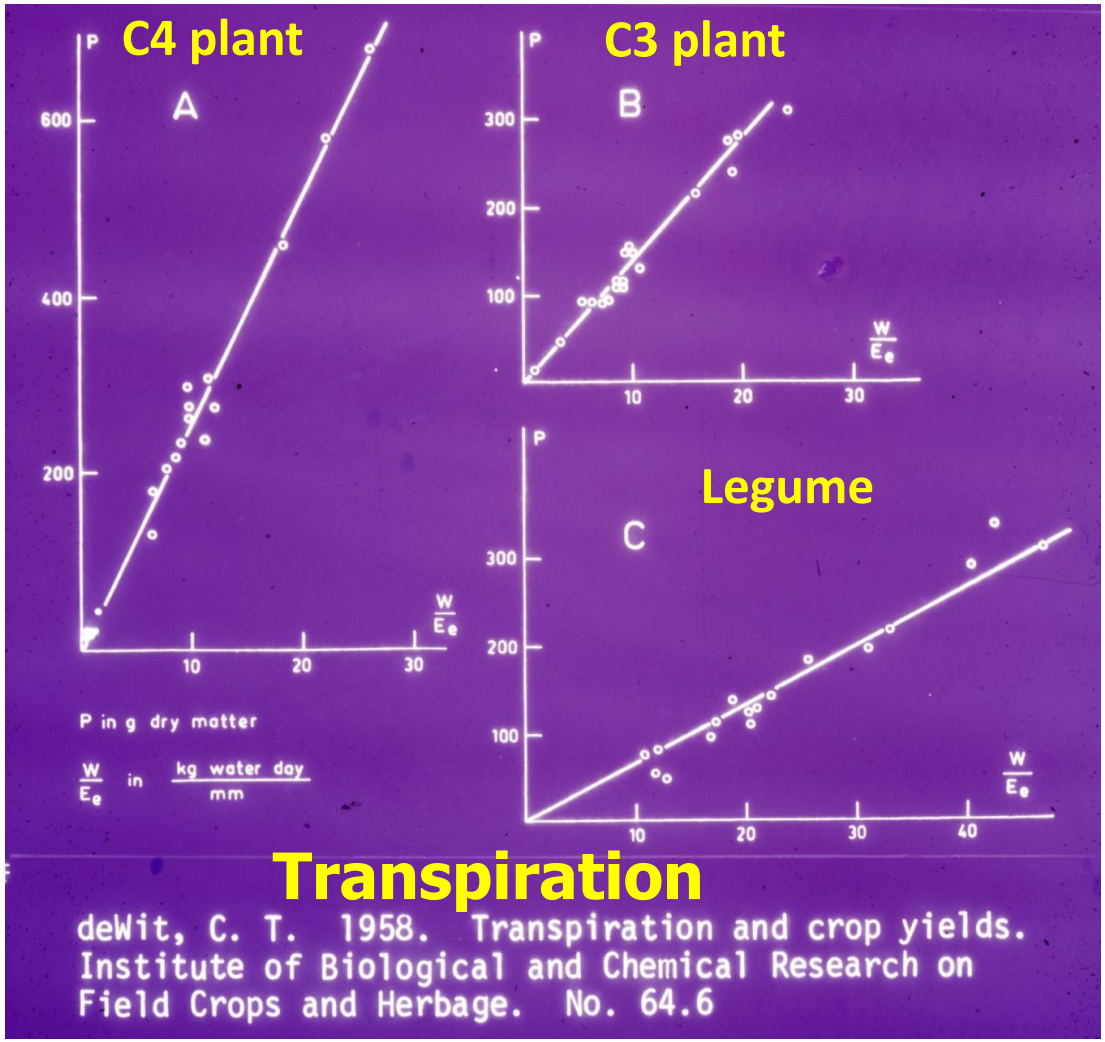
Per kilo fruit!

Fruit	Yield (ton/acre/year)	Irrigation (ton/ acre /year)	Water use efficiency (ton water /ton fruit)
Pear	6	2750	458
Peach	4.8	2500	523
Avocado	4.8 - 8.0	3800	472 - 786
Citrus	14 - 32	4000 - 4800	150 -285

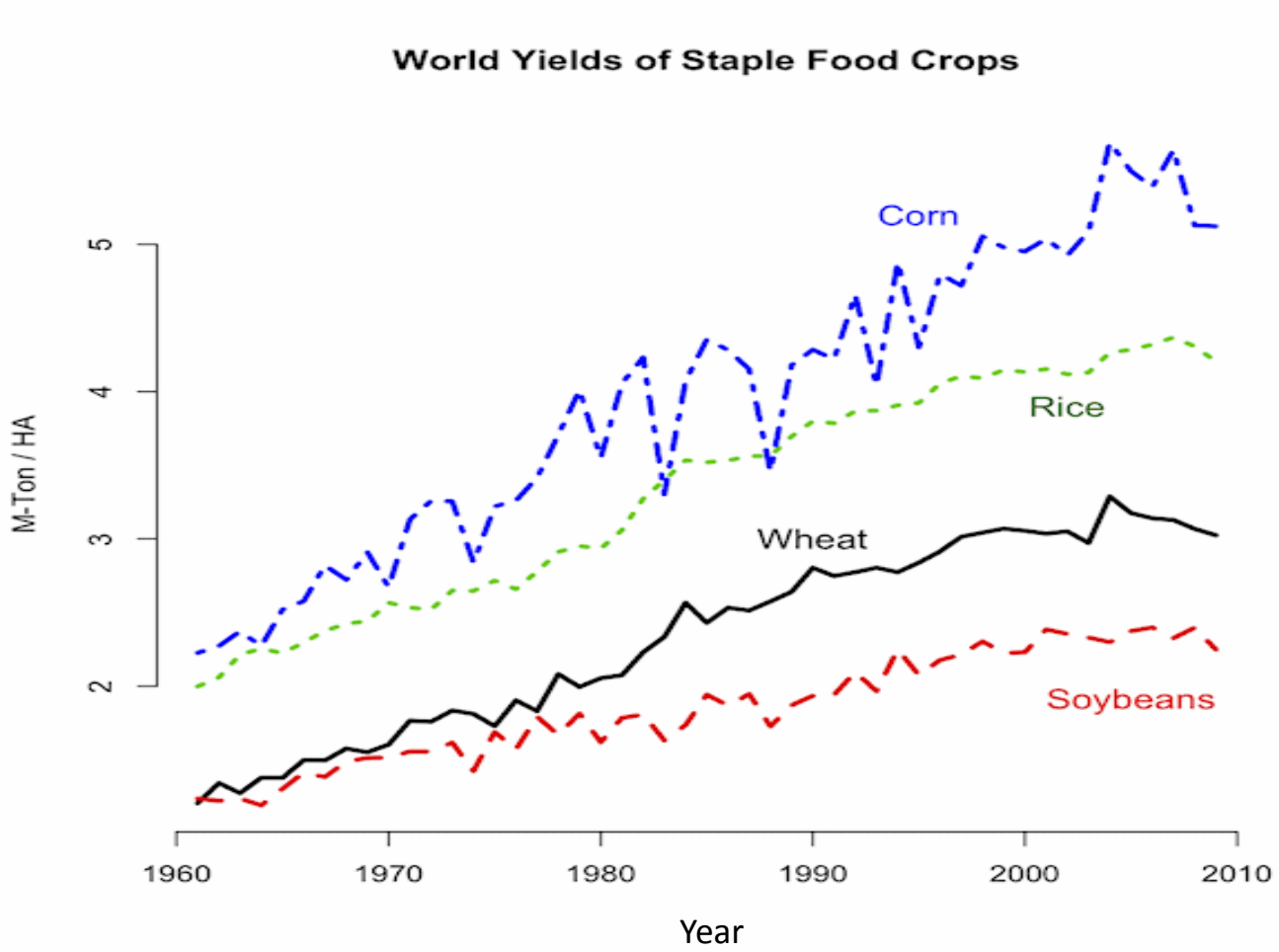
Modified from Mizrahi et al., Water and Irrigation2007

Transpiration use efficiency

A correlation between transpiration and crop yield



Agricultural yield performances



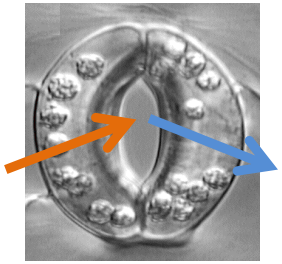
http://economistsview.typepad.com/.a/6a00d83451b33869e20154321b05c0970c-popup

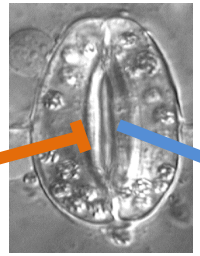
Cellular mechanisms controlling productivity and survivability trade-offs

Crop breeding

Canalized Traits

Photosynthesis ↑
Transpiration ↑



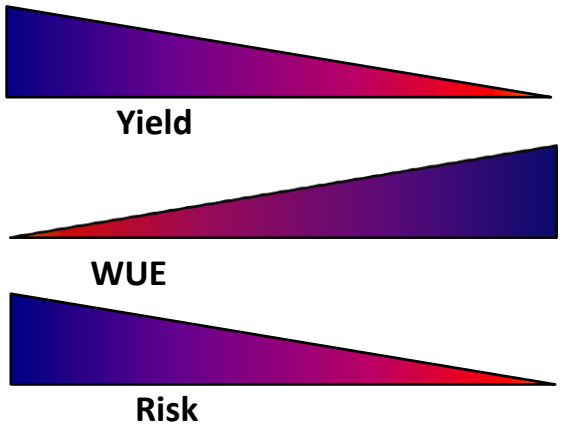


Plastic Traits

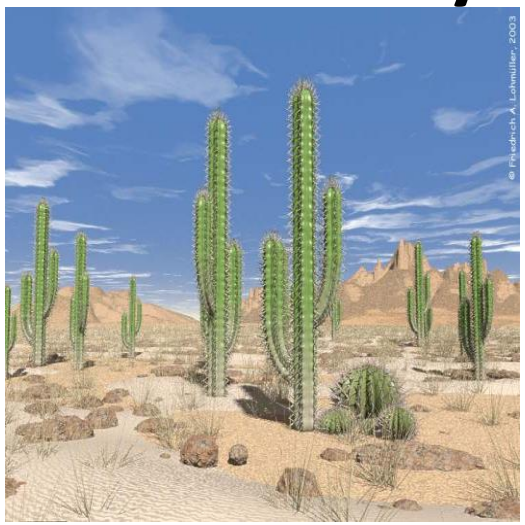
Photosynthesis ↓
Transpiration ↓

Productivity

http://wallpaper-download.net/wallpapers/flower-wallpapers-sunflower-field-wallpaper-32260.jpg



Survivability

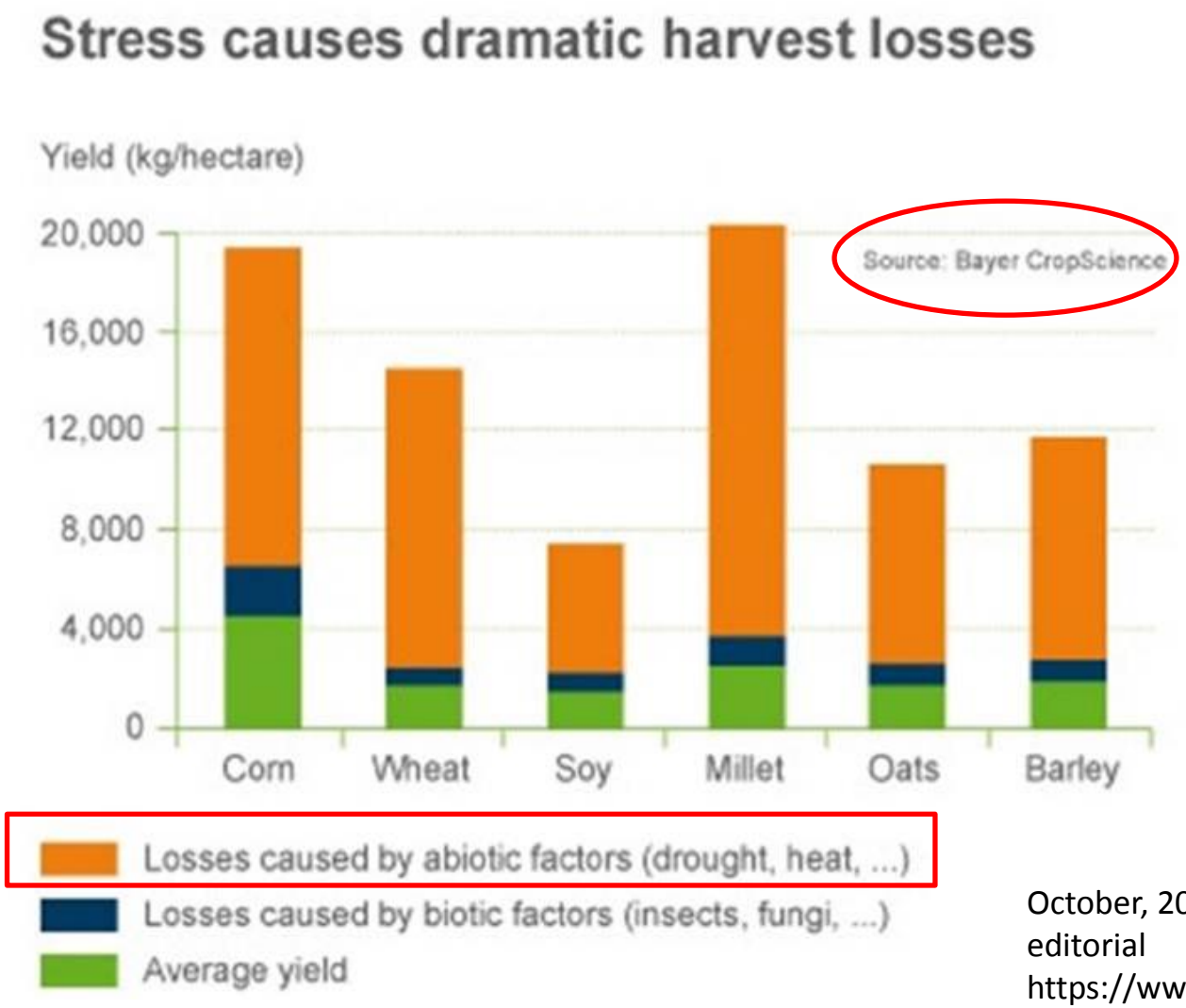


http://fvcgeography.files.wordpress.com/2011/10/cactus72.jpg

Crop

WT

The problem



October, 2008A [Bayer CropScience](#) editorial
https://www.seedquest.com/News/releases/2008/october/23973.htm

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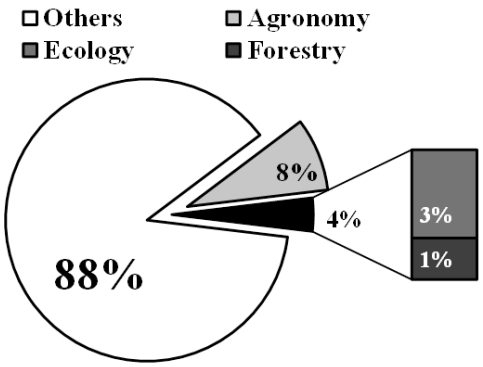
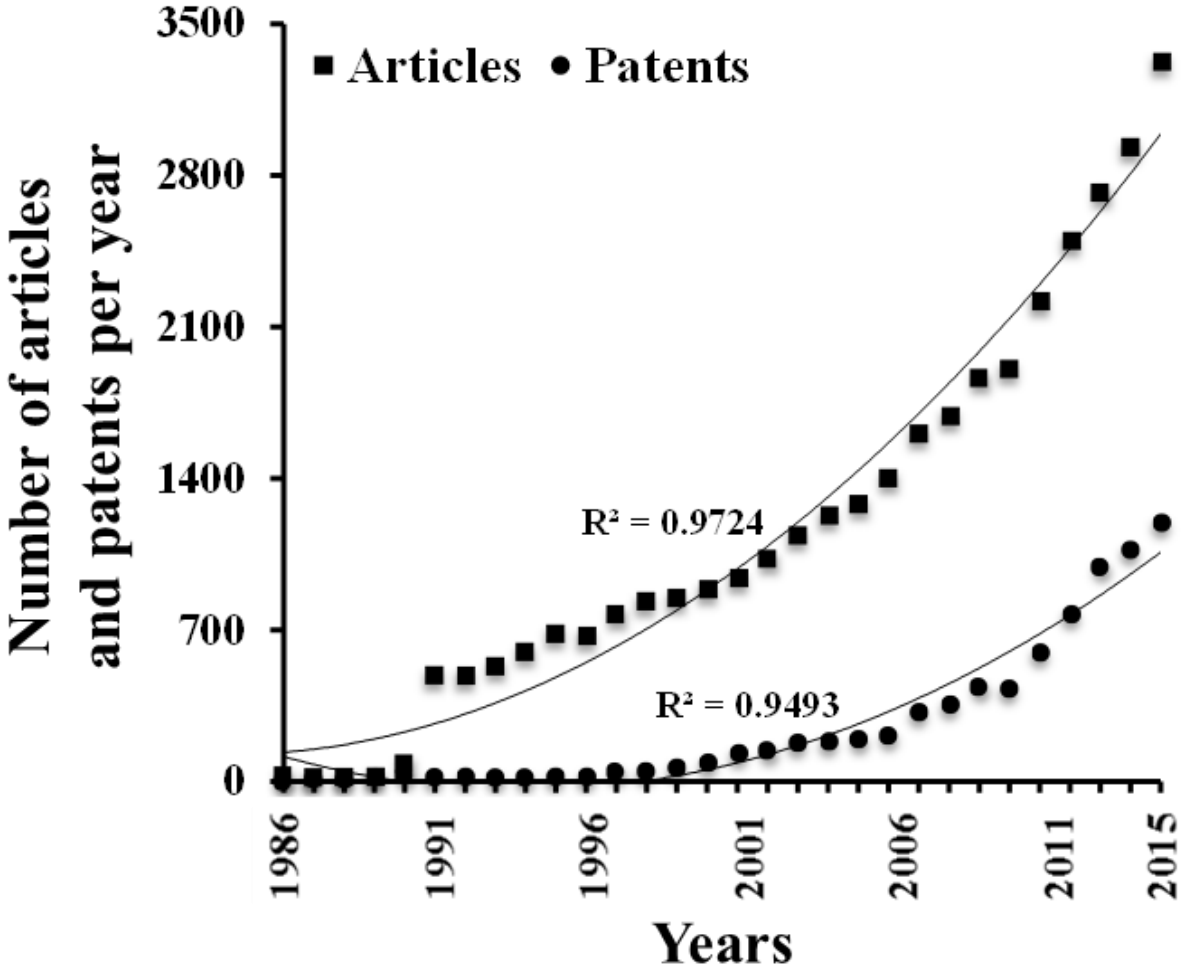
Publication distribution in different areas of plant stress research





The relative proportion of articles published in three decades (1986 - 2015)

Dalal, Attia and Moshelion, Unpublished

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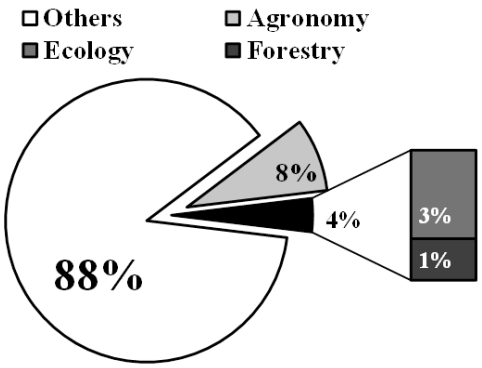
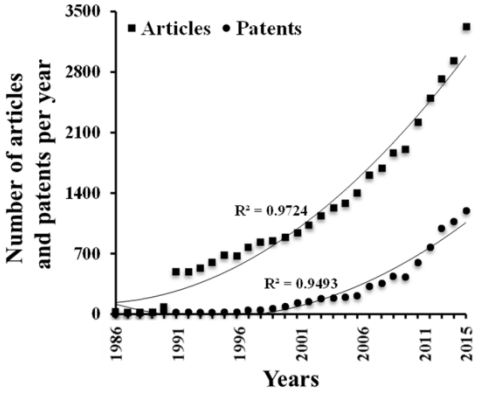
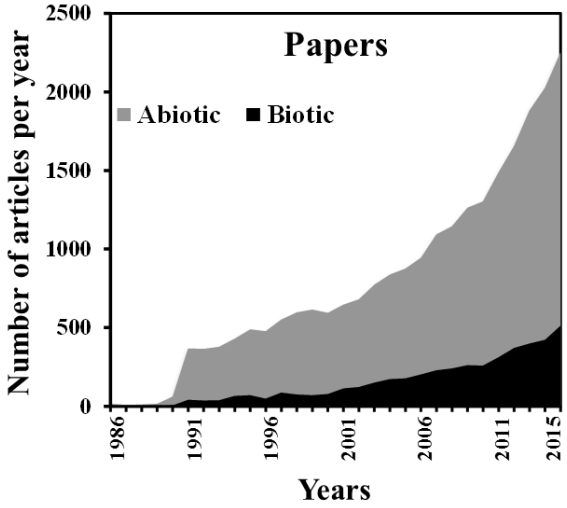
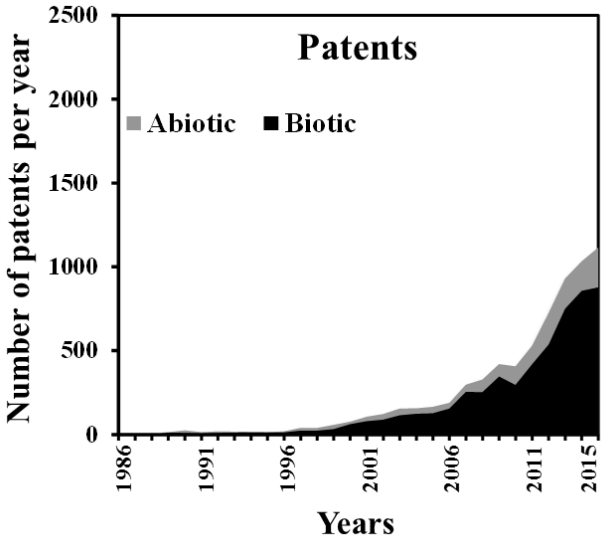
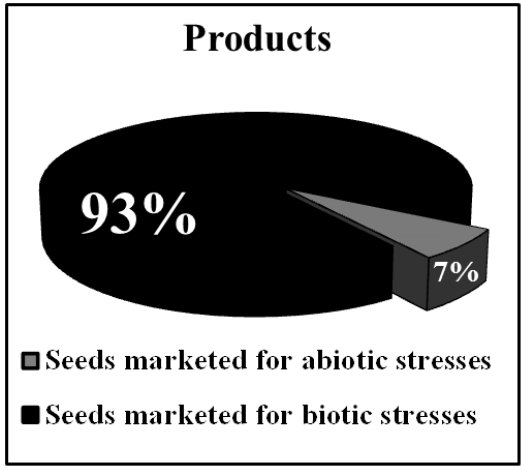
Publication distribution in different areas of plant stress research











The relative proportion of articles published in three decades (1986 - 2015)

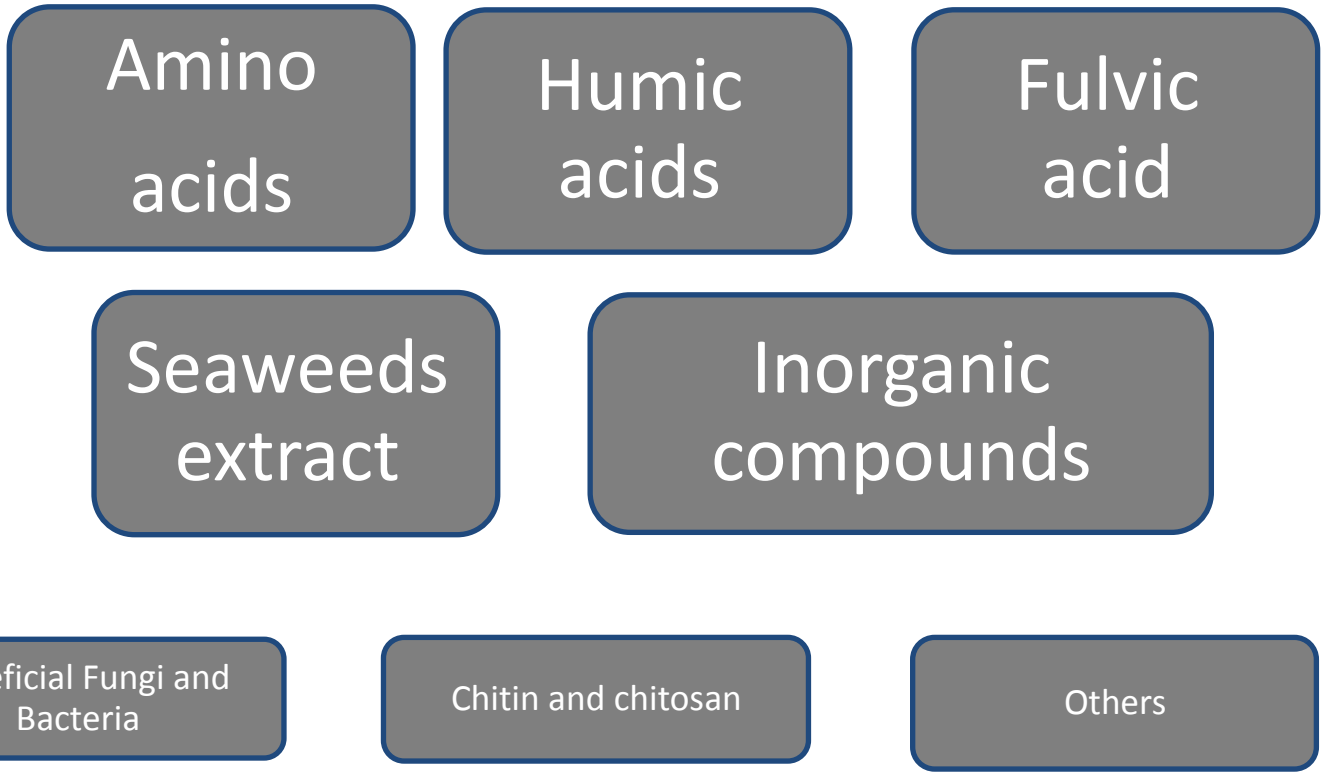
Dalal, Attia and Moshelion, Unpublished

What are Biostimulants?

"Any substance or microorganism applied to plants with the aim to **enhance nutrition efficiency**, **abiotic stress tolerance** and/or crop quality traits, regardless of its nutrients content."

(du Jardin, 2015)

Biostimulants groups



How too pick the winning horse ?

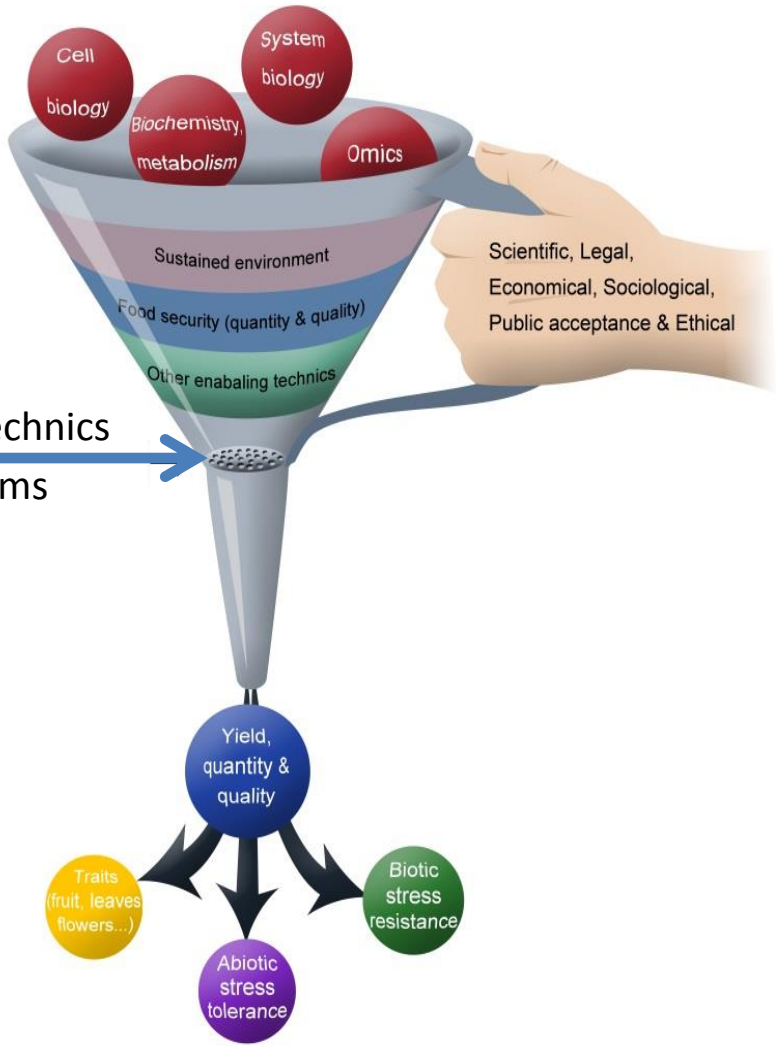
- Amino acids
- Humic acids
- Fulvic acid
- Seaweeds extract
- Inorganic compounds
- Chitin and chitosan
- Beneficial Fungi and Bacteria

High-throughput Phenotyping Bottleneck

The Pre-Breading stage

Phenotyping

Screening technics and algorithms



Moshelion and Altman, Trends in Biotechnology 2015

The data to knowledge problem

1. **What to phenotype ?**
2. **How to phenotype ?**
3. **When to phenotype ?**
4. **Where to phenotype?**
5. **How to translate it to practical decisions ?**

What to phenotype?

Well irrigation

Drought

Drought tolerant ?

Drought sensitive?

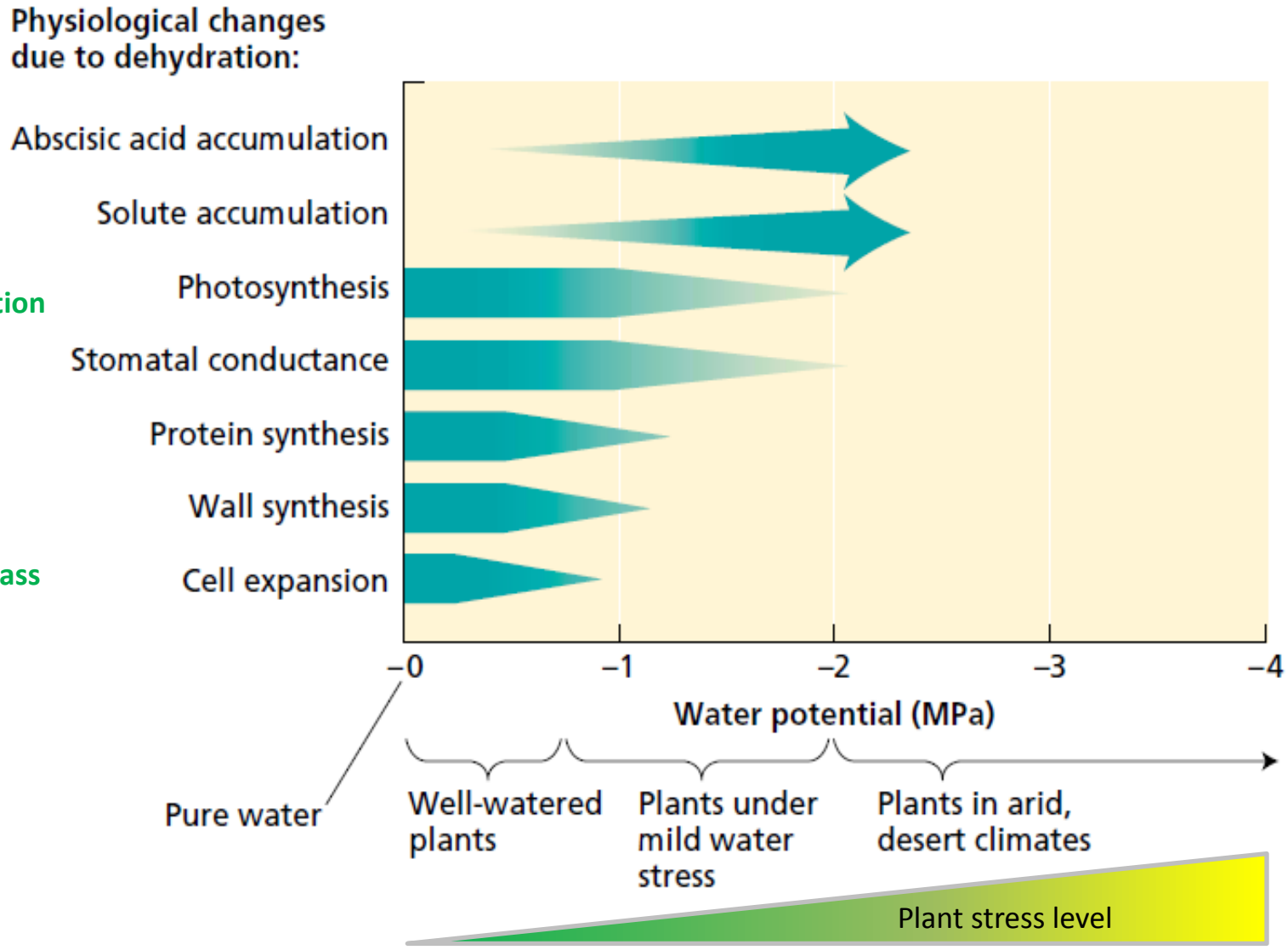
Drought

Conclusion:

Visual assessment is not enough!

A physiological characteristics in needed.

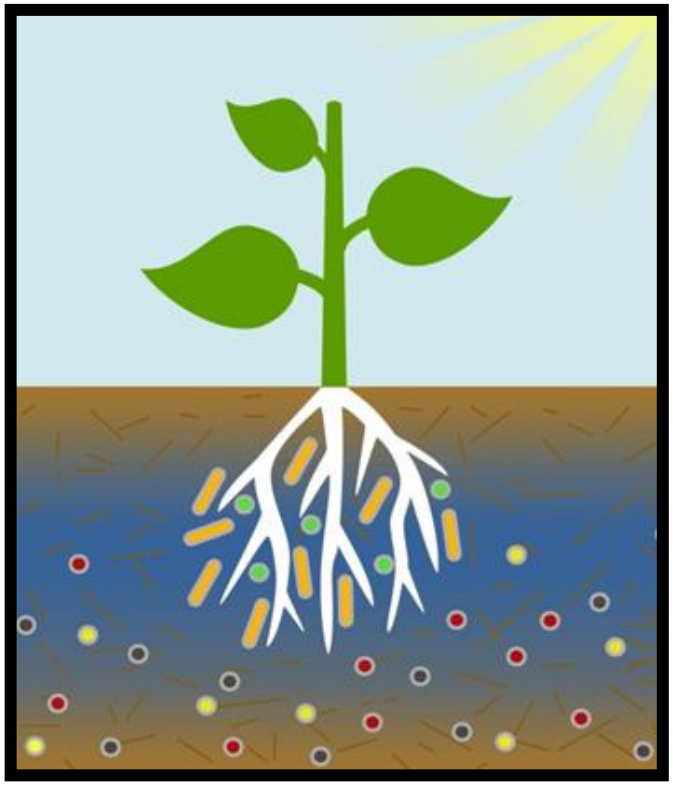
Stress phenotyping hierarchy



Plant physiology ,Taiz and Zeiger, 5th edition

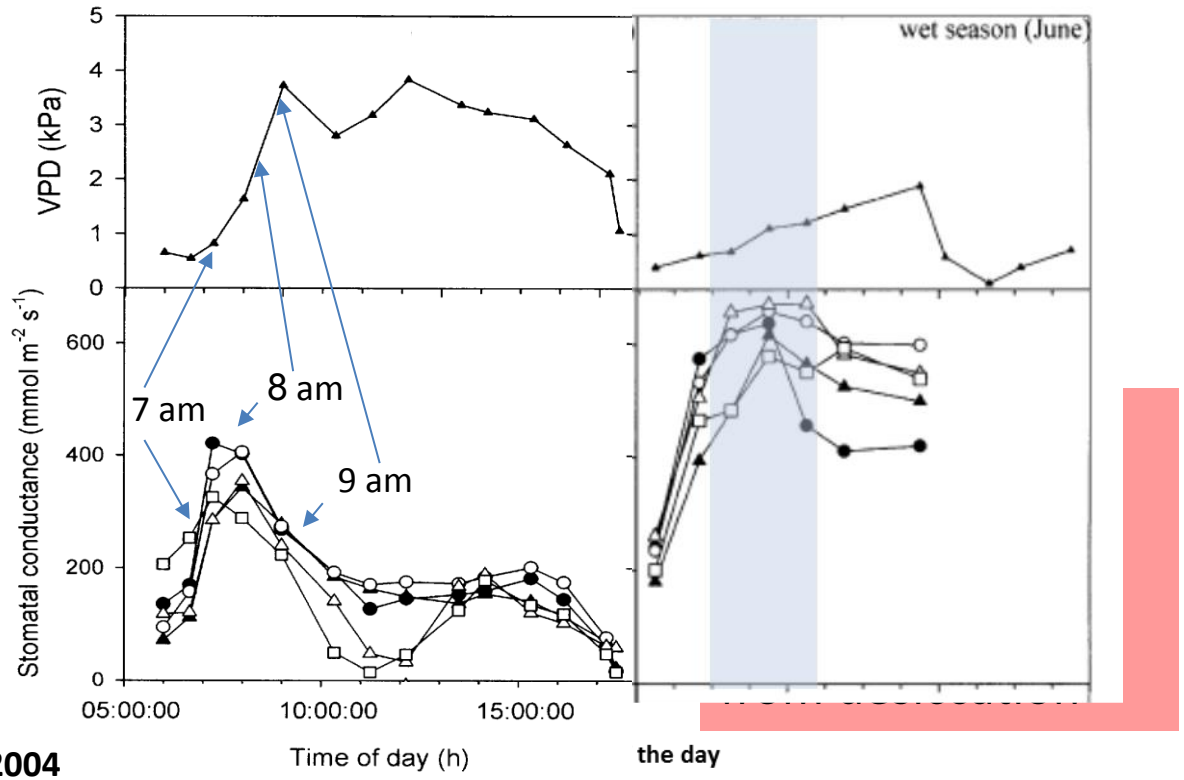
Phenotypic challenge:

Characterising the plant dynamic response to both atmospheric and soil dynamic environments



Stomatal conductance response to NORMAL ambient conditions

100% increase in stomatal conductance, in one hour!

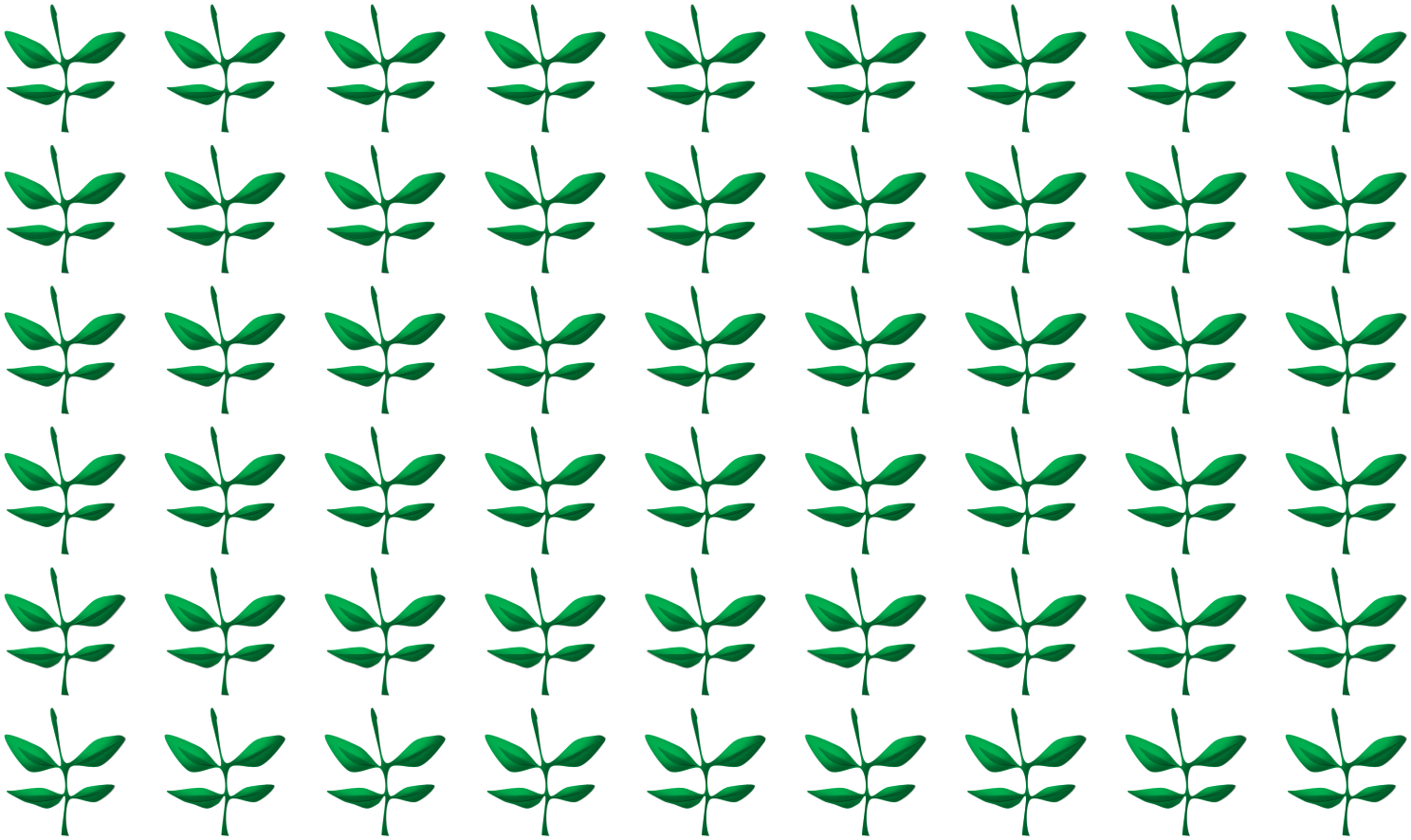


Brodribb and Holbrook, 2004

Moreover, Isohydric and anisohydric plants reveal different response patterns to the same environmental conditions

Phenotypic challenge:

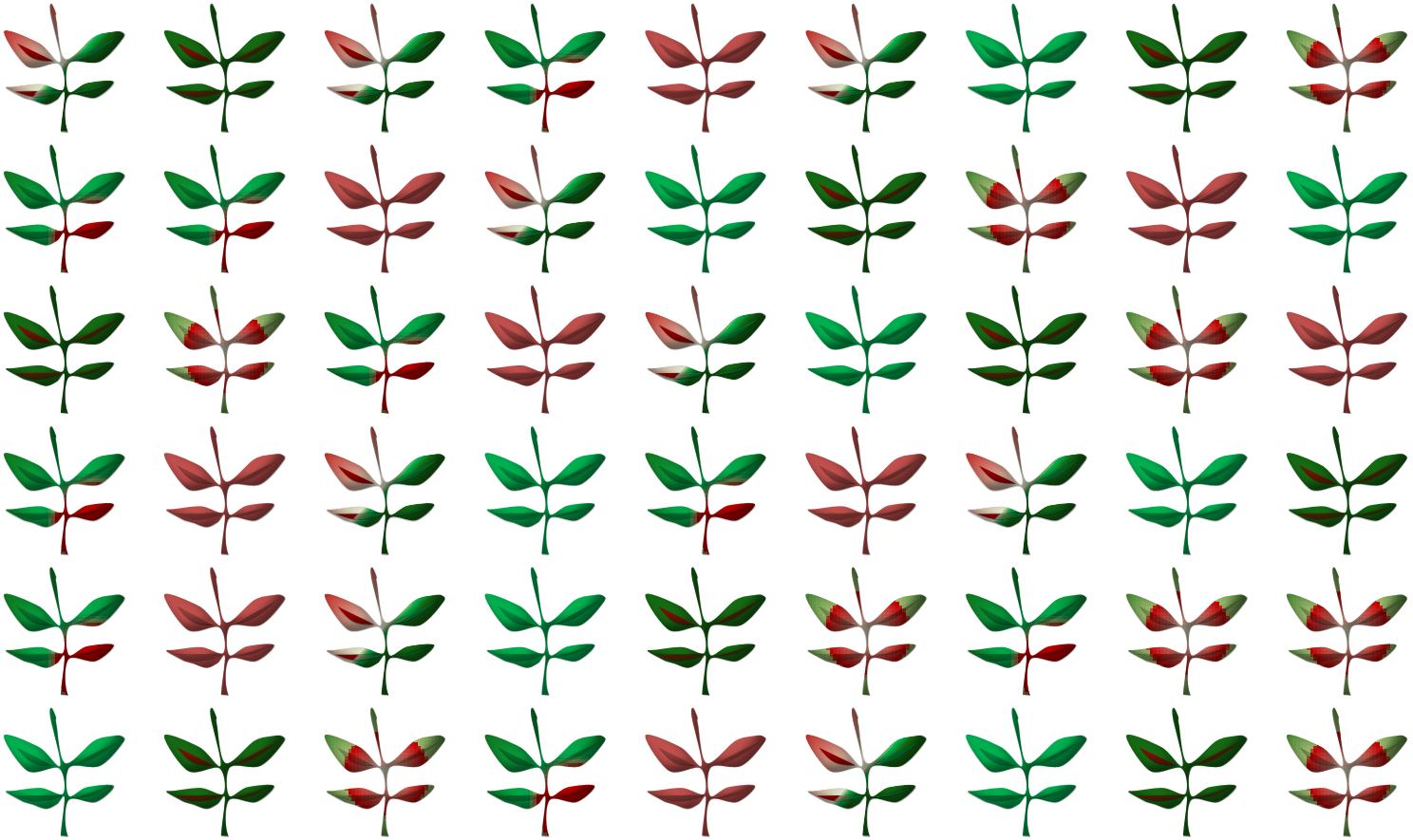
Comparing (many!) plants' water regulation behavior



Simultaneously measurement = minimal differences between the plants

Phenotypic challenge:

Comparing (many!) plant's water regulation behavior

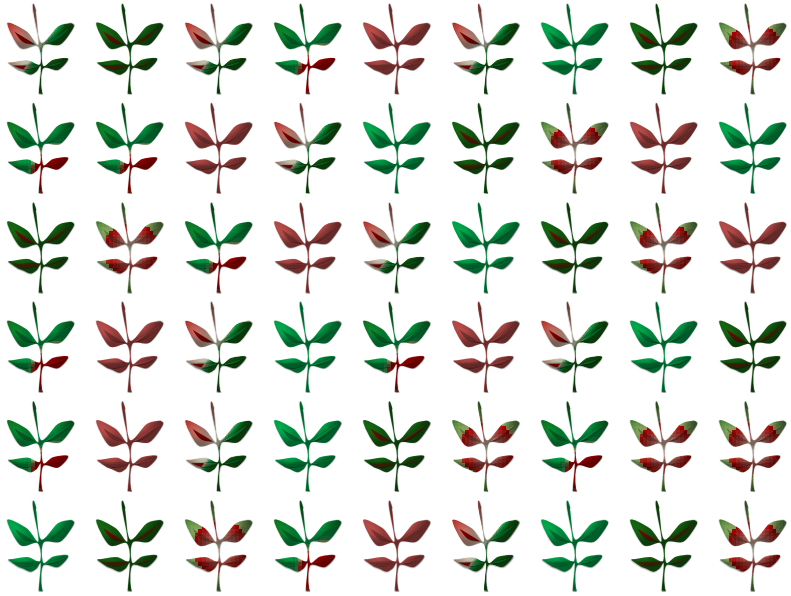


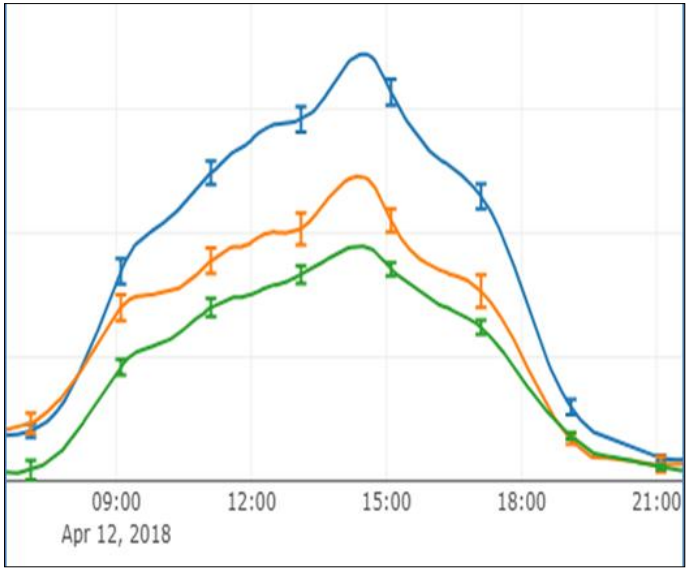
One by one measurement = differences between the plants

Hi Water potential

Low Water potential

Need to measure the plant dynamic response to the dynamic environment - **simultaneously and continuously**



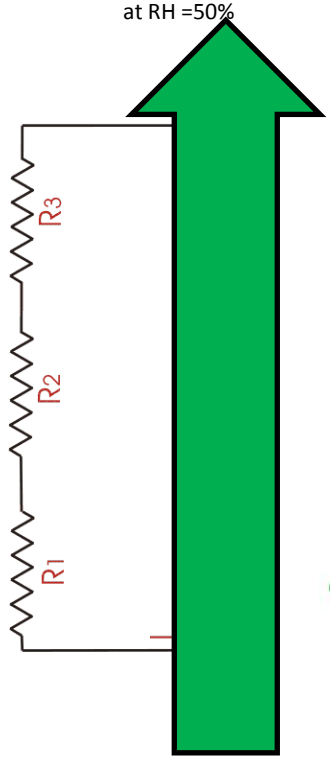


Direct water-balance measurements

Atmosphere

Ψ_w= -95 Mpa

at RH =50%



Soil

ysime

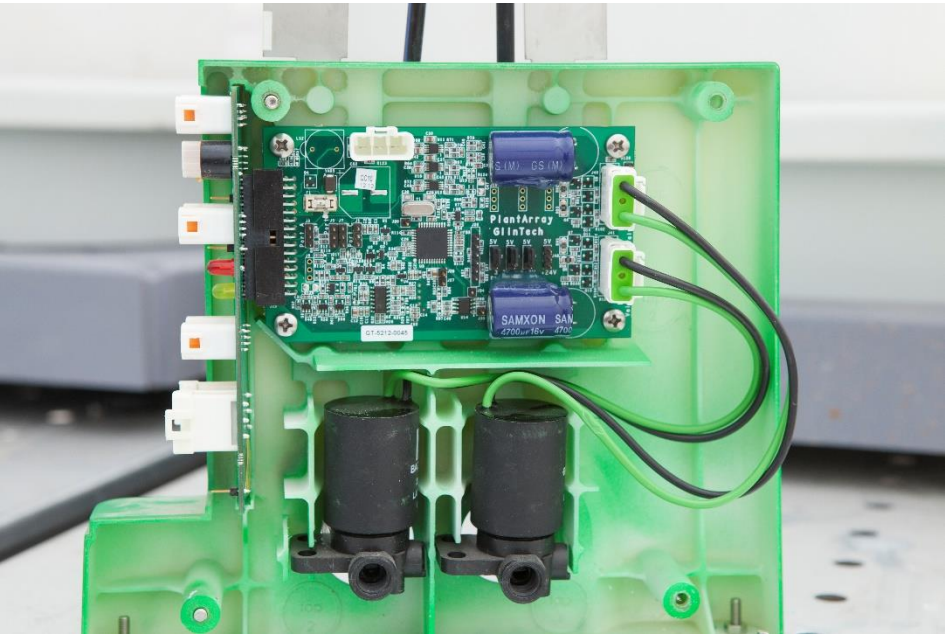
Patented technology

Controller

Feedback irrigation system

Feedback system for controlling soil required conditions

Our cutting-edge controller and unique water delivery system had replace the unfriendly Data-logger AND
Solved many of the pot effects



Plant-Ditech Controller

Unique irrigation system (which is part of the control unit) enabling different irrigation "cocktail" **to each plant** in the array

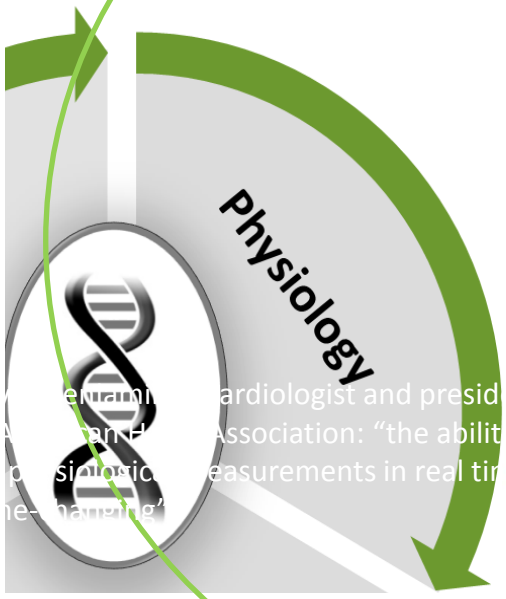
plantDitech

High-throughput Phenotyping

Functional (physiology) Phenotyping

+

Plant performance analysis

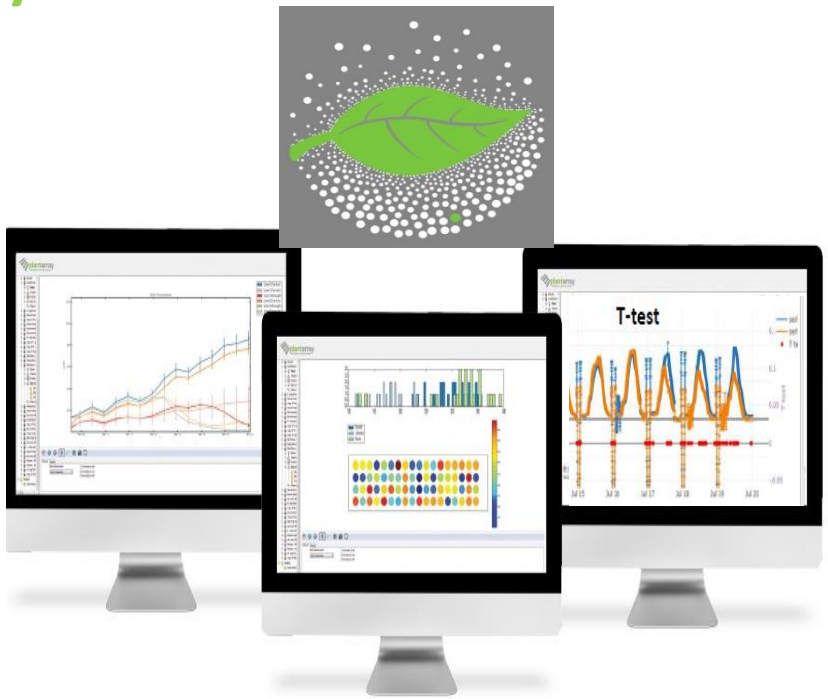


plantDitech

Identifying the Ideotype plant, based on its water relations, stress response and growth performances

Our key functional (physiological) traits

We measure (directly, simultaneously and continuously) the following water-balance related parameters:



- ✓ **Whole-Plant biomass gain**
- ✓ **Transpiration**
- ✓ **Water-Use-Efficiency**
- ✓ **Stomatal conductance**
- ✓ **Root fluxes**
- ✓ **Plant Relative-Water-Content**
- ✓ **Ambient measurements – Soil (temp/EC/SWC) and Atmospheric VPD, temp, RH and barometric pressure**
- ✓ **Auto plant parts weight (fruits, leaves, roots..)**

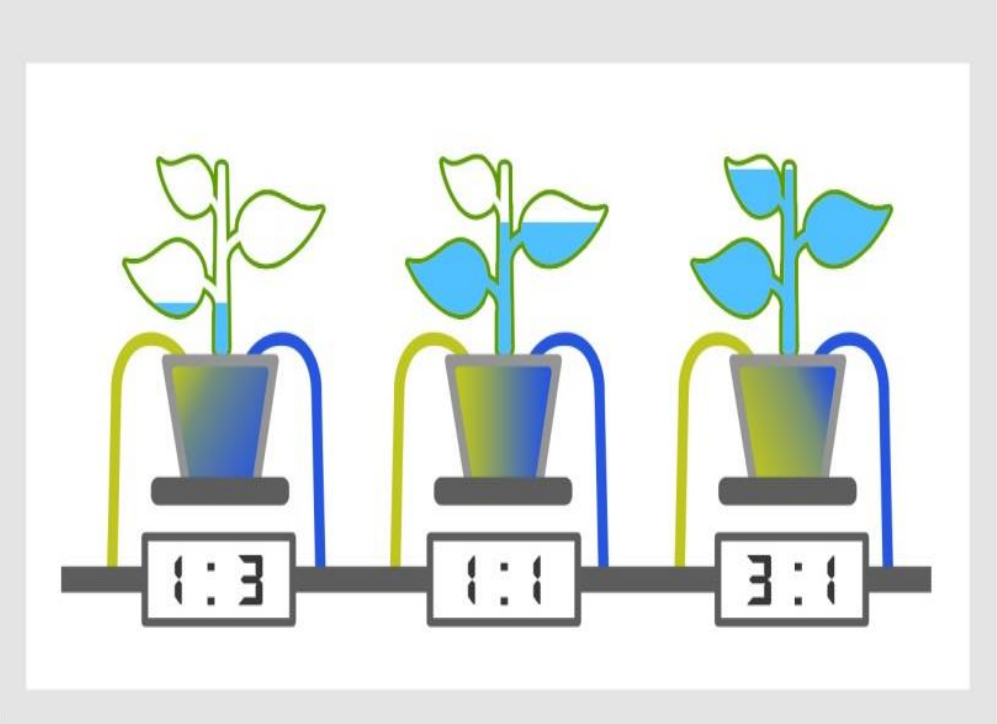
plantDitech

How too pick the winning horse ?

- Amino acids
- Humic acids
- Fulvic acid
- Seaweeds extract
- Inorganic compounds
- Chitin and chitosan
- Beneficial Fungi and Bacteria

Set & monitor test conditions

Different soil & water treatments <u>for each plant</u>



Drought | | Bio-stimulants

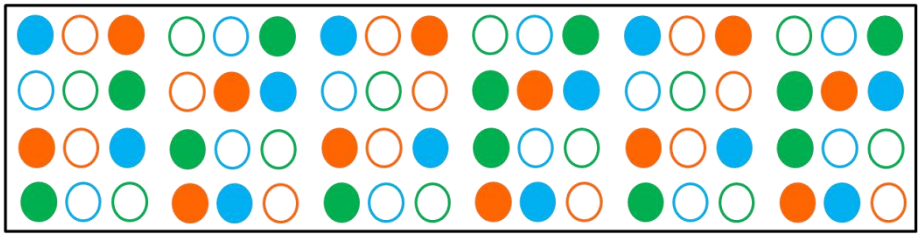
+ Combine treatments

plantDitech

Time- and Cost-Effective Screening of Potential Biostimulants

A

B



Randomized arrangement of plants

Pepper plants (*Capsicum annuum*), 20/30 sand

Biostimulants :

Seaweed extract provided once a week (ICL-SW, 3.53 mg/L) and

Metabolite extract formula (ICL-NewFo1, 0.133 mg/L provided daily)

Both manufactured by ICL Specialty Fertilizers, Holland.

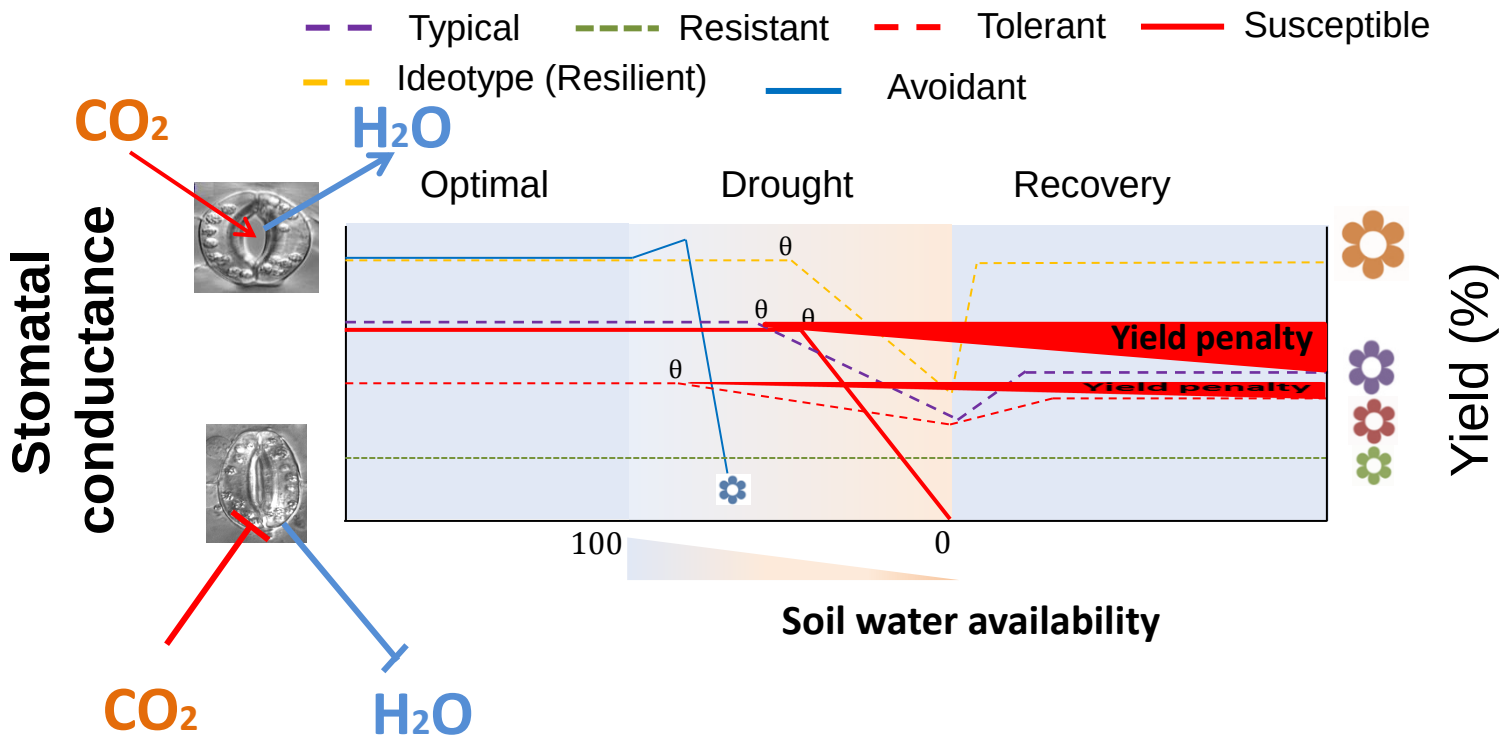
- Control-well irrigated
- ICL-SW-well irrigated
- ICL-NewFo1-well irrigated
- Control-drought
- ICL-SW-drought
- ICL-NewFo1-drought

TABLE 1. Nutrient composition of irrigation solution (before 20% dilution)

Mineral	Final concentration (ppm)	Final concentration (mM)
$NaNO_3$ (N)	195.8	2.3
H_3PO_4 (P)	209	0.000969
KNO_3 (K)	271.4	2.685
$MgSO_4$ (Mg)	75	0.623
$ZnSO_4$ (Zn)	0.748	0.0025
$CuSO_4$ (CU)	0.496	0.00198
MoO_3 (Mo)	0.131	0.00081
$MnSO_4$ (Mn)	3.441	0.0154
Borax (B)	0.3	0.00078
$C_{10}H_2FeN_2NaO_8$ (Fe)	8.66	0.0204

Drought response strategies– The yield penalty

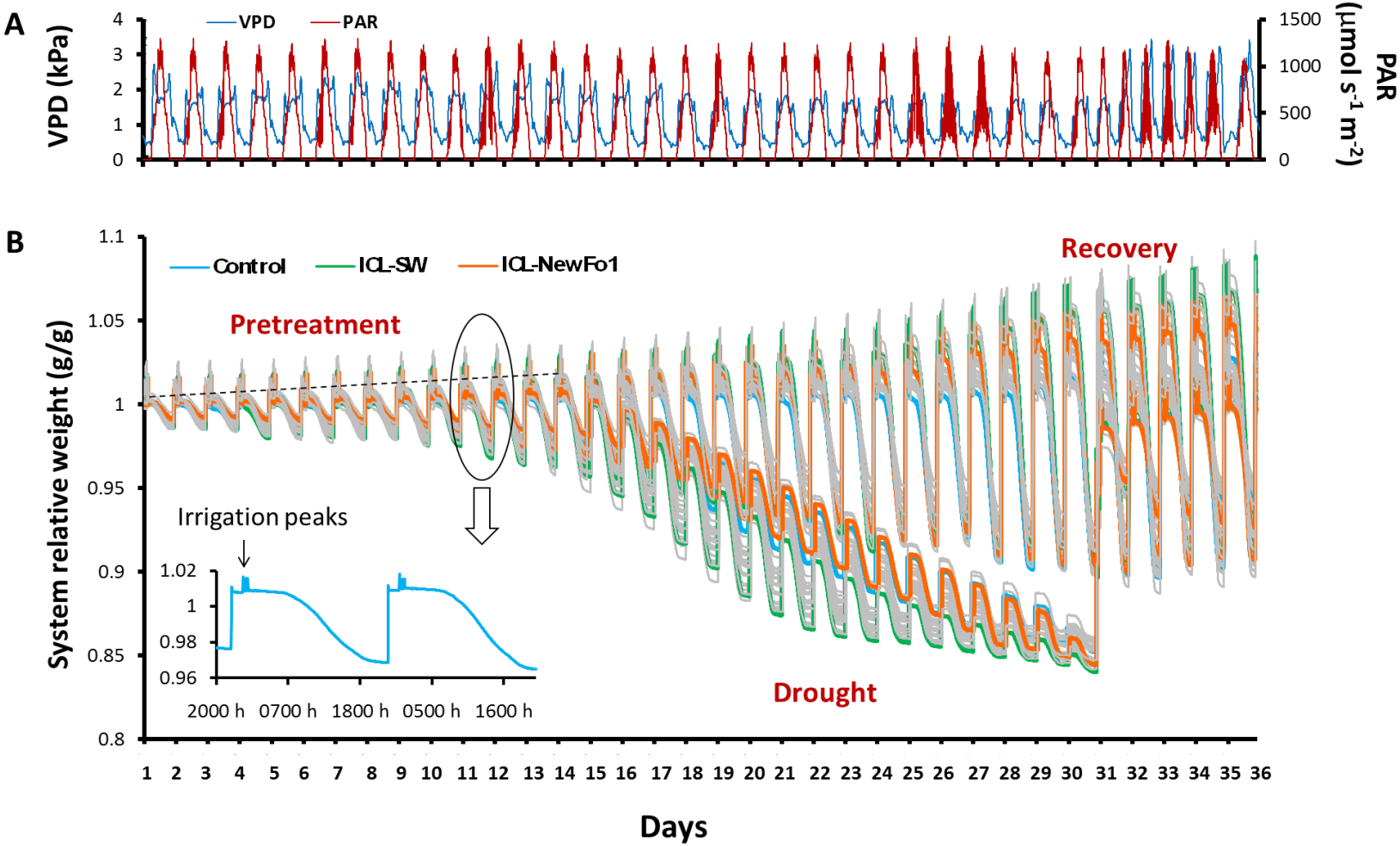
Environmental scenario : <u>Mild to moderate stress</u>



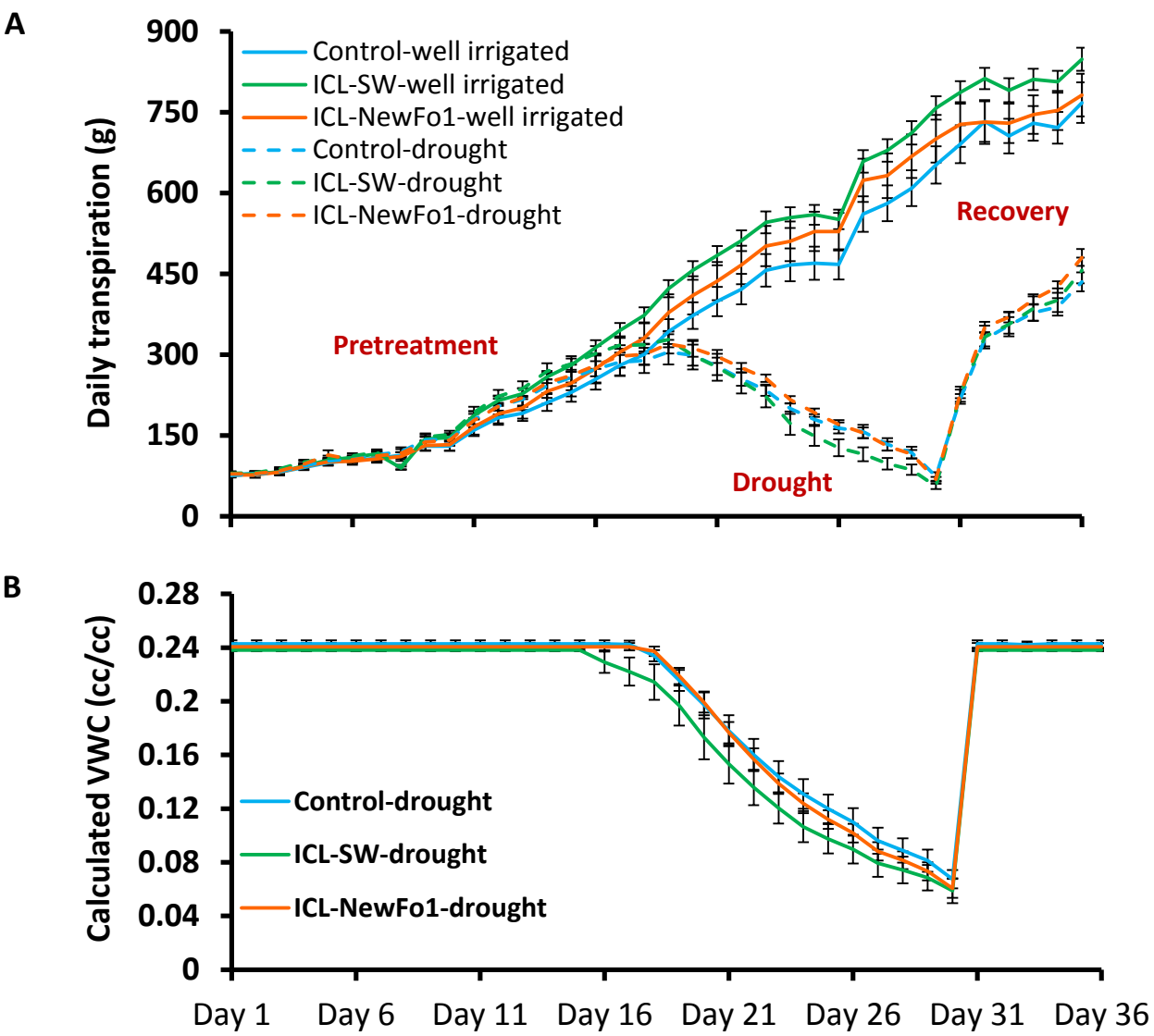
θ - Soil water content critical threshold

Negin et. al., (2016), Functional Plant Biology

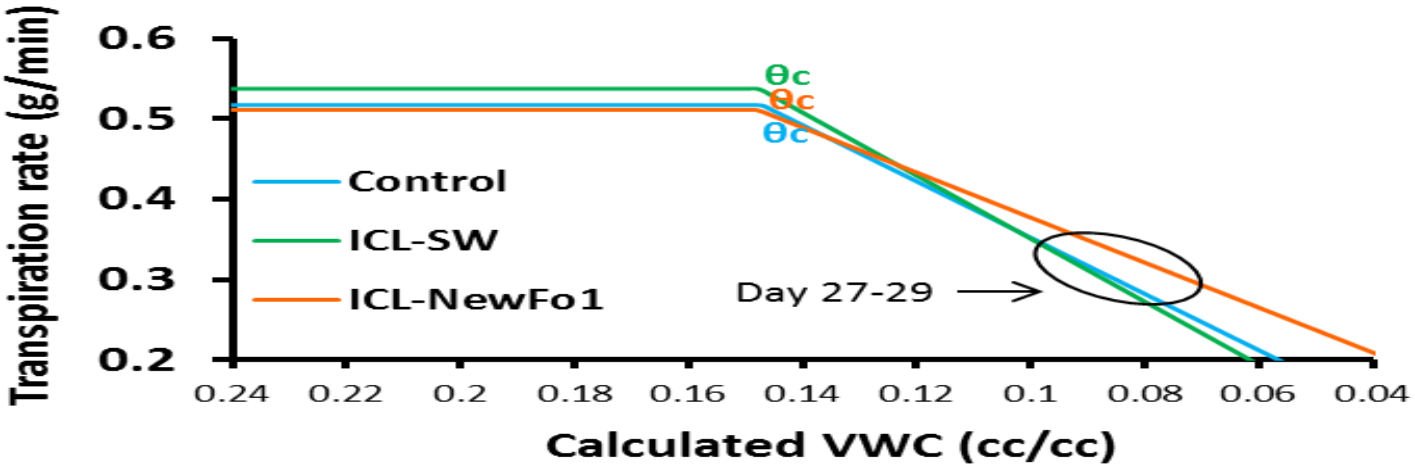
Raw data of the plants relative weight (to their respective initial weight) over the course of the experiment

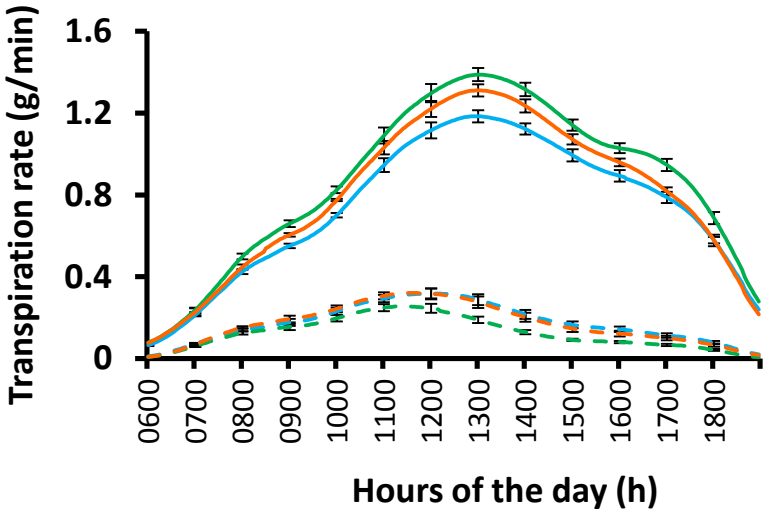


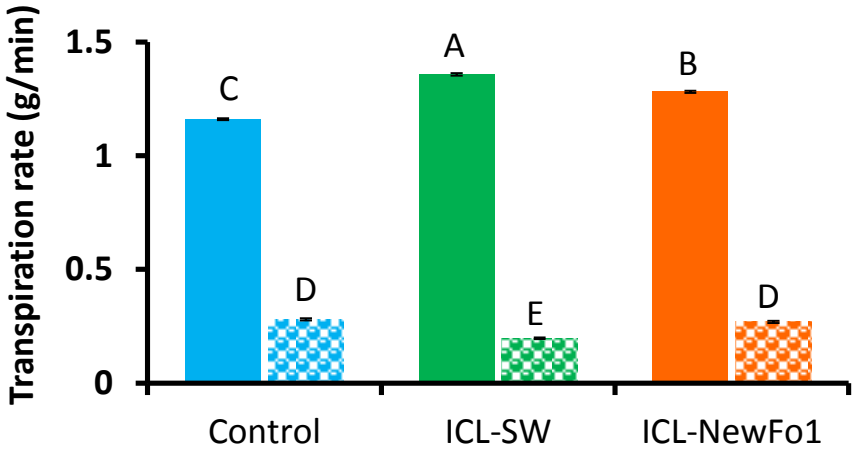
Effect of biostimulants on plant transpiration



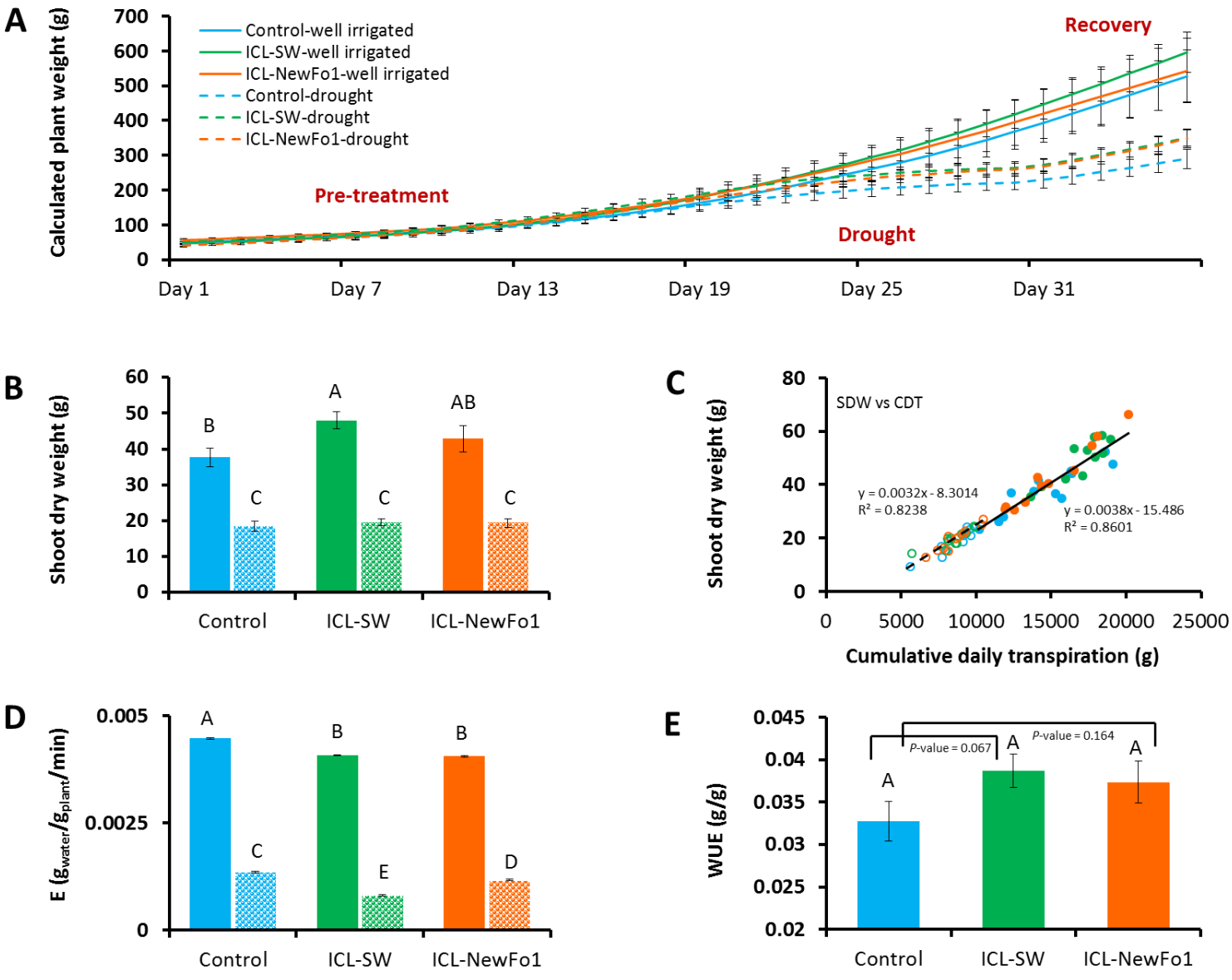
Effect of biostimulants on plant transpiration



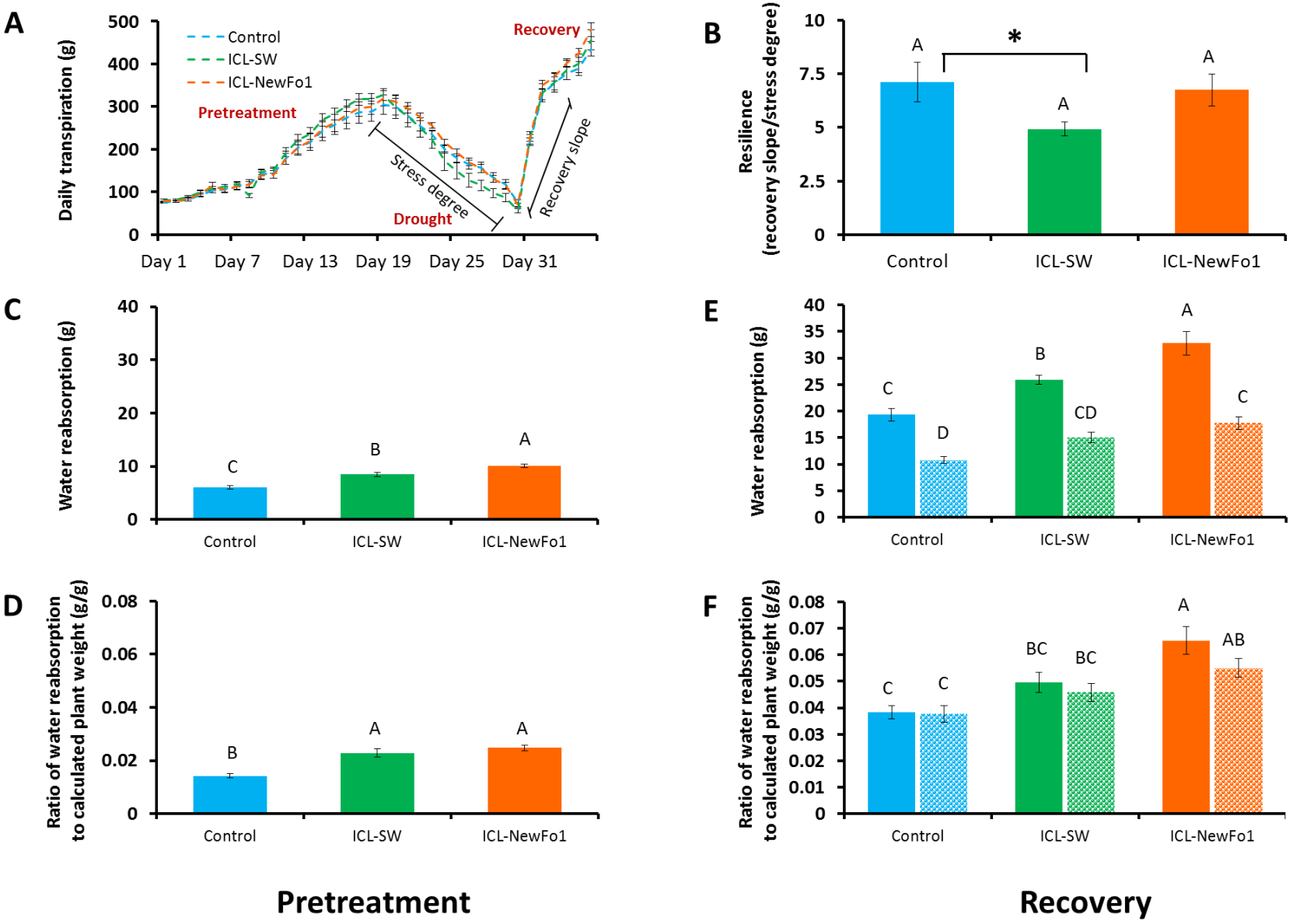




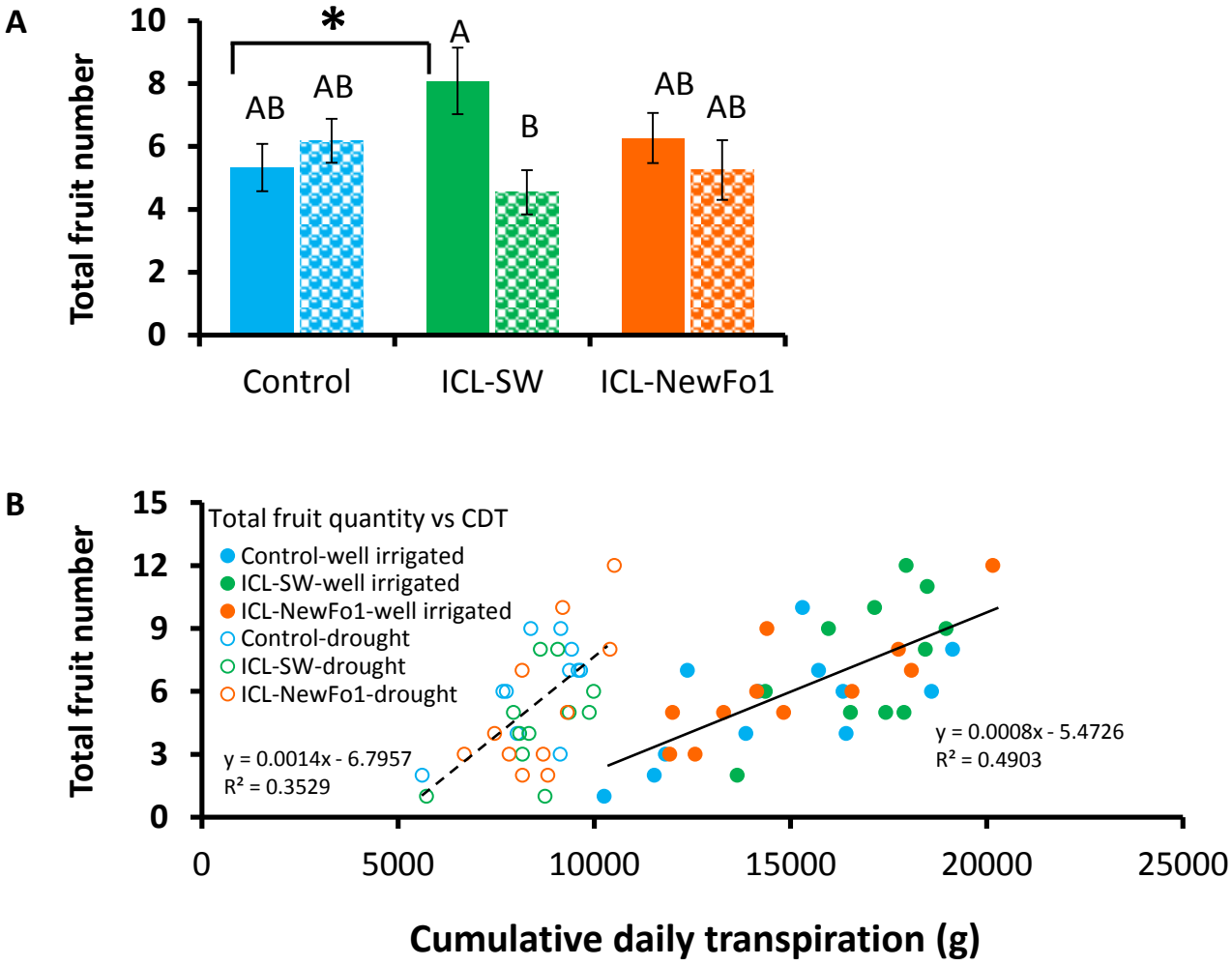
whole-plant weight and transpiration during the entire experiment



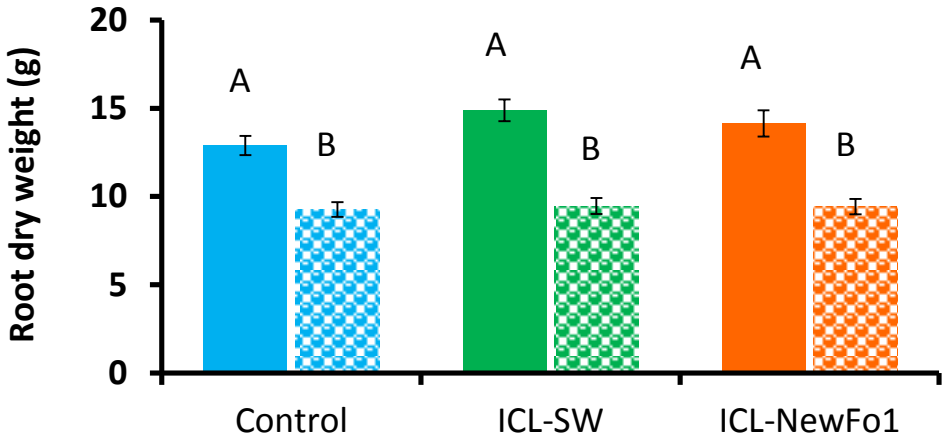
Effect of biostimulants on plant resilience during recovery



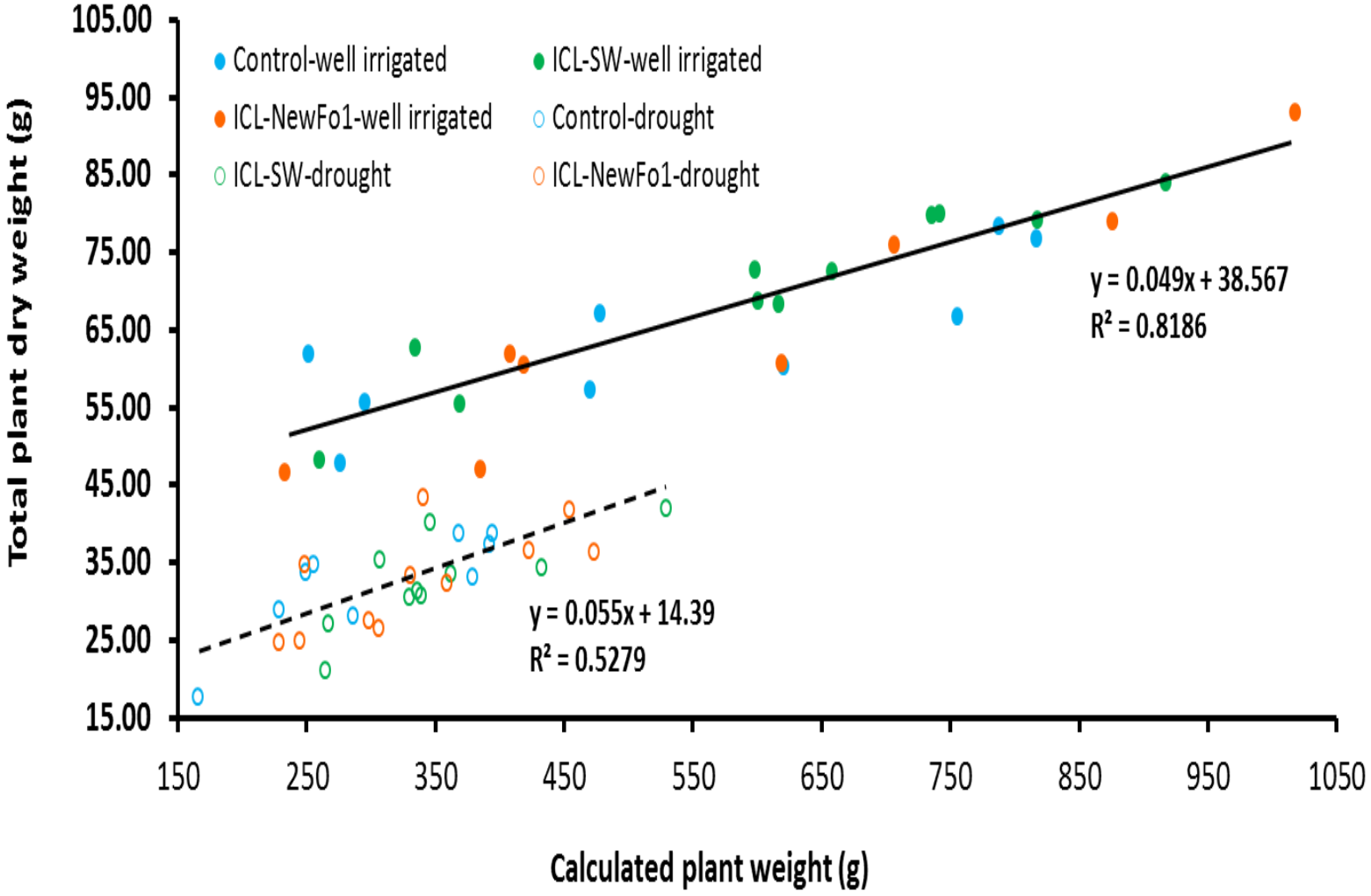
Effect of biostimulants on yield



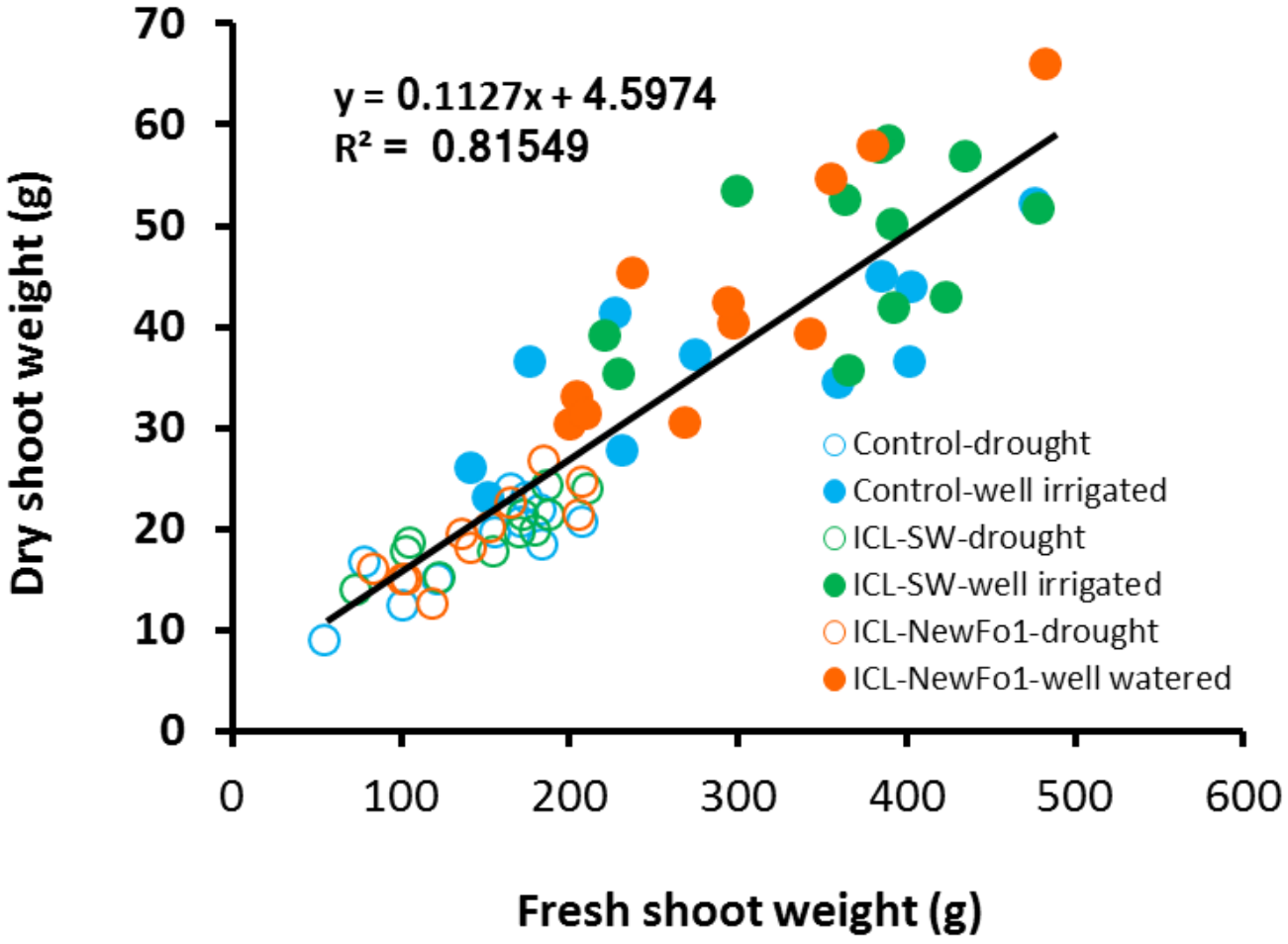
Effect of biostimulants on root dry weight



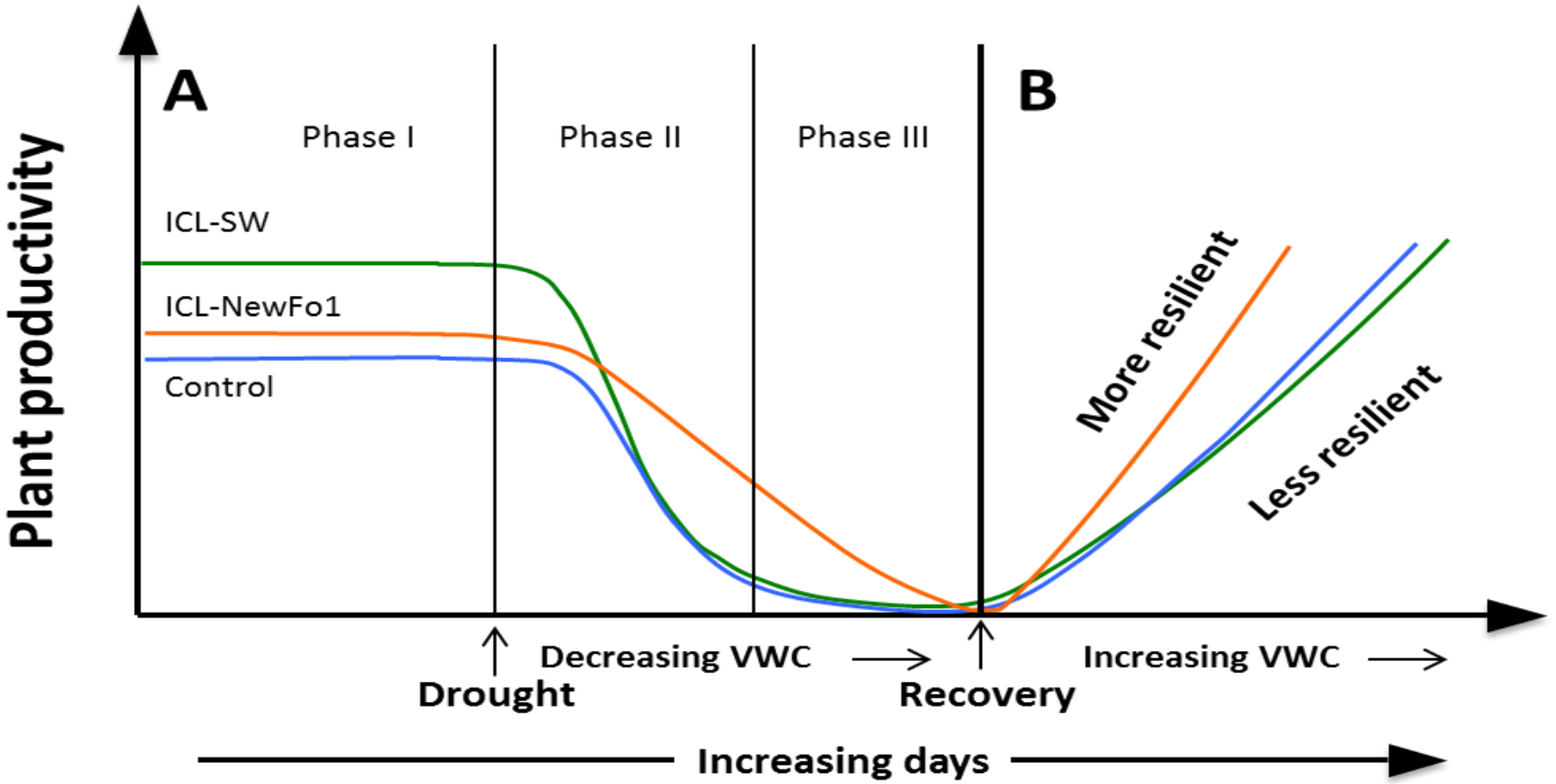
Correlation between the total plant dry weight and calculated plant weight



Correlation between dry shoot weight and fresh shoot weight

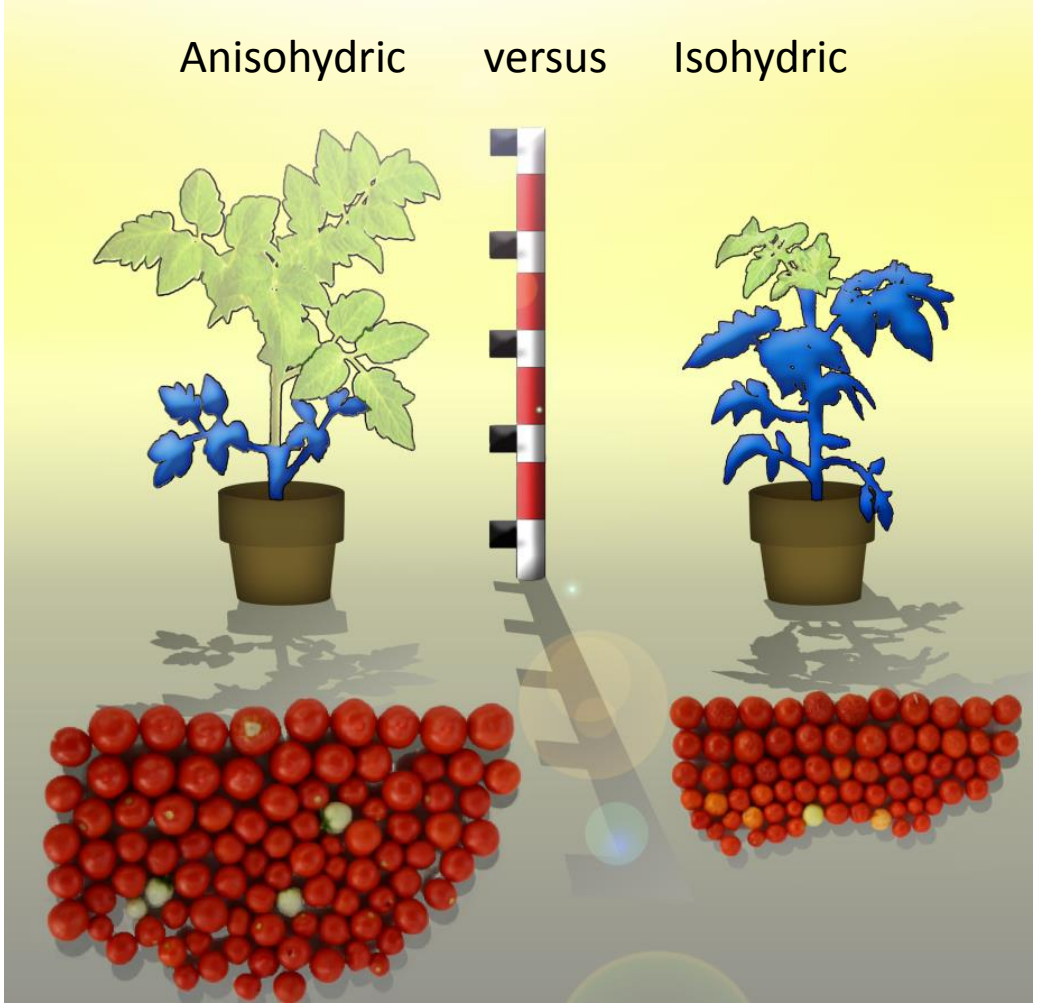


Calculated-risk-taking traits



Enable the selection of the right plant to the required conditions

Plant Water Balance



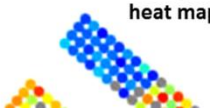
1. Sade et. al., (2009) New Phytologist. 181: 651–661.

2. Moshelion et al., PCE, 2015; Special Issue: Climate-Smart Agriculture and Forestry

In summary

Our Functional-phenotypic approach

- Whole plant Soil-Plant-Atmosphere-Continuum (SPAC)
- Controlling and maintaining the soil pre-determined conditions throughout the experiment
- Measure several physiological traits
- Continues and simultaneous monitoring under changing soil-atmosphere conditions



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Thank you