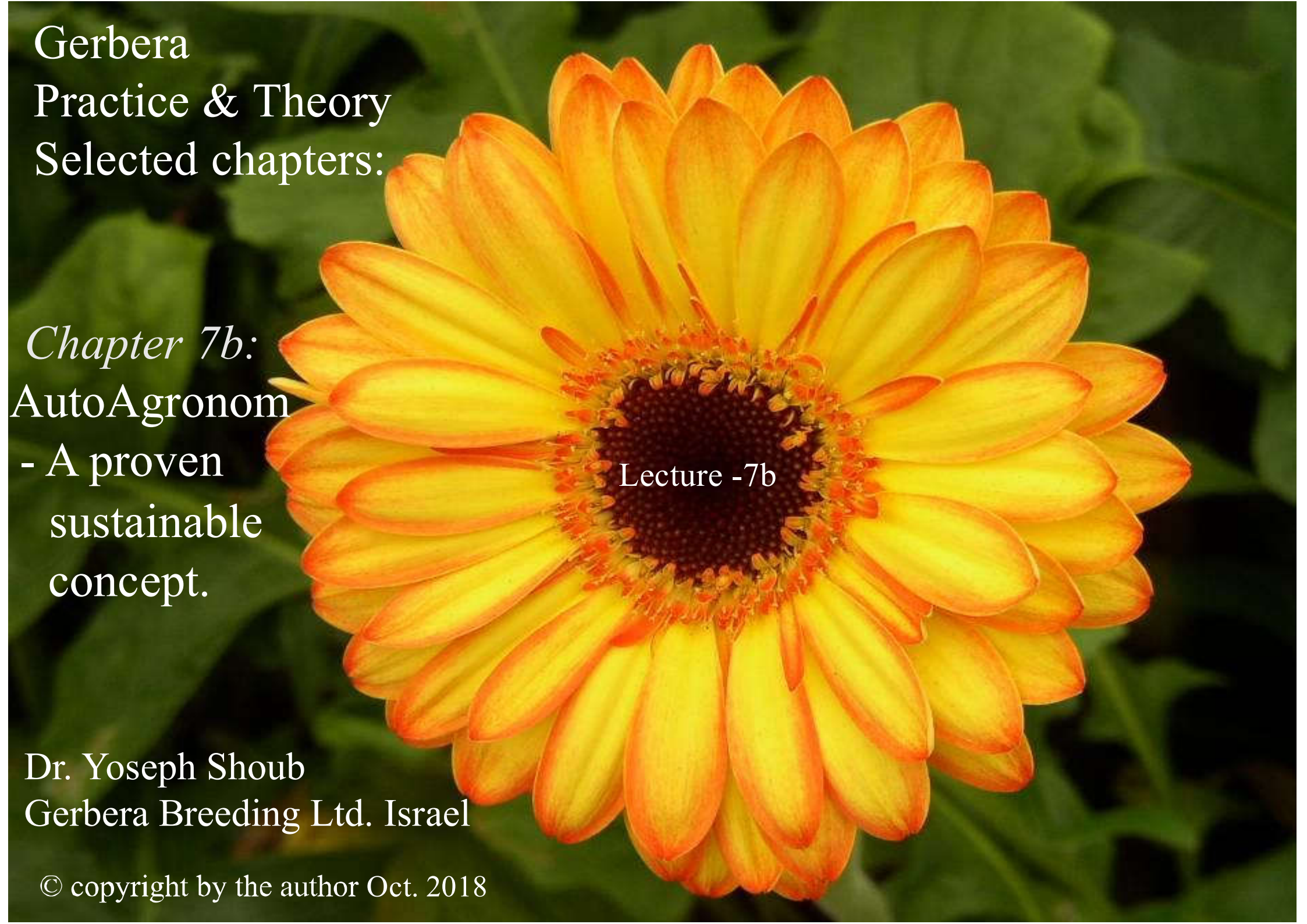
Gerbera
Practice & Theory
Selected chapters:
Chapter 7b:
AutoAgronom
- A proven
sustainable
concept.
Lecture -7b
Dr. Yoseph Shoub
Gerbera Breeding Ltd. Israel
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'AutoAgronom - A proven Sustainable Concept'

A presentation by Dr. Yoseph Shoub Feb. 2017

Gerbera Breeding. Ltd. Israel

A user of the AutoAgronom system since 2005

www.gerberaisrael.com

A lecture given on November 10, 2015 for the International course

"Crop Production Under Saline Stress"

The Hebrew University of Jerusalem, Faculty of Agriculture, Israel.

Revised Oct. 2018

The photos were taken by the author.

AutoAgronom Israel Ltd.

www.autoagronom.com

Crowded secondary roots of Pepper, 5 months after transplanting.
Controlled by the new 'AutoAgronom irrigation control system'.
Using local salty water (3.6 milimhos), Ein Yahav, Middle - Arava, Israel March 2005.

March 2005 - Experienced with gerbera for 42 years, I was introduced to a revolutionary new fertigation concept, named "AutoAgronom".

Something that I have been waiting for, mainly because of irregular salinity problems, that we have had. Soon it turned into a proven concept, which is far above my expectations.

8 major achievements with the 'AutoAgronom' ('AA') in Gerbera Breeding Ltd., 2005 – 2018.

1. Tripled the production of seeds.
2. Growing 4 seedlings in 4L. container, instead of 1 plant in the previous systems.
3. 110 days from transplanting the seedlings to end the selecting phase (when 95% of the seedlings are blooming), in comparison with 200 days in the previous system.
4. 3 growth-cycles per year in the same container, equivalent to 12 seedlings per container per year, in comparison with 1.7 plants, as before.
5. Saving 40% - 60% of water per plant.
6. Saving 60% of the fertilizers.
7. Saving the greenhouse heating-costs through winter nights.
8. Adding cold-resistance to our selecting parameters list.

Gerbera seeds May 2013

Yoseph Shoub ©

‘AA’ Gerbera-seedlings in our breeding greenhouse 8 weeks after transplanting, June 2014.

On planting day
(15.02.2016)

4 Gerbera seedlings,
in 4 L. ‘Rosier’ container.

and 78 days later
(03.05.2016)

21.8cm

Adventitious roots

Secondary roots

Shoub's gerberas are efficiently and successfully controlled in our greenhouse by an 'AA' system for almost 13 years.

Intensive - growth of the agricultural plants, depends on the presence of enough secondary active roots, and on their ability to absorb and transport: water, oxygen & minerals to the above soil organs.

Therefore they probably would declare: that in order to achieve their 'production-potential' all they needs is:

'Optimal growing conditions'

(or at least as close as possible to it.)

Do we really know what does it mean?

And if yes, can we providing it?

'AA' systems combined with Micro-irrigation, create and control the optimal conditions for the secondary roots to develop, and enable them to absorb efficiently the suitable soil-solution.

So; when they have it they do the work.

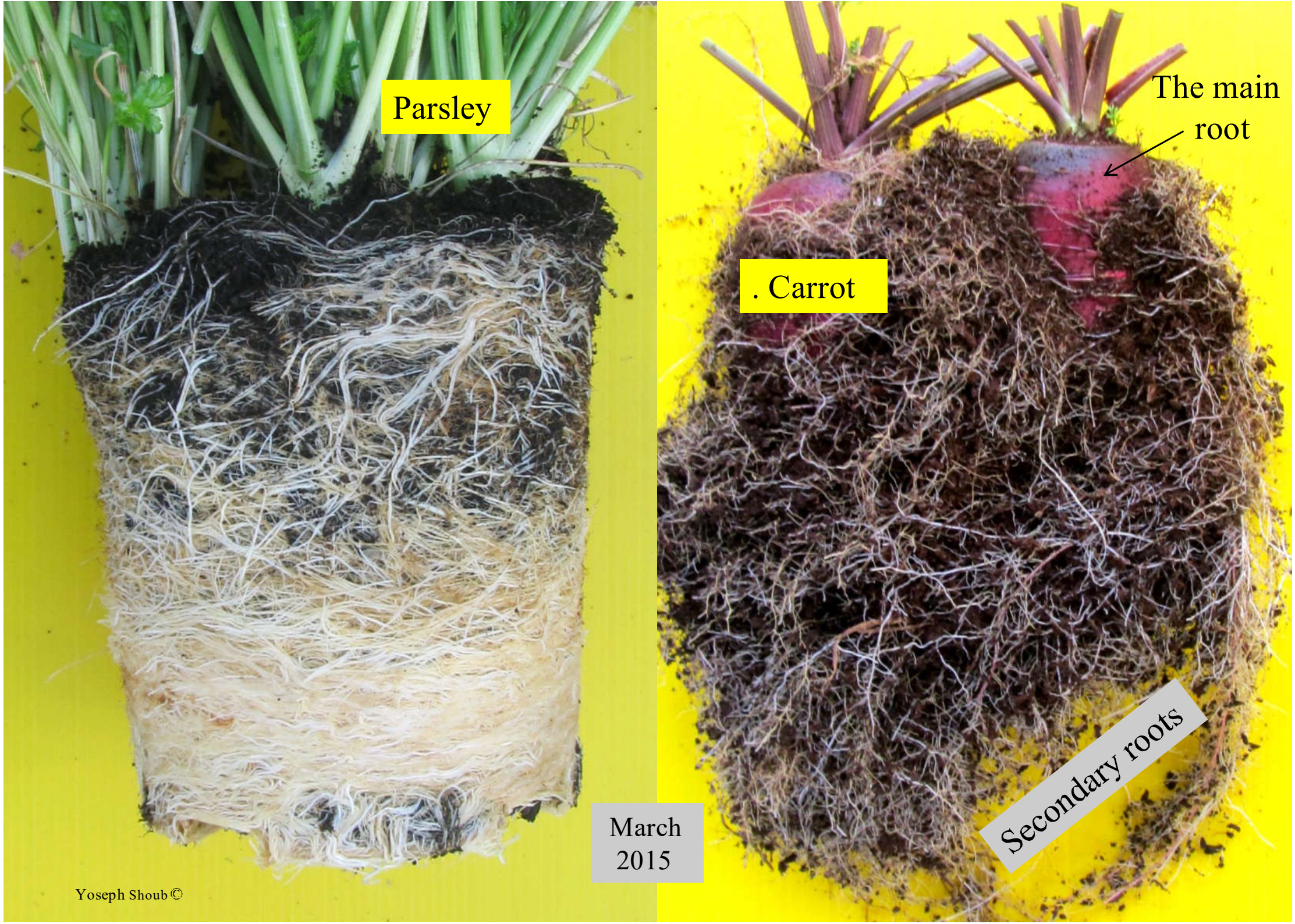
Roots of diverse 'AA' crops

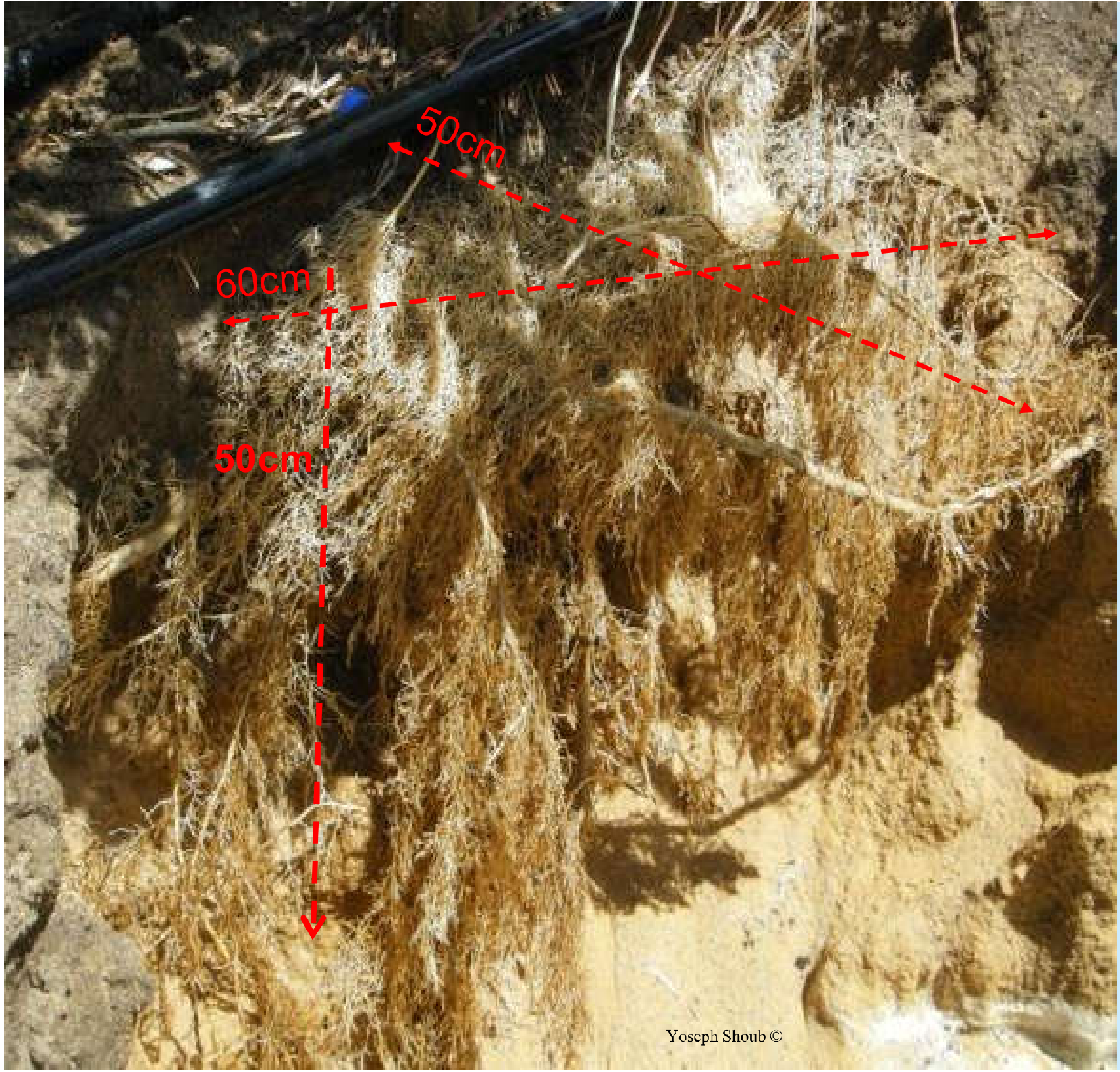
Roots of 2 month old cauliflower.

March 2015

Roots of 18 months old eggplant

Chlorophytum comosum ‘Variegatum' under ‘AutoAgronom’ conditions Feb. 2017.


Parsley
The main root
. Carrot
Secondary roots
March 2015
Yoseph Shoub ©



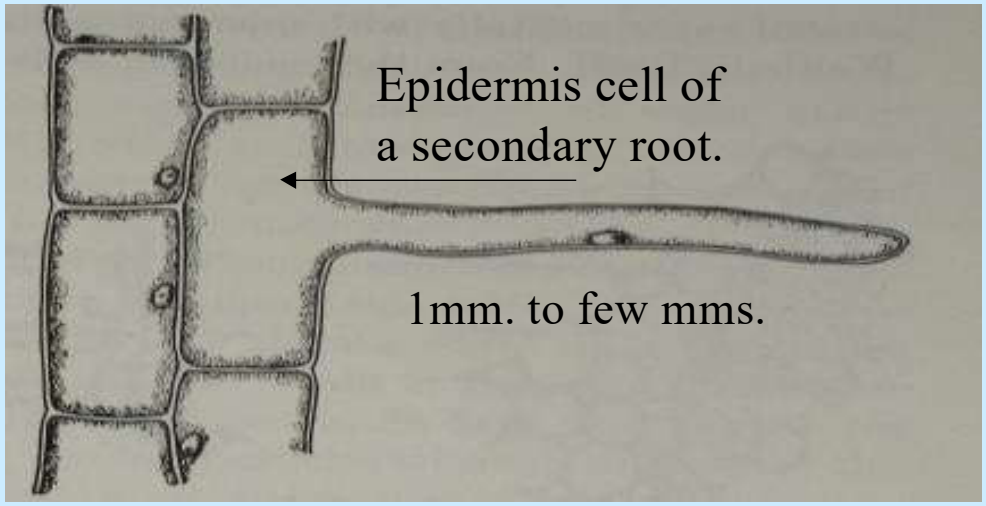
Secondary roots of 3-year-old citrus tree in soil controlled by 'AA' system.

Australia,

January 2010.

The 'Root-hairs' do the work.

Root hairs are elongated epidermis-cells located on the secondary roots.
Their function is to absorb the soil-solution (*water, oxygen and minerals)* into the plant's vascular system.



A scheme of a root hair

The productivity of intensive crops depends, to a great extent on the vital activity of the root-hairs.

Secondary roots of 'AA' - Allium schoenoprasum,
3 years after planting. May 2010.

Close up of ‘AA’ apple’s secondary root covered with countless root-hairs. Dec. 2010.

The root hairs are vital organs of the plant. Yet, they are very sensitive to the growing conditions of the root’s media as they are physically exposed and not protected like the other organs.

Root hairs of intensive crops develop optimally on the secondary roots’ tissue, in the upper soil layers, as they are highly influenced by the water / oxygen relations.


Yoseph Shoub ©
Tomato
Spring onion
Celery
Kohlrabi
Broccoli
Coriandrum
Celery
Celery
Wheat
Kale
The roots do the work!
No matter to whom they belong, they all do the same work, they are built for it.
So let them do it the easy way !
Yoseph Shoub ©
Tomato
Spring onion

However - four critical questions, are still under survey:

When to irrigate? and How much to irrigate?
When to fertilize? and How much to fertilize?

As an 'AA' user I raise here some thoughts:

How come? That the most vital actions in agriculture having the greatest impact on the plants' growth - supplying water, oxygen and minerals – is done according to predefined schedules, without even considering plant's physiological activities 'rhythm'.

How come? That salinity problems can be solved by washing salts into the aquifers.

.

Wrong management examples of Conventional drip irrigation -

Mexico, June 2012

'Soil-solution' drain, between 2 soil-beds of Cucumbers irrigated by a conventional drip irrigation.

The picture demonstrates that conventional drip irrigation, enriched with fertilizers, can endangers agricultural crops and the growers' income.

As:

Feeding-solution' is wasted.

Oxygen presence is prevented.

Growth is moderated.

Salinity conditions develop,

and besides -

the Soil and the Aquifers are being contaminated.

Yoseph Shoub

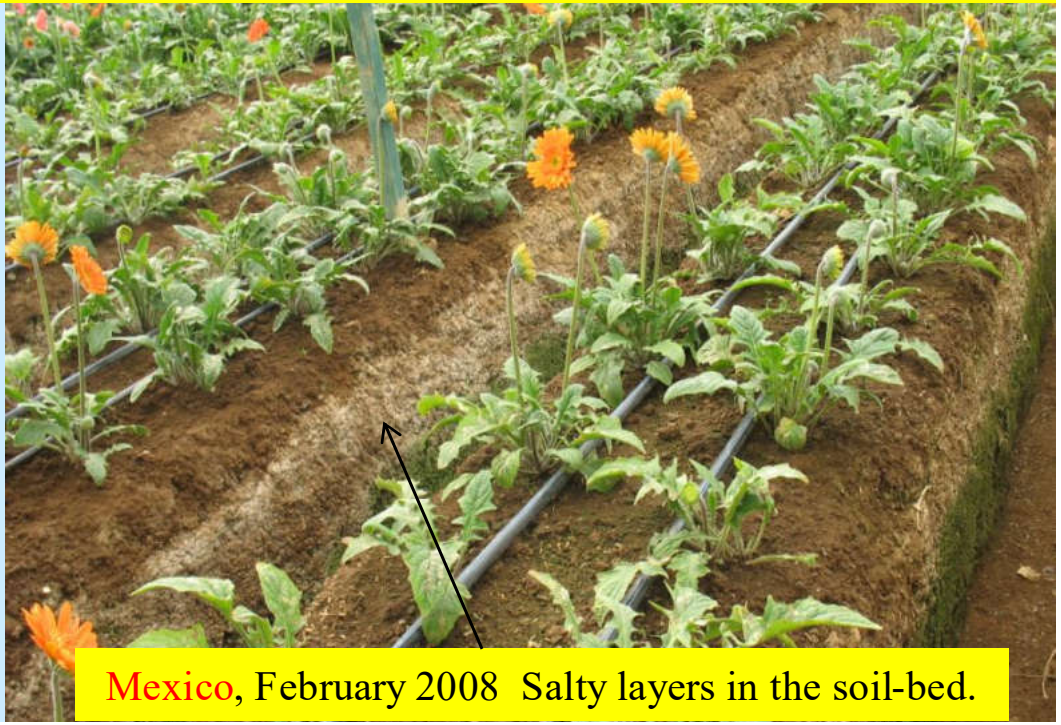

Common drip irrigation program
In Vine
in Pistachio
California August 2016; 7 years of drought and Californian growers still wasting water and fertilizers.
Yoseph Shoub ©

Salinity damage in gerbera

India, June 2009 - Severe salinity in the soil beds caused by high saltsconcentration, damaged the roots and blocked the growth.

Salinity-conditions in agricultural soils, are caused by mineral's excess, accumulate in the roots' volume, and not as a result of the original soil character.

Therefor it is quite common that - predefined dripping schedules, enriched with fertilizers - cause 'Salinity-conditions' in the roots' media.



Mexico, February 2008 Salty layers in the soil-bed.

Theoretically, plants are able to develop their secondary roots in any media or soil type, even in the air or in the water, on condition that 'Optimal-ratio' of Water (Humidity), Air and Minerals is present in their existing root's media.

Thus, one can say - The plant is interested **only** in the soil solution!
The growing media is a physical factor, and it is the **grower's concern!**

Secondary roots' performance of Bananas in clay soil, the Jordan Valley, Israel October 2010.

Under Conventional irrigation program.

Under AutoAgronom system.

It looks clearly that the roots of the Bananas grown in the same original clay soil, but irrigated differently, develop their absorbing system differently.

Once more: "The plant is interested in the soil solution! The soil type is the grower's concern".

Avocado salinity experiments: 'AA' - versus - Common fertigation, Jordan Valley, Israel 2009.

The same variety, the same climate & soil, the same water & fertilizers, and the same grower.

Salinity damage

'AA' - Water 3,5 cubic m / Dunam/day/ in pulses.
- Fertilizers 30 kg. May to October 2009.

Common fertigation - Water 7 cubic m /Dunam/day (once in 4 days 28 cubic m). - Fertilizers 70 kg. May to October 2009.

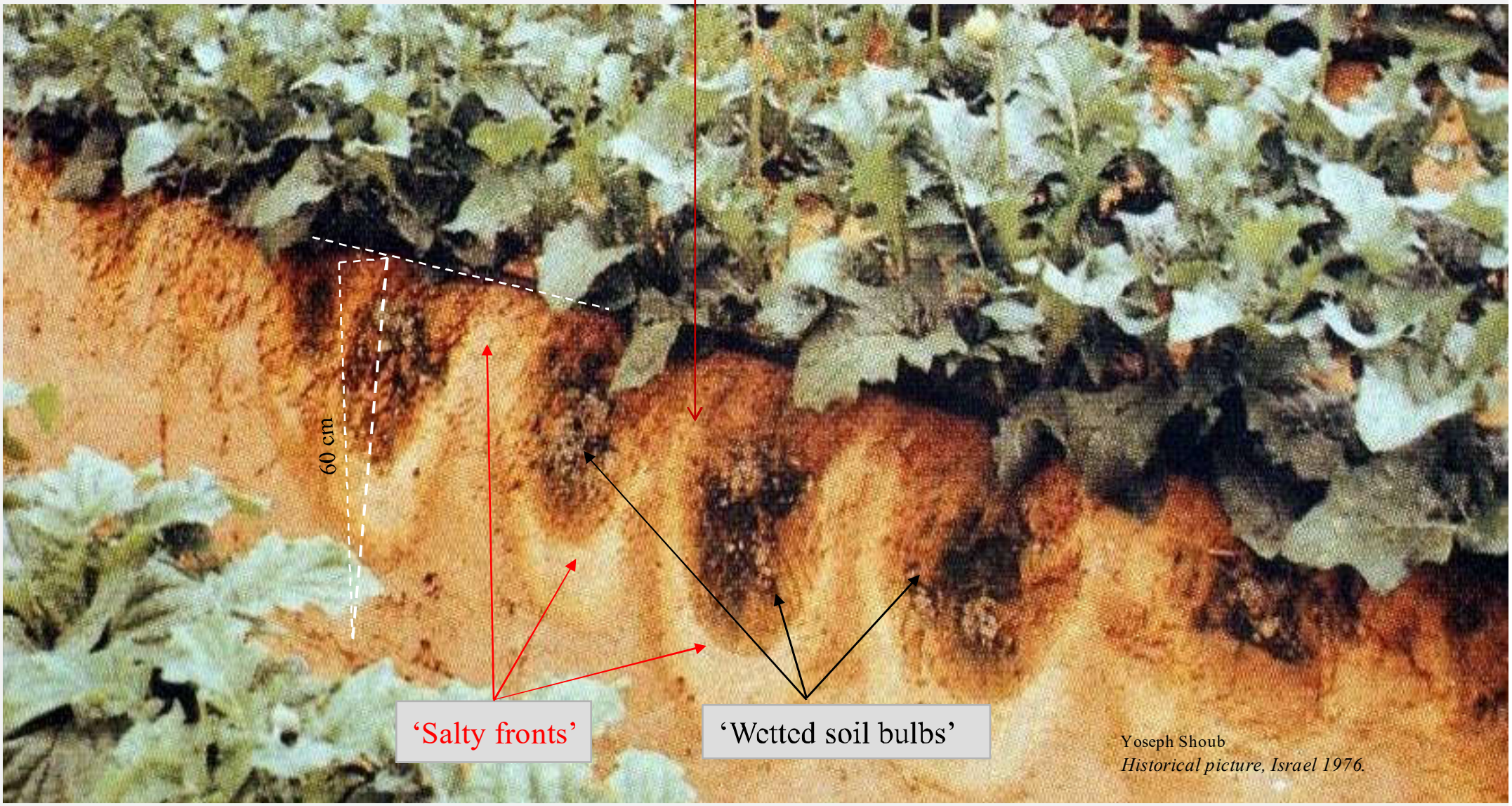
‘AA’ Avocado without Salinity

Salinity in Avocado under conventional fertigation.

Conventional fertigation = Disadvantages of Crisis management.

Salty Fronts - Fertigating via conventional drippers *(as 2 liter/hour)* creates along their usage a format, commonly called, the 'Wetted soil bulbs' surrounded by 'Salty-Fronts'. It develop under the drippers, as it tracks the **gravity movement** of the fertilizers-solution, and the accompanying **capillary movement** of the soil-solution.

Usually growers do not see the fertilizers 'Chromatography' as seen here on the soil-bed-wall.

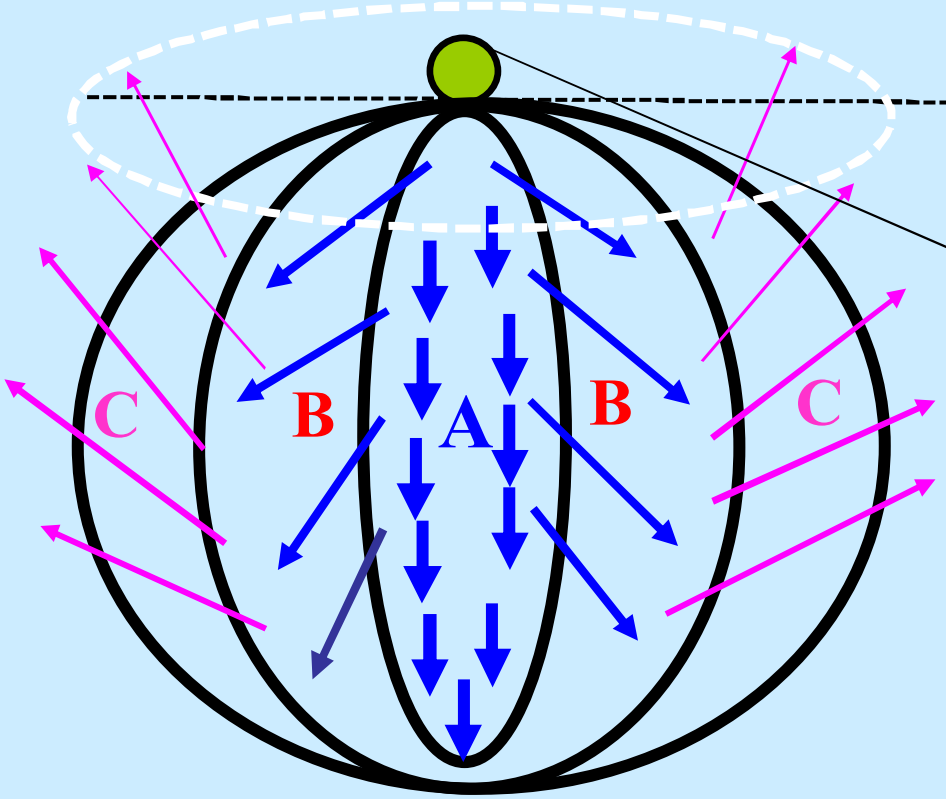


Shoub y. 2004, International Water & Irrigation, vol. 24, 4.

The Chromatography scene on the wall represents the considerable minerals-layers inside the soil-bed.

The movement pattern of fertigation-solutions in the soil (Gravity and Capillary) -

Graphic description shows the development of: 'Wetted soil bulbs', 'Salty fronts' and 'Salty halos', as affected by gravity movement (**A**) of the fertilizers-solution, followed by secondary capillary movement (**B**) of the soil-solution.



A Gravity movement

B Gravity movement & Capillary movement

C Capillary movement

Raised sandy soil-beds for gerbera.

Fertilizers salts-halos in Olives,
'Loess soil', Negev area, Israel 2009.

The Capillary movement of the fertilizers' minerals is caused by the evaporation. It transports the excessed minerals' towards the soil surface.

A grower who sees the salty-halos, have to realize that the halos are edges of the considerable unseen 'Salty fronts'.

Fertilizers salts-halos in Gypsophila, 4 weeks after transplanting. 'Heavy soil', Ecuador 2005.

Fertilizers ‘Salty halos’ in public garden, ‘Loess soil’, Yeruham, Israel 2018

Micro dripping advantages.

The advantages of 'Micro-dripping' in comparison to 'Conventional-dripping' are related to the following parameters:

1. Water area-surface.
2. Water movement.
3. Air and oxygen availability.

Conventional dripping
2 L/h creates 'Micro-flow' and gravity movement.

'Micro-dripping'
e.g. 0.2 L/h creates separated drops & enables capillary movement.

1. Micro dripping creates separated drops (~ 6000 / Liter) and a dripping intervals of 1.0 - 1.5 seconds between the drops. Therefore the water area-surface is much greater than the area-surface of the Micro-flow. Micro dripping increases the permeability of the oxygen into the irrigated water. *(New compensated 'low volume drippers' are available now in the markets).*

2. Dripping separated drops above the wetting point, enables and encouraging the capillary movement of the irrigated feeding-solution, both transversal and downwards directions.

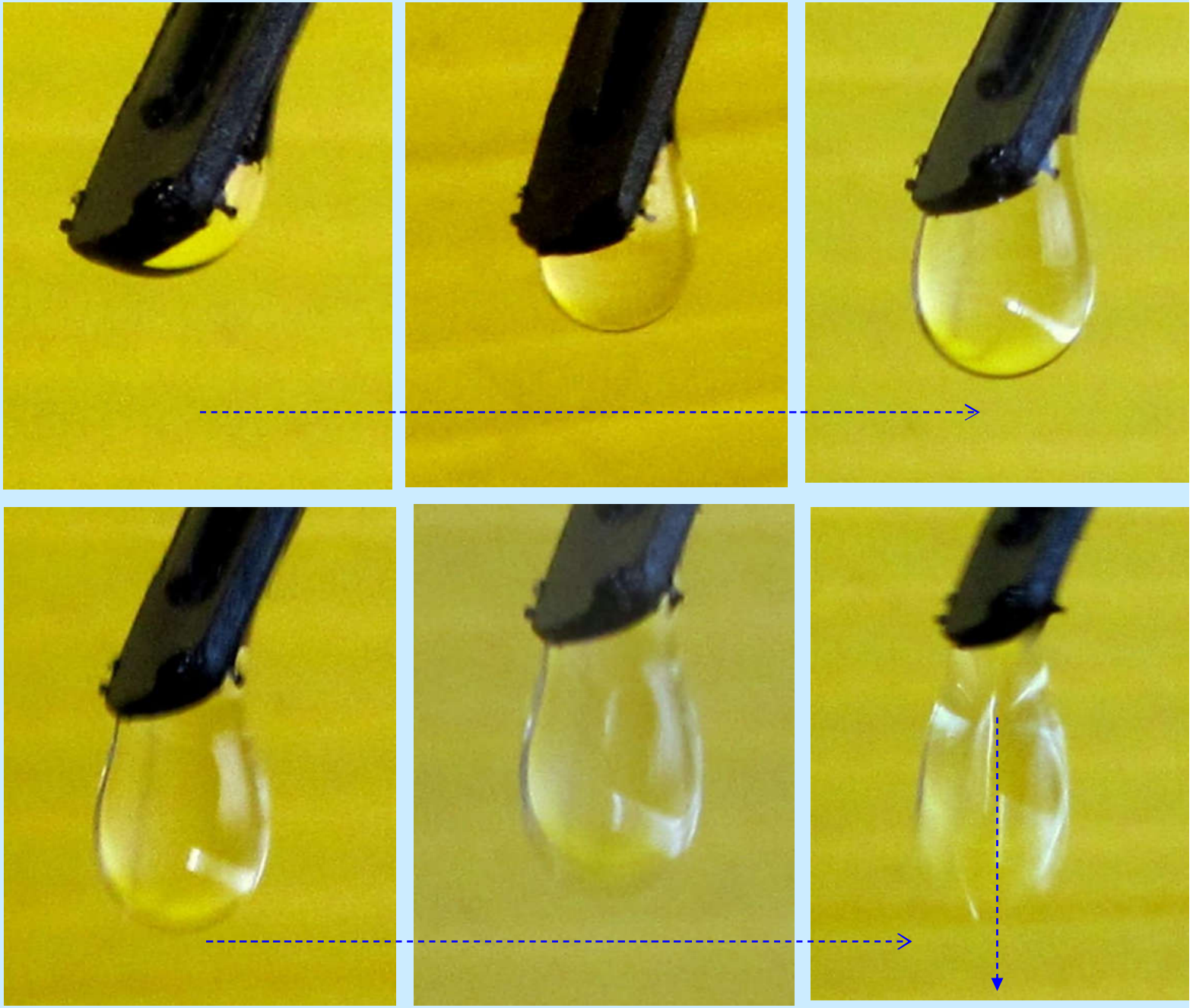
3. The great water area-surface and the slow water movement in the aerated roots media, improve the oxygen dissolving-process into the feeding-solution, and increases its' availability to the absorbing roots system.

Born of a water drop - produced by micro irrigation systems.

Its maximal volume will be ~ 0.166cc

The next drop start to develop ~1 second later, and it released subsequently after ~ 1 - 2 secs. after the previous one.

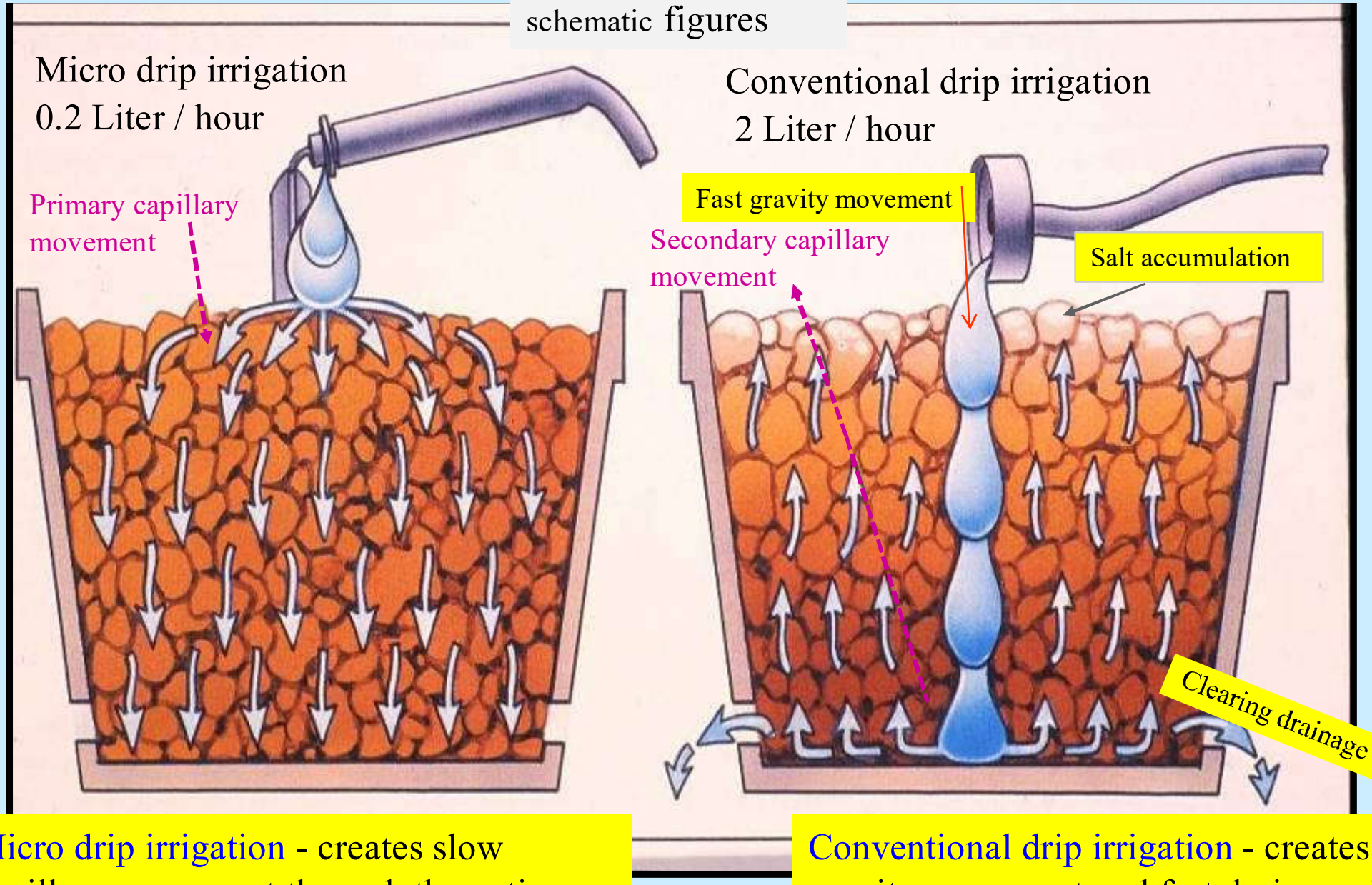
The small water volume and the slow water movement create the ideal capillary movement.



This is the primary step towards ‘Sustainable Precision Agriculture’.

Capillary movement - versus - Gravity movement in containers-media.

schematic figures



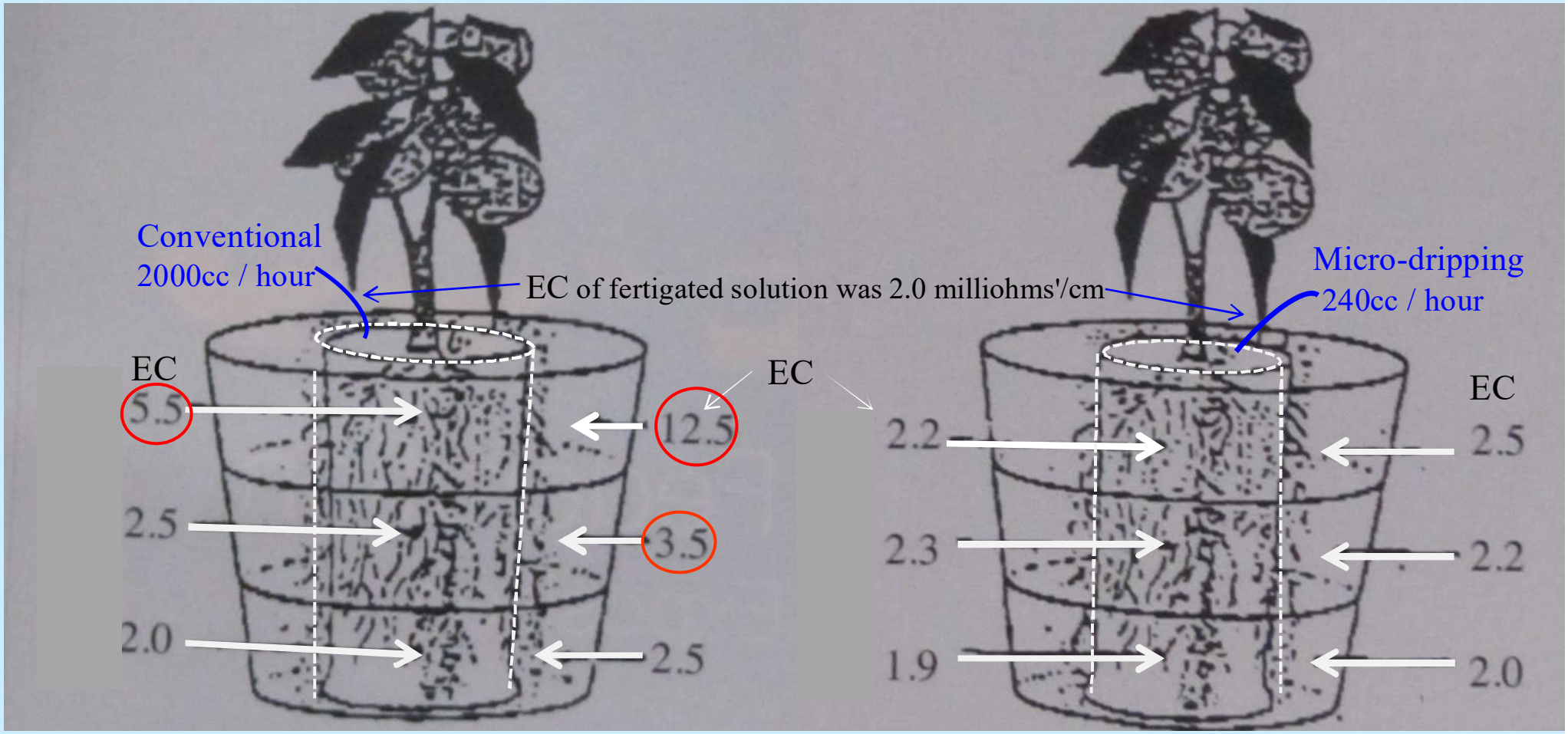
Shoub y. 2004, International Water & Irrigation, vol. 24, 4.

Micro drip irrigation - creates slow capillary movement through the entire root volume, and helps to avoid salinity damage.

Conventional drip irrigation - creates fast gravity movement and fast drainage, but at the same time promotes upward capillary movement of minerals and causes 'Salinity'.

Conventional irrigation - versus - Micro-drip irrigation as related to salinity in potted gerbera. Valued as the 'Electrical conductivity' (EC) in 6 media compartment (vertical and horizontal).

Shoub y. 1999, International Water & Irrigation, vol. 19, 2.



Severe salinity caused in potted gerbera grown in coco peat by conventional drip irrigations, 6 weeks after planting.

Micro drip Irrigations didn't cause salinity in potted gerbera, in coco peat, even 4 months after planting.

Practically; the 'AA' concept deals with supplying water - as micro drip irrigation - (15 - 60cc/irrigation) on 'real time', back to the volumes from where and when the water has been taken.

Theoretically; the concept is far more sophisticated as it deals with the plant's physiological activities that affect the water consumption and the associated parameters.

Under 'AA' control, the wetted volumes are limited, but full loaded with secondary roots!

4 litters of 'AA' gerbera roots system, 3 months after transplanting.

The ‘Essential Nutrients’ - The organic ingredients *(Carbohydrates, Proteins, and Fats)* are the plant’s photosyntates products. They are considered Essential for the plants themselves and for all who are nourished by the plants.

4 Important notes -

> The organic material share 85 - 92% of the plant’s Dry Matter. *

> They originated from the primary photosyntates, the sugars.

> The primary Mono-sugar, the ‘Glucose’ $C_6H_{12}O_6$ originates from

Carbon (C) as CO_2, Hydrogen (H), and Oxygen (O).

> And these widespread 3 elements are for free in the air and in the water.

* while the rest 8 -15% of the dry matter comes, partly, from the fertilizers, the ‘Soil minerals'.

Leaf analysis -

Mineral content of Bean leaves (Almeria, Spain).
comparison between conventional formula (control),
and an 'AA' reduced formula.

(Sampling date 20/01/2010) Fertilizers milligram / Liter		Control 800 100%	'AA' 300 38%
Macro elements % of total Dry matter.	N	3.6	4.0
	P	2.0	4.5
	K	1.6	1.95
	Ca	3.5	3.2
	Mg	0.8	1.6
% of total Dry matter		11.5	15.3
Microelements ppm.	Fe	59	82
	Zn	29	38
	Mn	42	70
	Cu	3.6	5.5
		100%	147%

Mineral content of some crops.
% elements of total dry matter.

* 'Soil testing and plant analysis 1973'
** Self information

Gerbera**	Peanuts*	Tomatoes*
2.9	3.6	3.5
0.5	0.28	0.6
3.1	2.56	3.1
1.2	1.3	4.5
0.5	0.4	0.7
8.2	8.1	12.4
180	160	13
40	45	2
126	182	62
21	12	7

Leaf deficiencies identified by 'Leaf analysis' are not direct evidence of mineral deficiency in the soil, but difficulties of the roots to absorb minerals.

Citrus leaves of the same variety from neighboring plants-lines, grown in the same 'alluvial soil', Israel 2007.

Leaf of a tree irrigated by 'AA', 20 L / day (in pulses), with only 8.5L of fertilizers throughout the season.

Leaves of a tree irrigated according to pre-defined irrigation programs, 60L / day (240L every 4 days) with 95L fertilizers throughout the season.


“Predefined rich fertigation programs contaminate the aquifers”.
Winter crops greenhouses -
Farhan, Middle-Arava, Israel, Dec. 2012
Yoseph Shoub ©

An update experimental example, of using exaggerated fertilizers in agricultural crop:

Water and fertilizers input for Pepper, Middle-Arava, Israel September 2012 - April 2013.
In Pepper controlled by 'AA' - Versus - Pepper fertigated as officially recommended.
(Estimated figures calculated for 30,000 Dunam).

Note: The official program yielded 9.5 tons / Dunam, and the 'AA' pepper yielded 9.8 tons / Dunam.

Water:

Recommended water supply = **30** million cu. (*1000 cu. / Dunam/ per season*) = ~ **15** million $

'AA' (estimated figures) 16 million cu.(**53%**). (14 million cu. were washed to the aquifer) ~**7** million $

Fertilizers:

Recommended fertilizer supply = **22,500** tons. (*750 gram / cu. water*) = ~ **35** Million $

'AA' (estimated figures) ~**3,500** tons (**15.5%**). (19,000 ton were washed to the aquifer) ~ **30** Million $

14 million cu. water were used just for wash 19.000 tons fertilizes.
Which means an annual loss of ~ 7,400 $ per farm of 60 Dunam.

Is this tolerable? economically, nationally and environmentally !

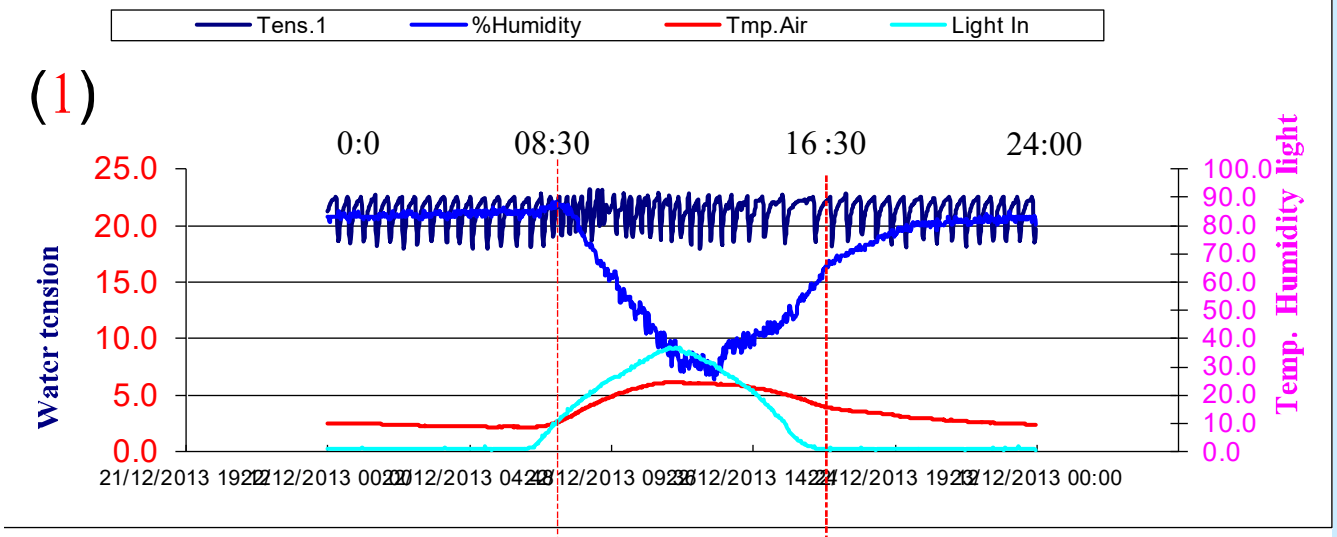
Unfortunately…. this is the story!

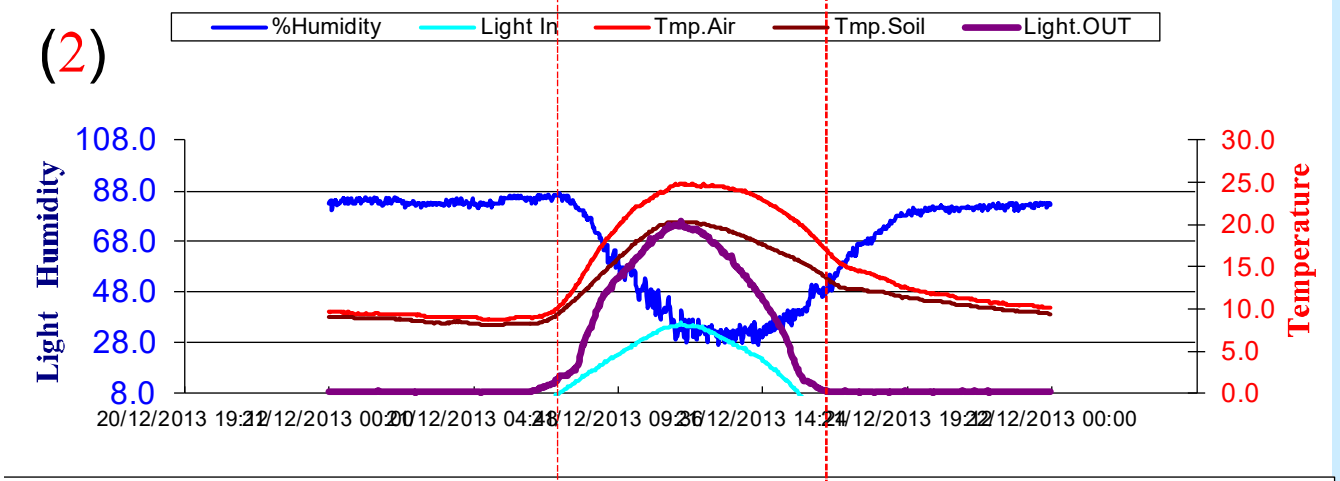
The AutoAgronom Tensiometer

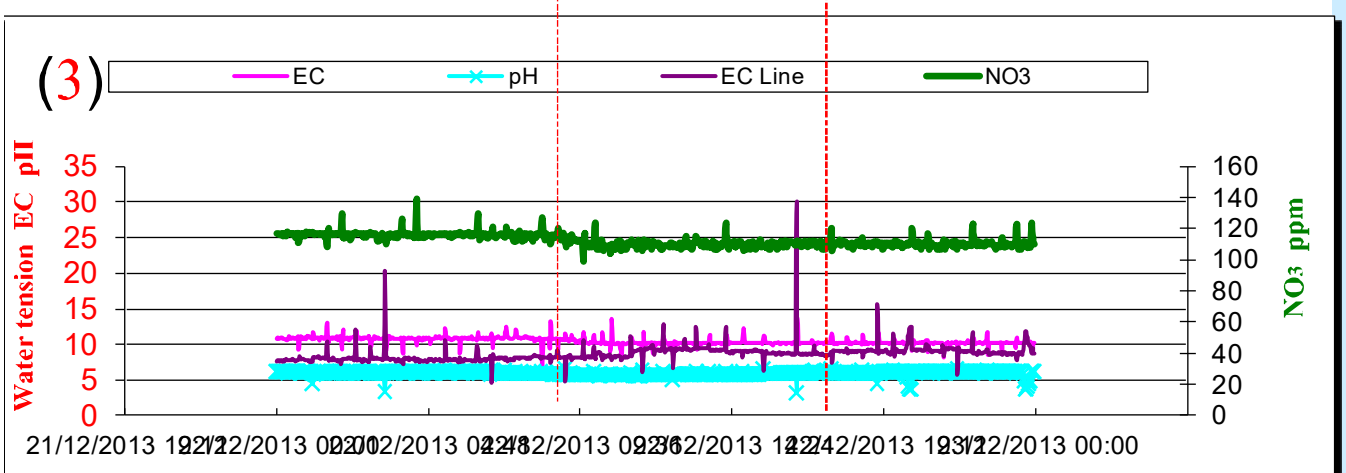
measures in the roots' media, on real time, the micro changes of the 'Water tension'(*a physical value)*, Which are related to the actual amount of water in the measured-location. And accurately synchronizes the fertigation schedules to the rhythms of the plant's physiological activities, expressed by absorbing the 'soil solution'.

Practically the 'Water tension' cyclic-changes, are resulted by the Decreasing / Increasing *(used / irrigated)* amounts of the soil solution in the roots media.

The high accuracy of the 'AA' sensors, allows it to maintain: 'Hydroponic conditions values - in solid media'.







AutoAgronom daily data

22.12.2013

Growing conditions values controlled by 'AA' system

Gerbera Breeding Ltd, Israel,

(1,2) 6 Physical values

water tension

relative humidity (%)

air temperatures (c)

media temperatures (C)

light out (1000 lux)

light in (1000 lux)

(3) 4 Chemical values

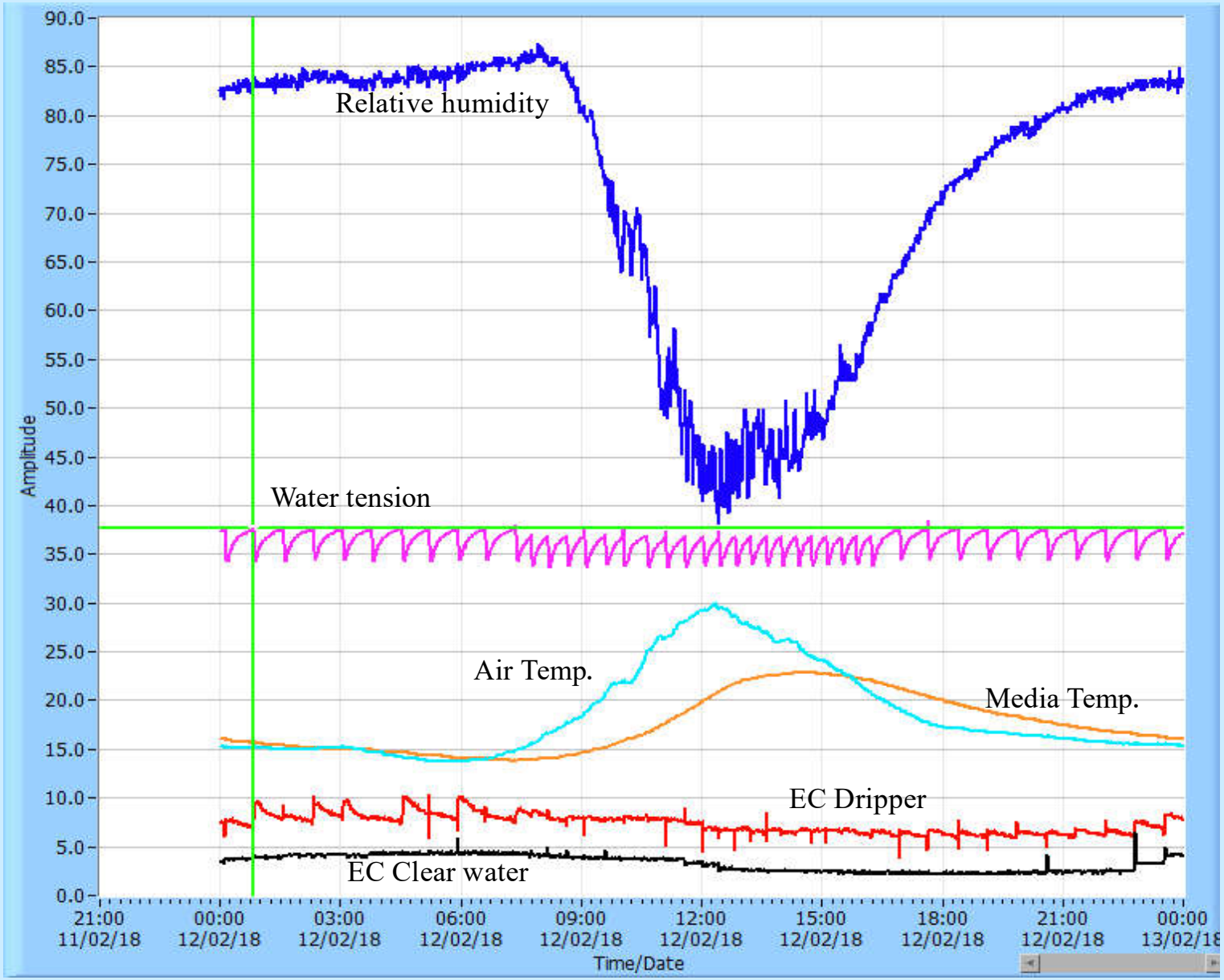
NO_3 - drainage (ppm.)

EC - drainage (ppm.)

EC - feeding solution (ppm.)

pH - feeding solution

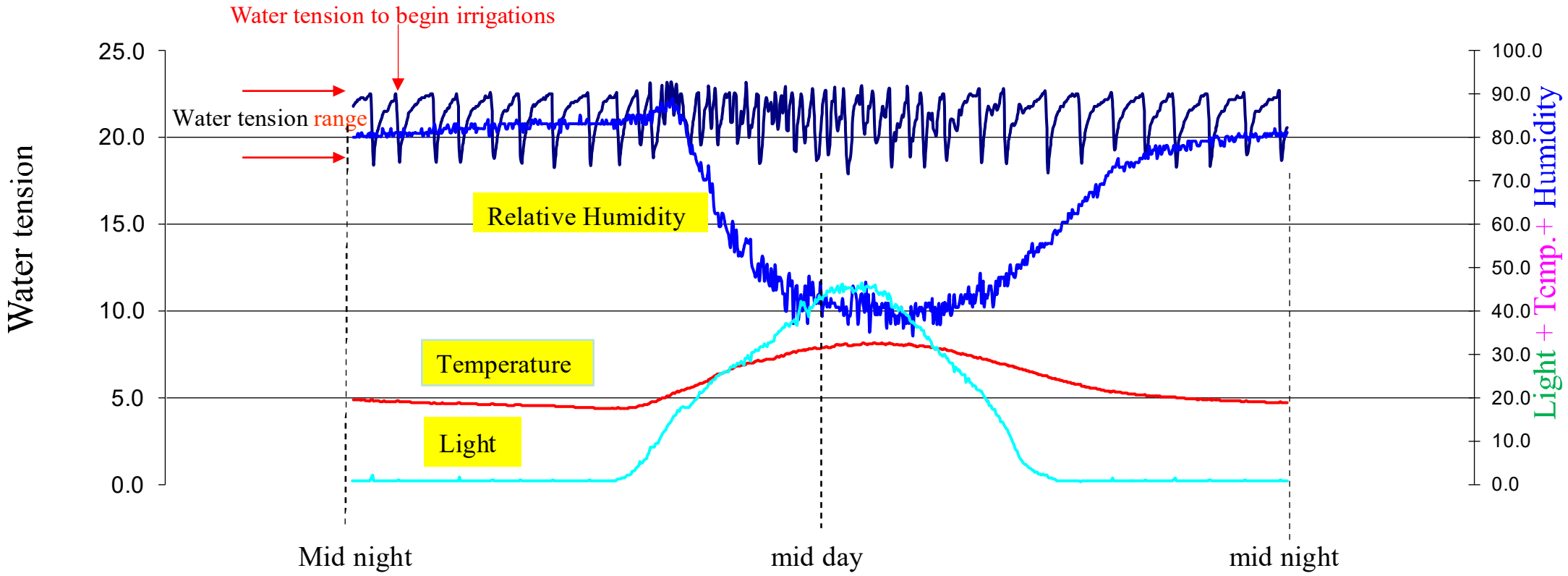
Day by day in the greenhouse: 00:00 ⟷ 24:00 02.12.2018



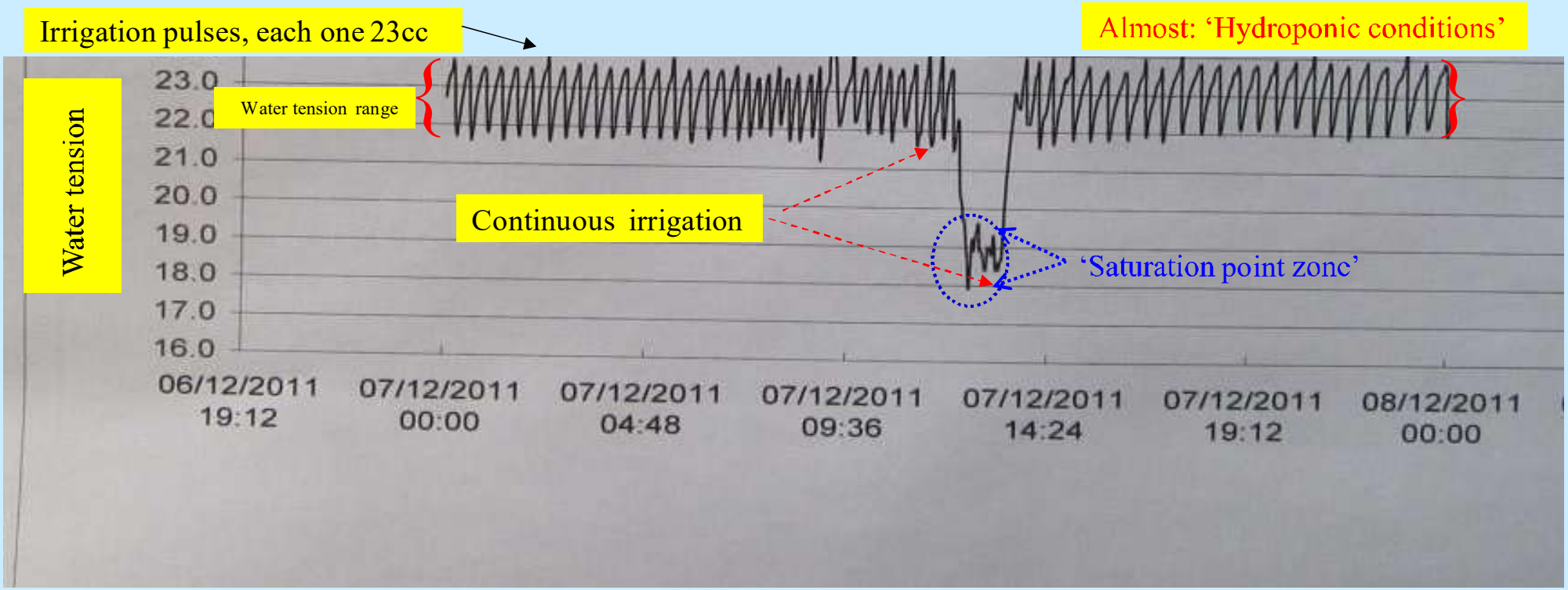
The daily rhythms of the plants' activities are affected mostly by 3 vital environmental conditions: The Light, the Temperature, and the Relative Humidity.

These parameters are recorded daily by the 'AA' sensors, and together with other 'AA' parameters they control the optimal growing conditions maintaining the 'AA' qualities.

Water tension cyclic-changes along an Israeli autumn day (13.10.2014), as recorded by the 'AA' tensiometer in the roots media of a well developed gerbera plant, in4 liter container.



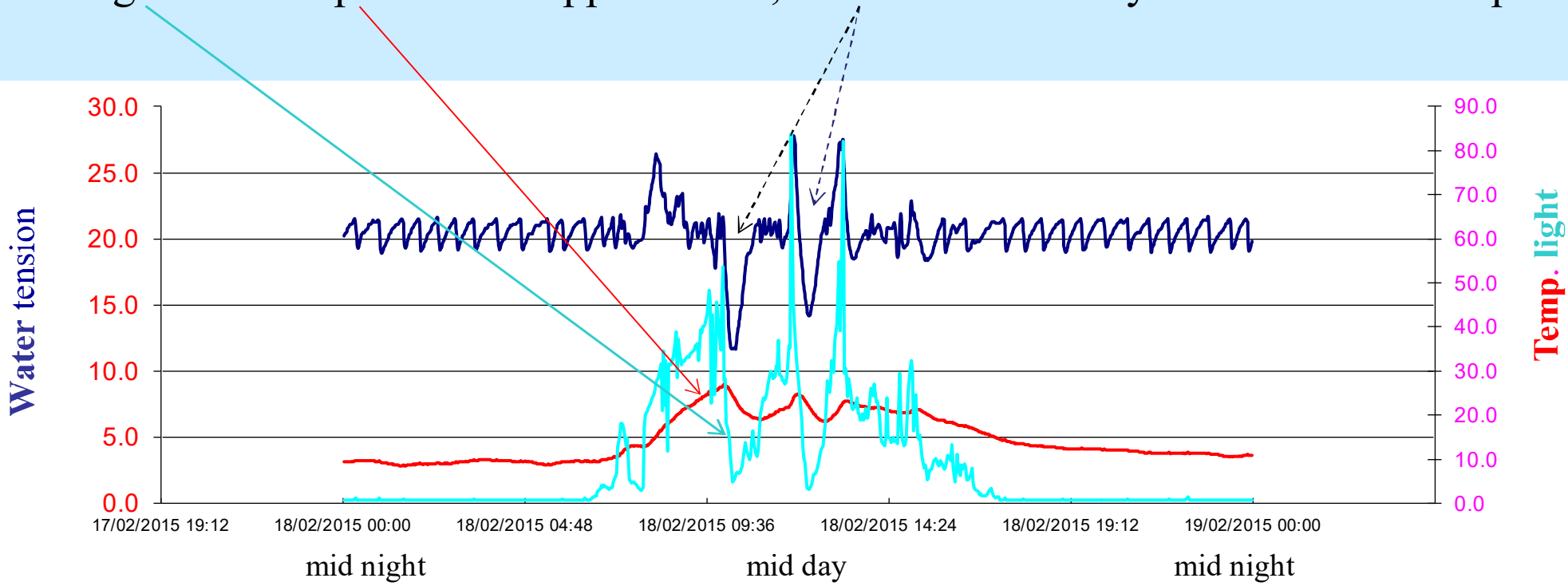
Water tension ranges of 'AA' irrigations-pulses are close to the "Saturation point" .



The regular 'Water tension' ranges in the roots' volume depend on the media physical character. In 'Coco peat' used for gerbera plants it is about 24 – 21 millibar - What we defined as: 'Close to the saturation point'. The 'Saturation point' of a growing media is a physical situation in which all the capillary empty spaces are full of water, additional water quantity will cause draining.

For demonstrating how close is the 'Optimal water tension' in the coco media to 'Saturation point', We Didactically, created Saturation point zone (~18-19 millibar), by continuous irrigation.

Significant changes during the day, as regards the light intensities and the temperatures, affect immediately the plant's physiological activities.
When light and temperature dropped down, it cuts immediately the water consumption.



Note: at the same time as the plant's activities rhythms are affected by the environmental conditions, they affected also by 'internal growing factors'; e.g. absorbing water during the night, for the oxygen *(as an energy supplier)* needed for running the accumulated sugars through the phloem cells' membranes.

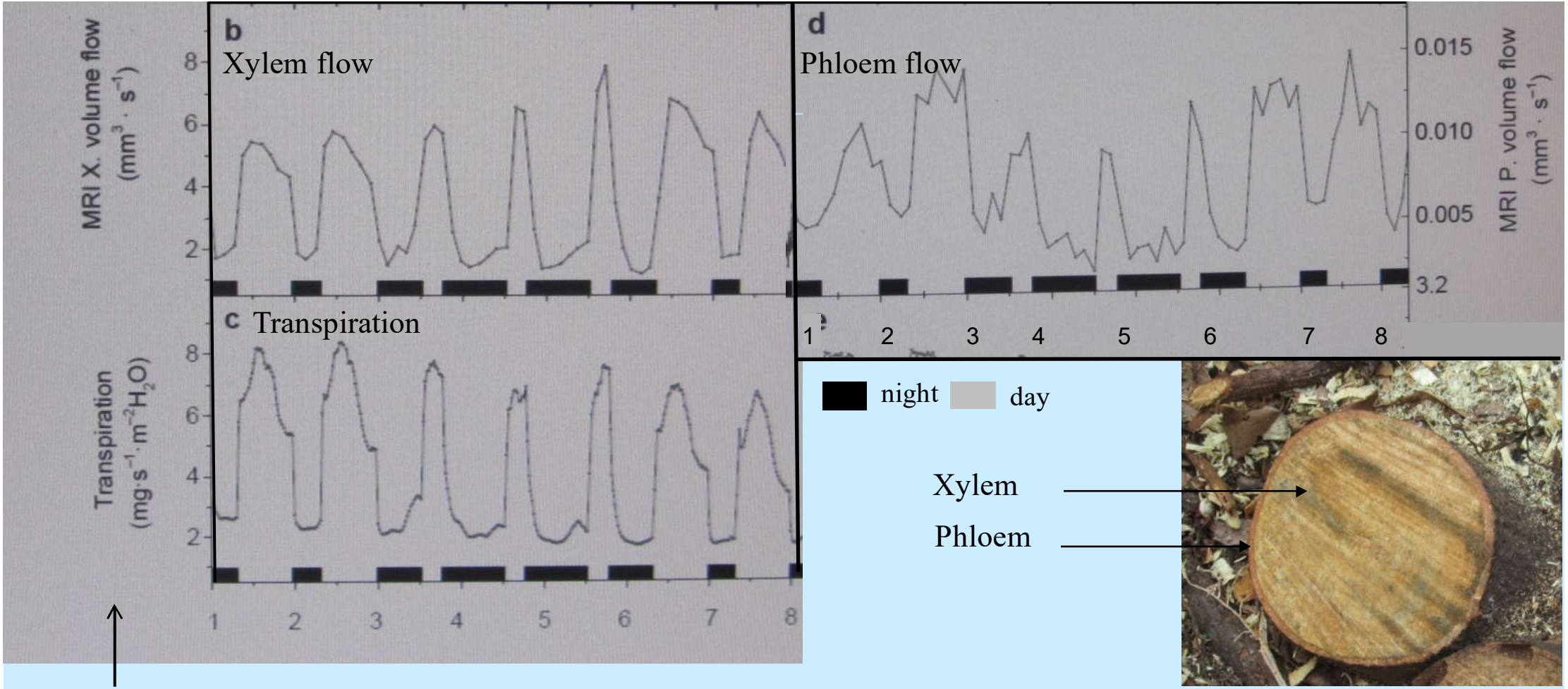
Water consumption during the night by 'AA' controlled crops. -

The phenomenon of water consumption during the night was discovered in all the 'AA' controlled crops.*
Thus we may say, carefully, that the active phenomenon of water consumption over the night is an integrated physiological activity of intensive-crops. Which the highly sensitive 'AA' Tensiometer exposed it, and bring it about to our understanding.
Therefore we should not ignore it. **
We assume that during the night the plants absorb the soil-solution mostly for the oxygen needed for their physiological activities.

---

* *Surprisingly there is almost no information in the scientific literature, regarding the active night water consumption by plants.*

** *Only lately, a PhD thesis by Alena Prusova, "Light on Phloem Transport", submitted (on 2016) to Wageningen University, Holland,* clarifies the information of the newly findings of the AutoAgronom systems. It enlighten the continuous flow phenomenon of the Phloem sap and the Xylem, over the 24h cycles *(by using the MRI tool)*.



(measured in tomato)

Laurus nobilis (cut down trunk).

The effect of short photoperiods on (b) xylem volume flow measured with MRI,
(c) transpiration,
(d) volume flow of phloem sap measured with MRI.

The AutoAgronom reactions are adjusted to the Plants' activities rhythms -

Physiological and biochemical processes related to water supply -

Physiological activities occur in plants 24 hours a day. It occurs on conditions that the plant's tissues maintain aqueous solution containing oxygen and minerals.

The soil-solution is the water reservoir, and it absorbed by the secondary roots.

Plants' activities during the day -

Transpiration - Absorbing and suppling water that transpire via the leaves as pure water vapors, targeting to cool the plant's sensitive green-tissues for preventing radiation and heat damage.

Photosynthesis - The supplied water convey the oxygen needed for the sugars production.

Sink - Translocation of the photosyntates products toward the growing sites

Plants' activities during the night -

Sink -The same as in the day hours, the absorbed-water is used for emptying and translocating the assimilates towards to all the developing sites of the plants.

Note: During the night as in the day, the oxygen used here as an energy supplier for the executing the complicated transition movement of the assimilates' via the perforated membranes of the Phloem cells.

24h Ongoing processes -

Breathing - Cellular respiration
Water absorption and usage - Water movement
Transportation of the photosyntates - Sink
Cell division and cell elongation - Growth.
Hormonal processes - Growth control.
Converting and activating the assimilates to the essential nutrients –
Carbohydrates, Proteins, Fats, Vitamins and the Hormones - Metabolic processes.

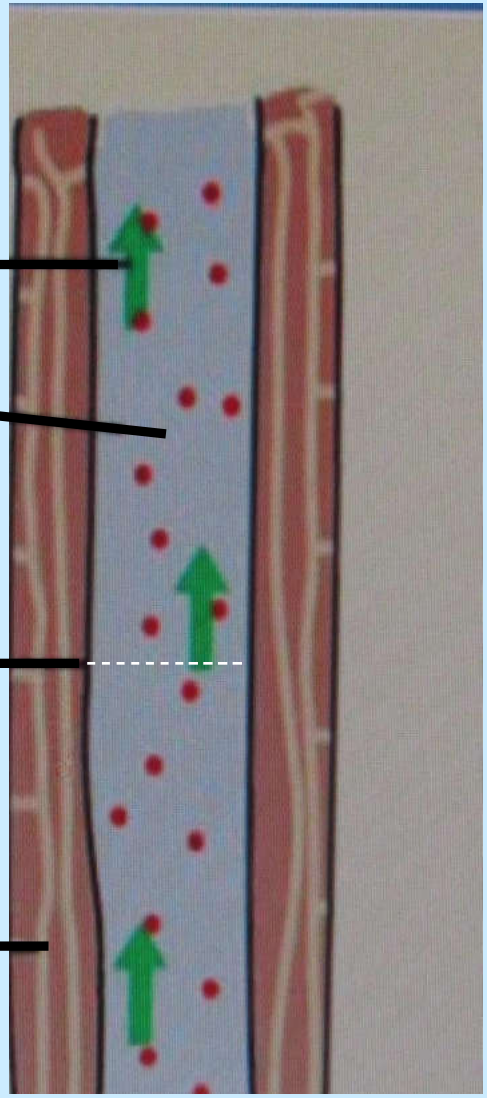
Two types of water movement involved in the plant physiological activities:

1. Passive movement - Conducting soil solution carrying oxygen and minerals, via the xylem vessel (*by physical forces)* for transpiration and assimilation.

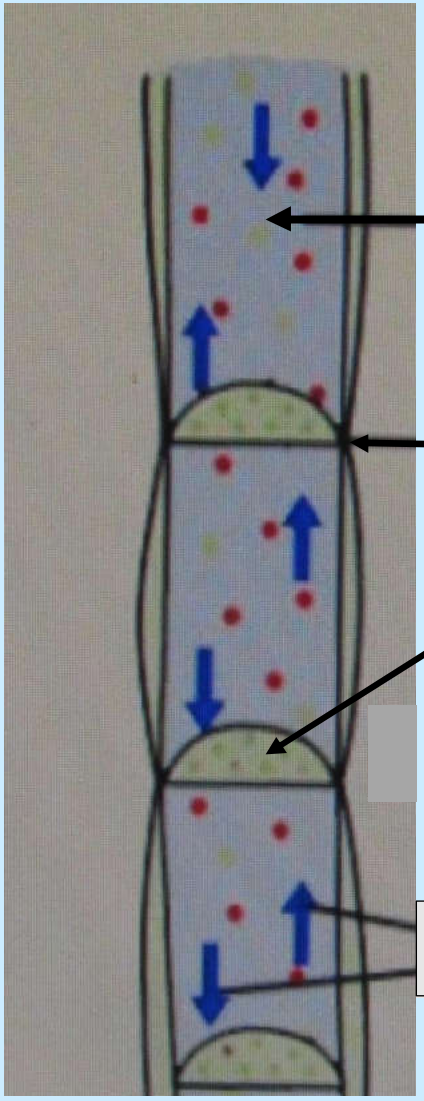
2. Active movement - Transportation of assimilates and minerals to the growing sites, passing through the cell's membranes of the phloem vessel.

The active movement uses energy that requires continuous oxygen supply.

Schematic figures of xylem & phloem vessels functioning.



Xylem vessel
Passive movement



Phloem vessel
Active movement

Water stress in plants - definitions and remarks:

- Plants under water stress slowdown their physiological activities.
- Avoiding early stages of water stress means avoiding accumulated water deficit.
- During water stress the plant's transpiration rates are higher than its root's ability to retrieve adequate water volumes.
- The roots' ability to supply water is faster than the water movement rates in the soil.
- The plants reactions to water tension's changes in the growing media, are faster than the reaction of the commonly used measurements appliances.

The AutoAgronom system detects even small changes of water tension in the growing media, and reacts in 'real time' by balancing back the water volume in small and accurate water doses, without reducing the Oxygen availability .

Absorbing Oxygen - Important note!

Even though plants are the producers of the oxygen, they are not able to absorb the oxygen by their leaves, *(the way it was released)*.

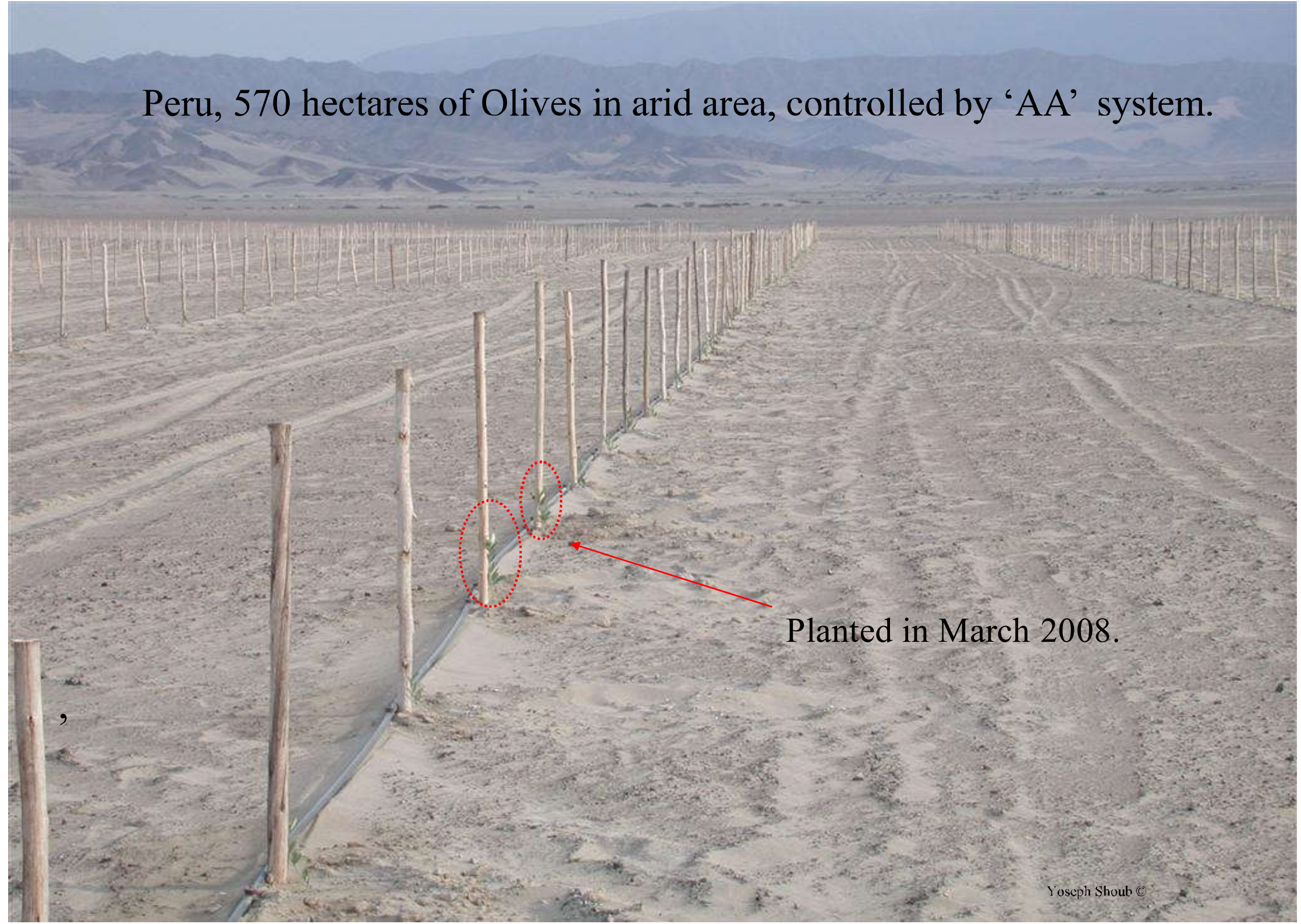
It should be clear, once and for ever, that the plants absorb oxygen only by their roots! when it dissolved into the soil-solution.

Therefore; air presence in the soil, and the oxygen availability in the soil-solution are critical for the roots of agricultural crops!

However, most of the conventional drip irrigation methods are not able to maintain a stable and continuous oxygen supply for the plants, as they do not maintain a stable water/air ratio in the root zone.

First greenhouse Cherry-Tomatoes under ‘AA’ control, August 2009 Israel.

Irrigated with 1,200L./ Dunam/day compare to the 5,000L./ Dunam officially recommended.


Peru, 570 hectares of Olives in arid area, controlled by ‘AA’ system.
Planted in March 2008.
Yoseph Shoub ©

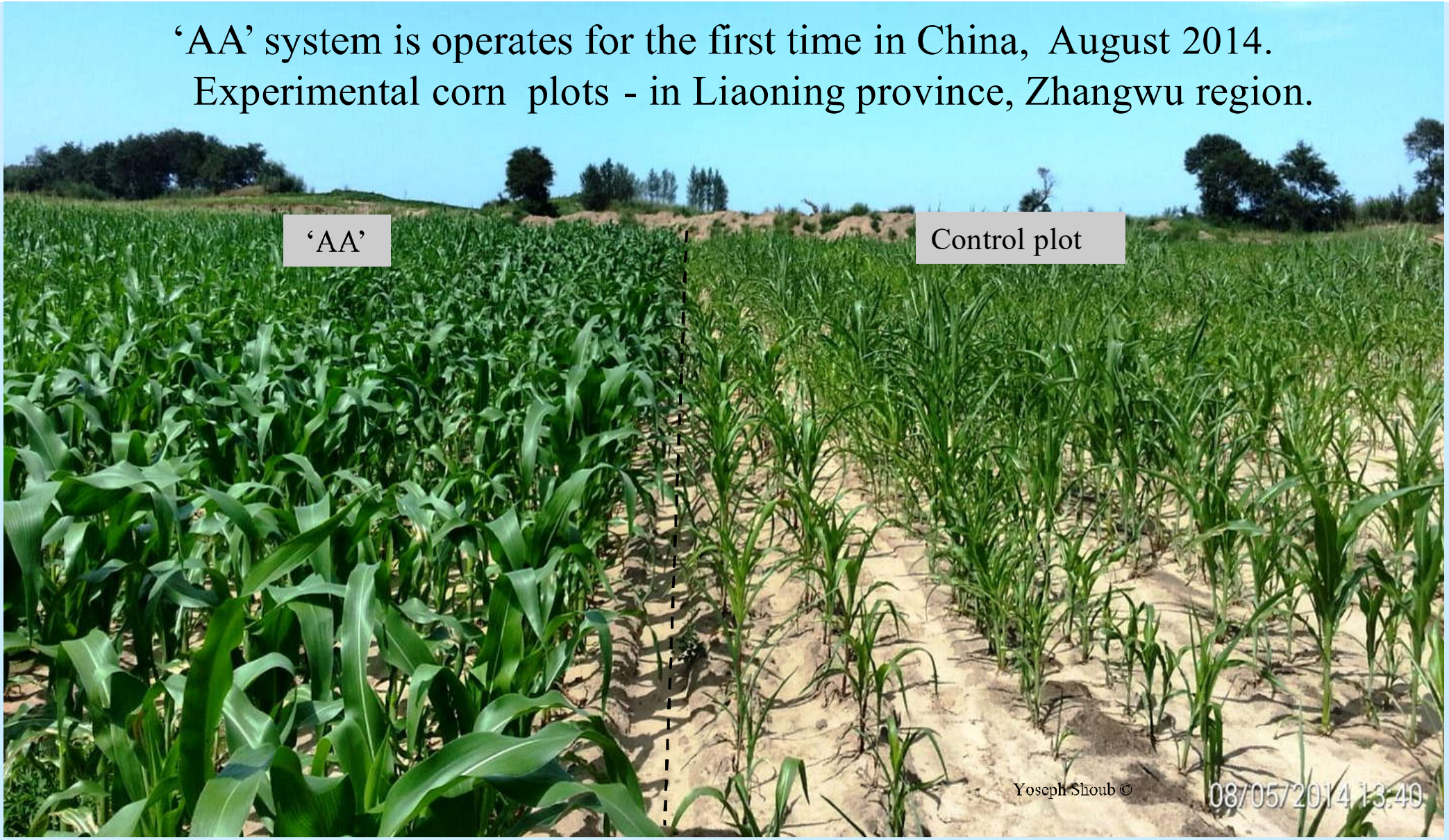
The same olive trees June 2009

Exposed roots, July 2010.

1.5 years old ‘AutoAgronom’ Olive trees. Hula valley Galilee, Israel December 2011.

Precise agriculture supports the plant’s activities and *serves the grower’s economy.*

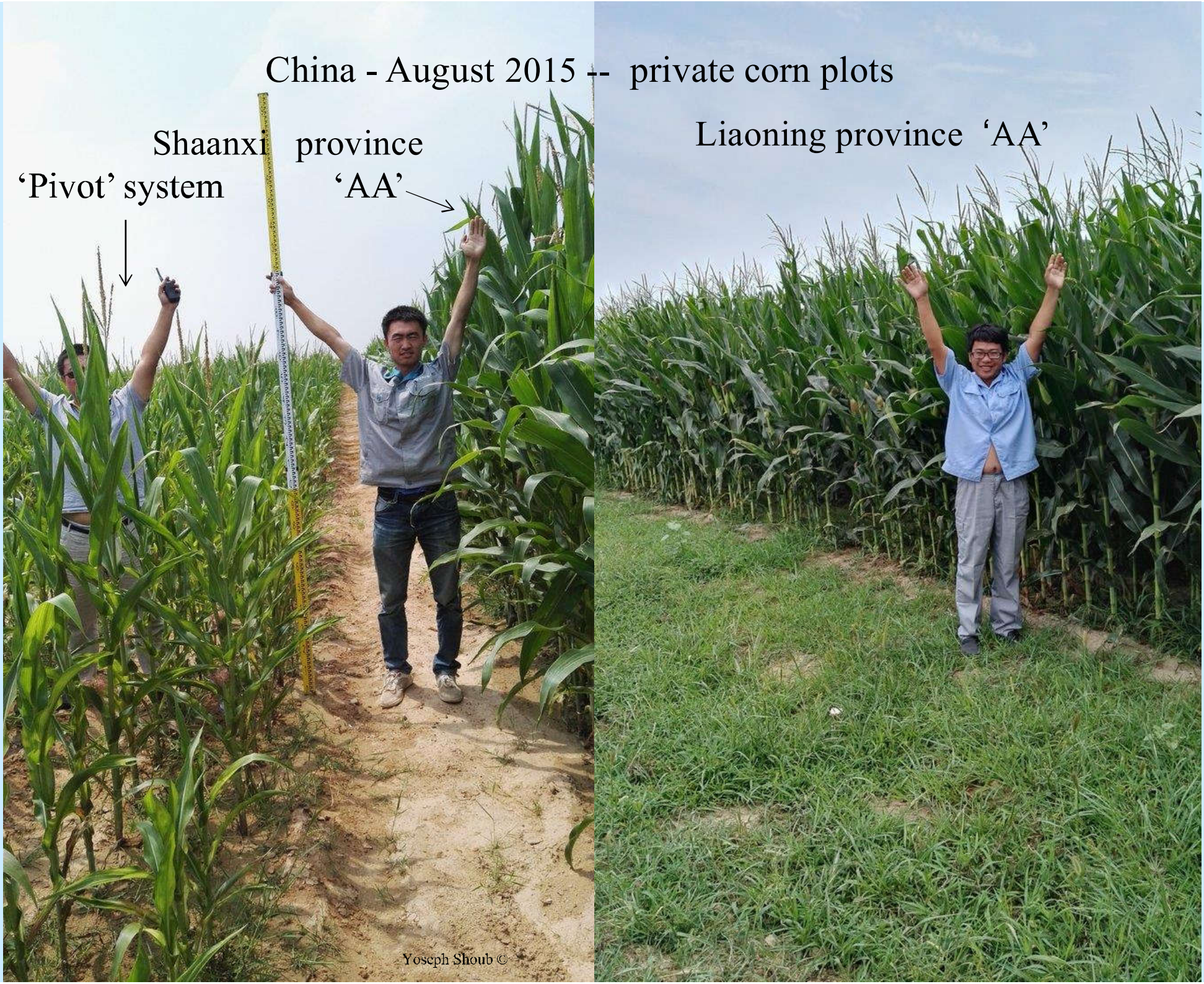
‘AA’ system is operates for the first time in China, August 2014.
Experimental corn plots - in Liaoning province, Zhangwu region.



Comparative experimental corn plots (*7 replications*), grown in uniform sandy soil, irrigated with the same water, using the same fertilizers, and the same compensated drippers.

Right - controlled by irrigation system known in China for getting good results. Total yield 1.0
Left - ‘AA’ controlled system. Total yield 1.7, with 50% of the water used for the control plots.

China - August 2015 -- private corn plots



‘AA’ Strawberries’ in tunnels in growing media, and in soil.
Cyprus January 2010.

'AA' Tomatoes in ducts of coco peat, Malesia February 2009.

5 weeks after transplanting

2 weeks after transplanting,
4 plants in 4L. Containers.

‘AA’ controlled gerbera seedlings in coco peat, winter season.

"The man is not the Crown of the Creation, its origin might be the ape"

Charles Darwin - On the Origin of Species (1859)

And so said Wester Bishop's wife about Darwin's ideas:

"Let us hope it is not true, but if it is, let us pray it does not become widely known"

"Wise Judgment comes from Experience, but Experience comes from Wrong Judgment".

My dear late friend Prof. Naftali Zieslin

‘Wise Agriculture will win’

By the courtesy of the happy-growers of ‘AA’ Bananas’
Shaar-Hagolan, Jordan Valley, Israel October 2010.


The end
Yoseph Shoub ©