Can we do better with Silicon?

The Silicic Acid Agro Technology

SAAT

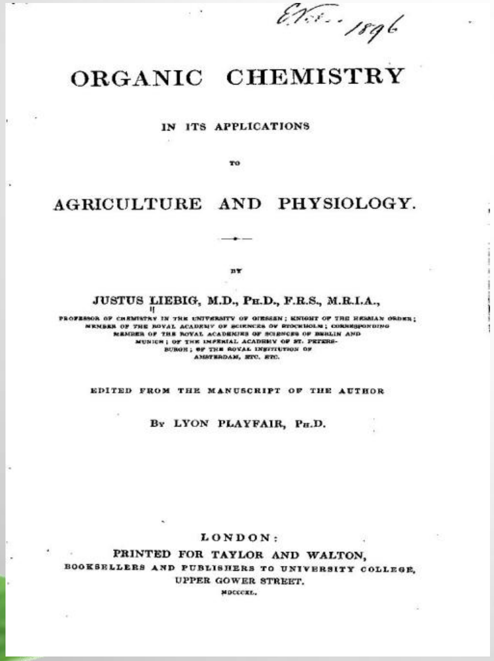
CropSIL®

Presentation on CropSIL®:
“can we do better with silicon”?

- General information about Silicon
- Silicon in soils; monocots and dicots
- Plant’s Silicon-problem: deficiency and bioavailability
- Increase the bioavailability of Si : stabilized silicic acid
- Silicon role in defense and stress
- Silicic Acid Agro Technology: SAAT
- Trial results
- Silicon and legislation (Asia, Europe, USA)
- Summary and conclusions

History of the use of Si in Ag

2000 years ago people in China started to use rice straw (high Si content). The technology (developed by ancient Chinese scientists) was supported by **special edict of the Emperor** obliging peasants to apply a part of rice straw into the soil. **THE FIRST FERTILIZER ACT !**



ORGANIC CHEMISTRY

IN ITS APPLICATIONS

TO

AGRICULTURE AND PHYSIOLOGY.

BY

JUSTUS LIEBIG, M.D., PH.D., F.R.S., M.R.I.A.,

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BY LYON PLAYFAIR, PH.D.

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MDCCCXL.

Justus Liebig (1803-1873). Agronomist, chemist from Germany. He first suggested the use of silicon fertilizer (sodium silicate) in 1840 ("Organic Chemistry in Its Application to Agriculture and Physiology"). First greenhouse experiment was conducted on sugar beet. https://archive.org/details/organicchemistr00playgoog

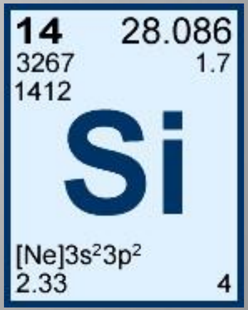
Today: hardly any recognition of the importance of Silicon in Ag

Mineral element in crop plants

Element		Concentration (dry weight)	Remarks
Nitrogen	%	0,5-6	Essential macronutrient
Phosphorus	%	0,15-0,5	Essential macronutrient
Potassium (K)	%	0,8-8	Essential macronutrient
Sulfur	%	0,15-0,5	Essential macronutrient
Calcium	%	0,1-6	Essential macronutrient
Magnesium	%	0,05-1	Essential macronutrient
Iron	ppm	20-600	Essential micronutrient
Manganese	ppm	10-600	Essential micronutrient
Zinc	ppm	10-250	Essential micronutrient
Copper	ppm	2,5-50	Essential micronutrient
Nickel	ppm	0.05-5	Essential micronutrient
Boron	ppm	0,2-800	Essential micronutrient
Chlorine	ppm	10-80.000	Essential micronutrient
Molybdenum	ppm	0,1-10	Essential micronutrient
Cobalt	ppm	0,05-10	Essential in nitrogen fixing systems
Sodium (Na)	%	0,01-8	Essential or Beneficial
Silicon	%	0,01-15	Essential or Beneficial

Some more information on Silicon

- Silicon is the second most common element in the earth’s crust (27%) after oxygen (46%).
- Compare with Carbon: 0,03% . . . .!
- Silicon is an element and found in > 100.000 different compounds. In Ag: silicates (Si. salts), biogenic silica & silicon dioxide (sand, rock, etc.), are the most important Si compounds.
  - Monocots: microelement 1-15%,
  - Dicots: microelement 0,1-1%



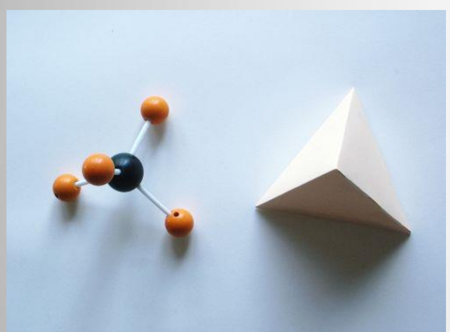
Silicon in the soil

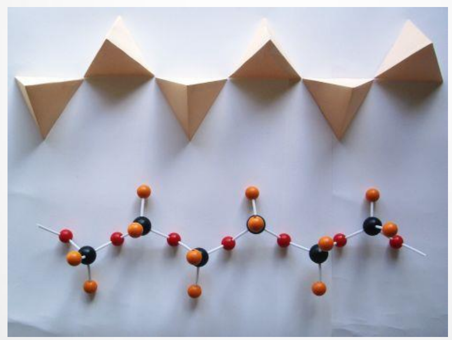
- Silicon has an abundant presence in almost any soil type (as silicates / SiO_2 / biogenic silica). Average: 35%. So the common opinion: ‘enough silicon’.
- But silicates / SiO_2, etc. are **not** plant available. Only **mono-silicic acid** (SA) can be absorbed by plants.
- But Silicic acid is (very) unstable. So the concentration of this ‘biosilicon’ is (very) low causing a **‘silicic acid deficiency’** in most soils.
- This instability is also the reason why there was until recently no *stabilized silicic acid* technology.

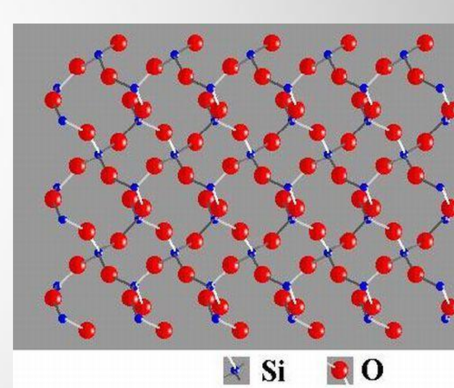
Why silicic acid deficiency?

1. Limited production capacity of SA from Si sources **(*)**
2. Instability of (mono) Silicic acid: bioactive Si:

   mono-silicic acid ←→ oligomeric ←→ micro-colloidal → macro-colloidal → gel. Overall trend: polymerizing



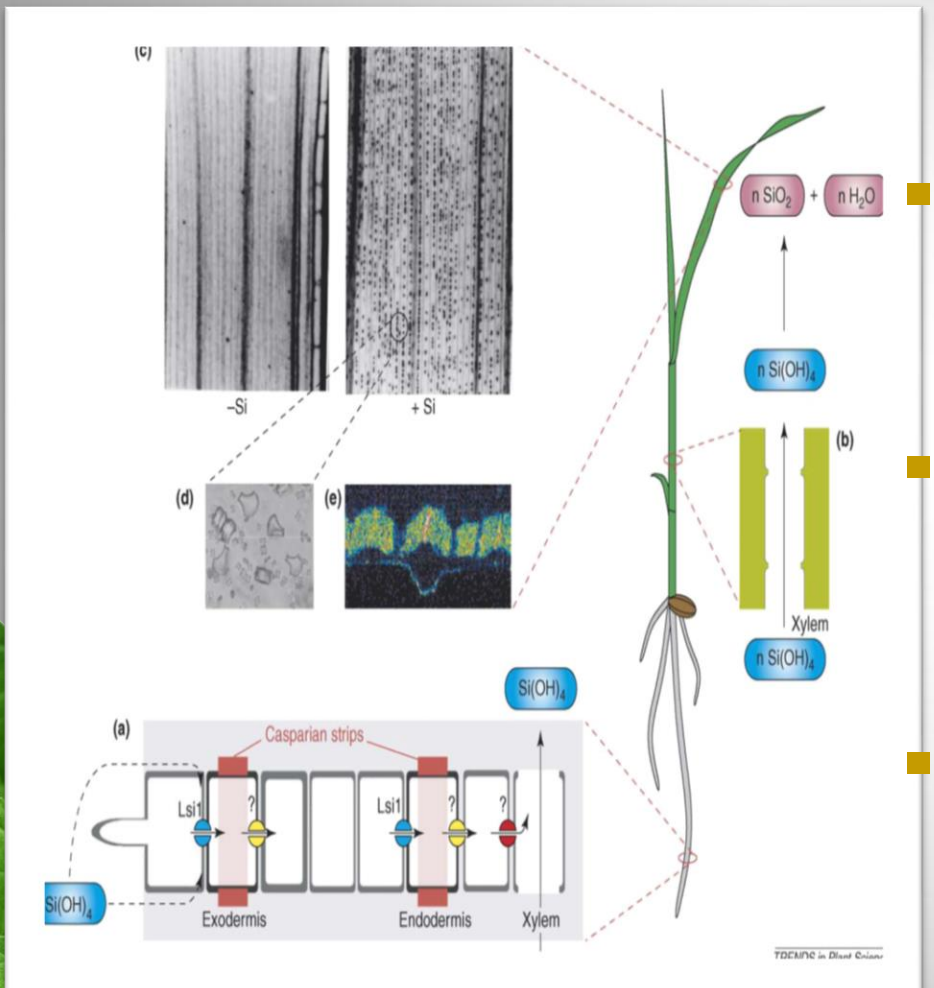




Result: low concentration of MSA in the soil →

'Silicic acid deficiency'

Another limiting factor: SA uptake in plants



Structural (Anatomical) Role:

- Tissue analysis show that silicon makes up between 0.1 and 15% of a plants dry weight: *Monocots:1-15% and Dicots:0.1-1%.*
- Silicon is prominent in cell walls (root, shoot, leaf) as solid amorphous silica, providing a structural barrier to pathogens.
- Silicon is also found inside the cell in the cytosol / chloroplast membranes.

Solution for SA deficiency?

- **Problem**: Low SA concentration, limited uptake roots → suboptimal growth
- **Solution:** supply stabilized and concentrated SA (generic name: SAAT)

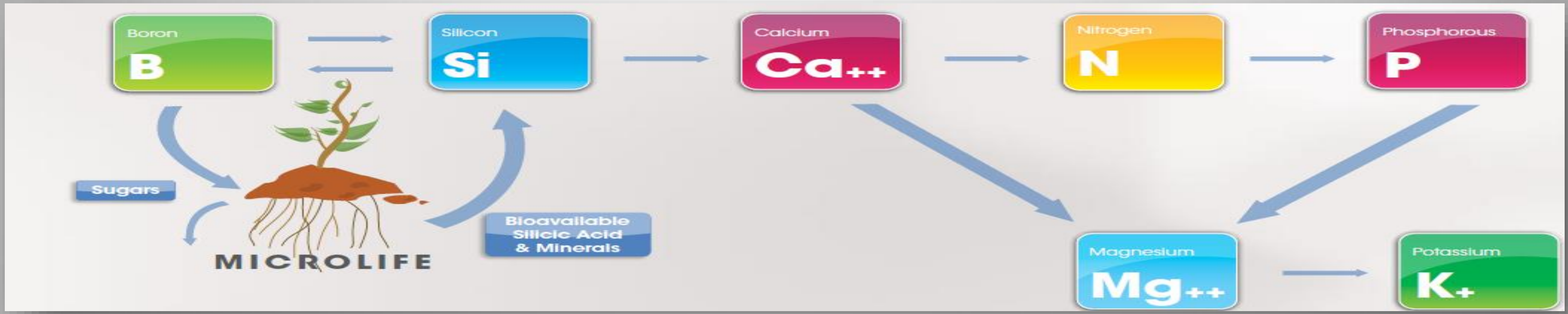
Silicic Acid Agro Technology = **SAAT =** CropSIL®

- Patent pending technology; trials since 2006
- Testing: - foliar application
  - root application

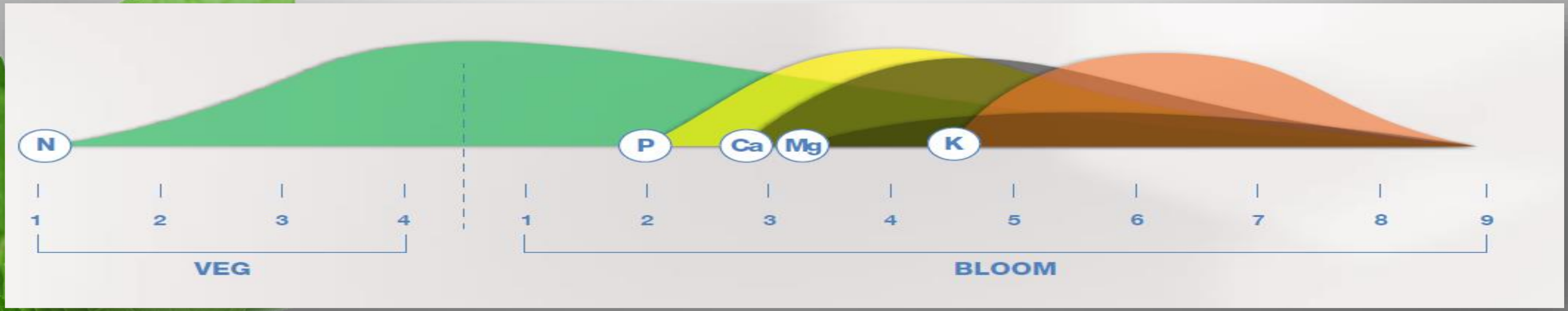
Foliar application: bypassing the roots

Solution for deficiency

CropSIL® works with natural plant mechanisms to provide the right nutrition in the right amounts at the right time. Timing is of the essence to gain the extra pound



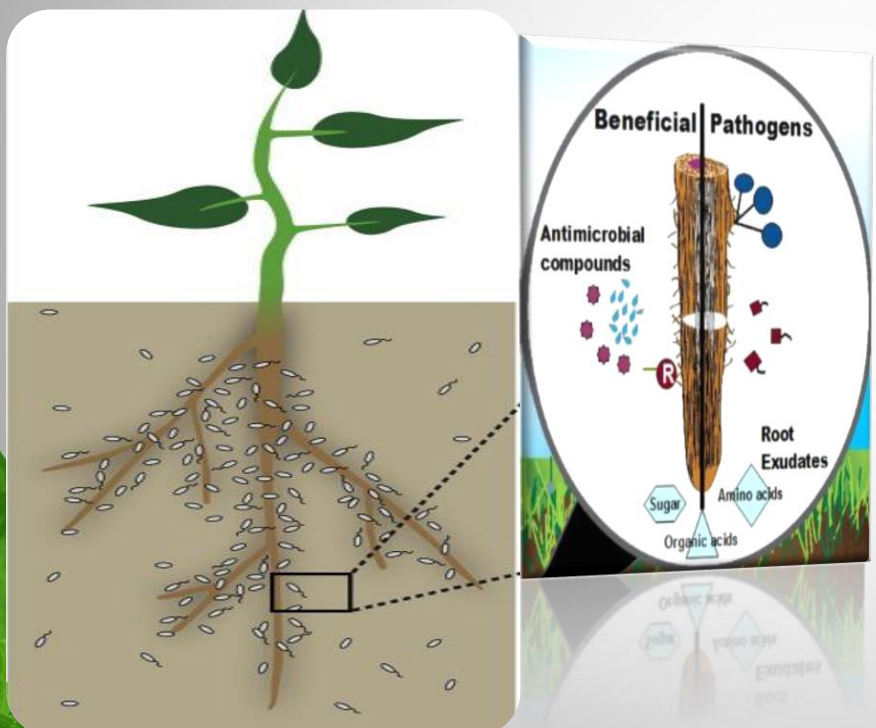
The Bio Sequence of nutrient uptake by plants



Increase bioavailability of Si?

Silicic Acid Agro Technology: CropSIL

Used as a foliar CropSIL delivers 99.9% plant available silicic acid directly to the production facility/ engine of the plant, the leaves.



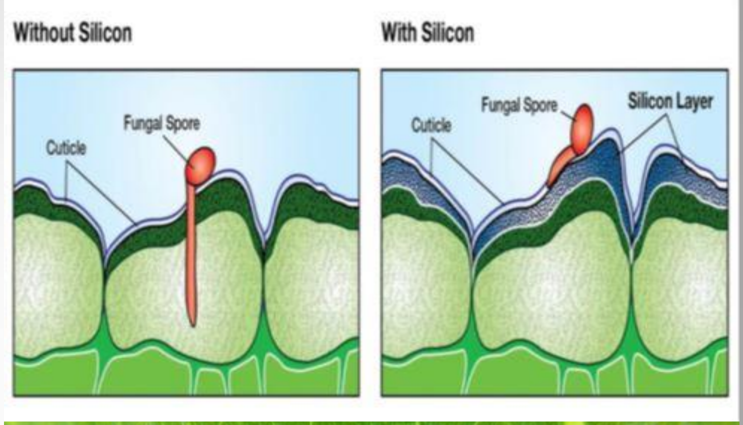
CropSIL:

- Aids in the increase formation of chlorophyll in leaves.
- Encouraging the formation of beneficial root microbiomes
- Encourages symbiotic relationship to produce more SA available.

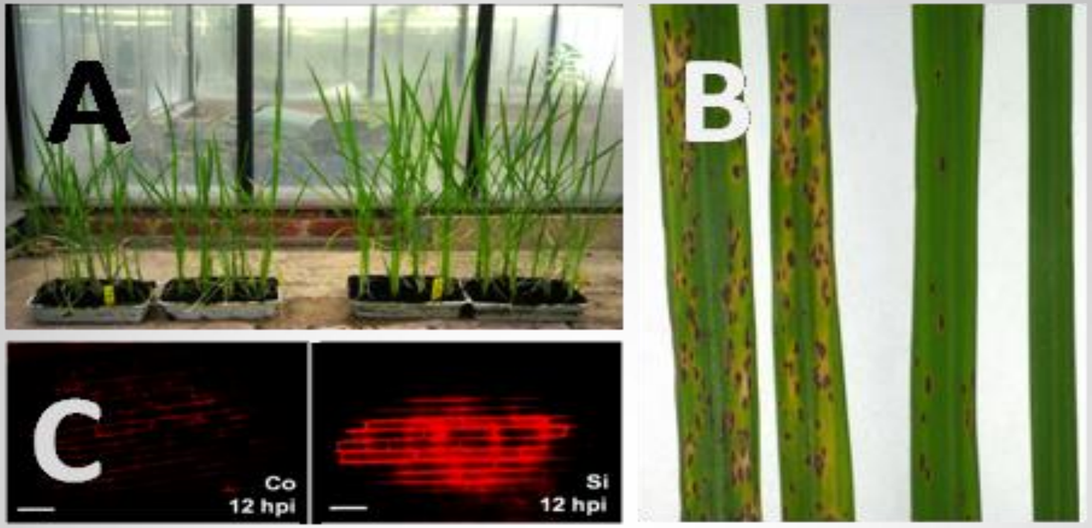
Silicic Acid and Plant Defence

Passive immune system

Silicon acts as a physical barrier, where Si is deposited beneath the cuticle such that this Si layer (opal layer / phytoliths) mechanically obstructs the penetration by fungi, thereby reducing the infection. This Si layer also acts as a deterrent to chewing and sucking, by wearing down or breaking mandibles and proboscis.



Silicic Acid and Plant Defence



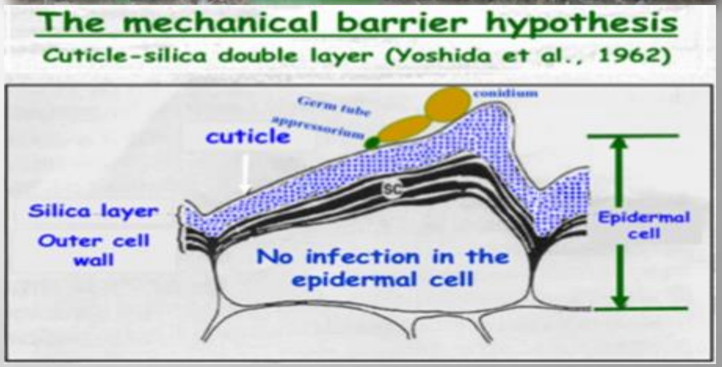
Active immune system

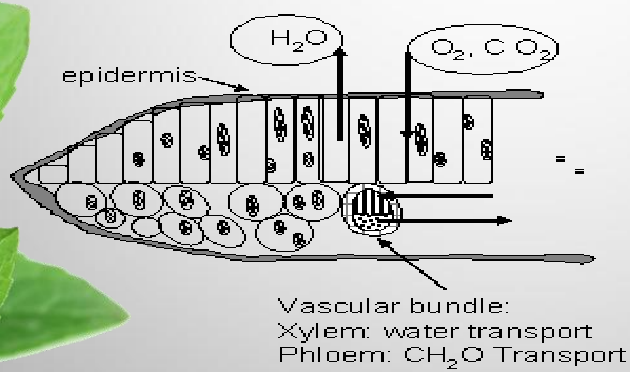
Silicic acid acts as a modulator of host resistance to pathogens Plants respond to foliar pathogens by releasing chitinases, other proteins and phenolic compounds to kill its own cells, isolate the pathogen and prevent the infection of adjacent cells. The mode of action of silicon can be found in the priming of the defense mechanisms.

Silicic Acid and Plant Stress

Active transpiration system

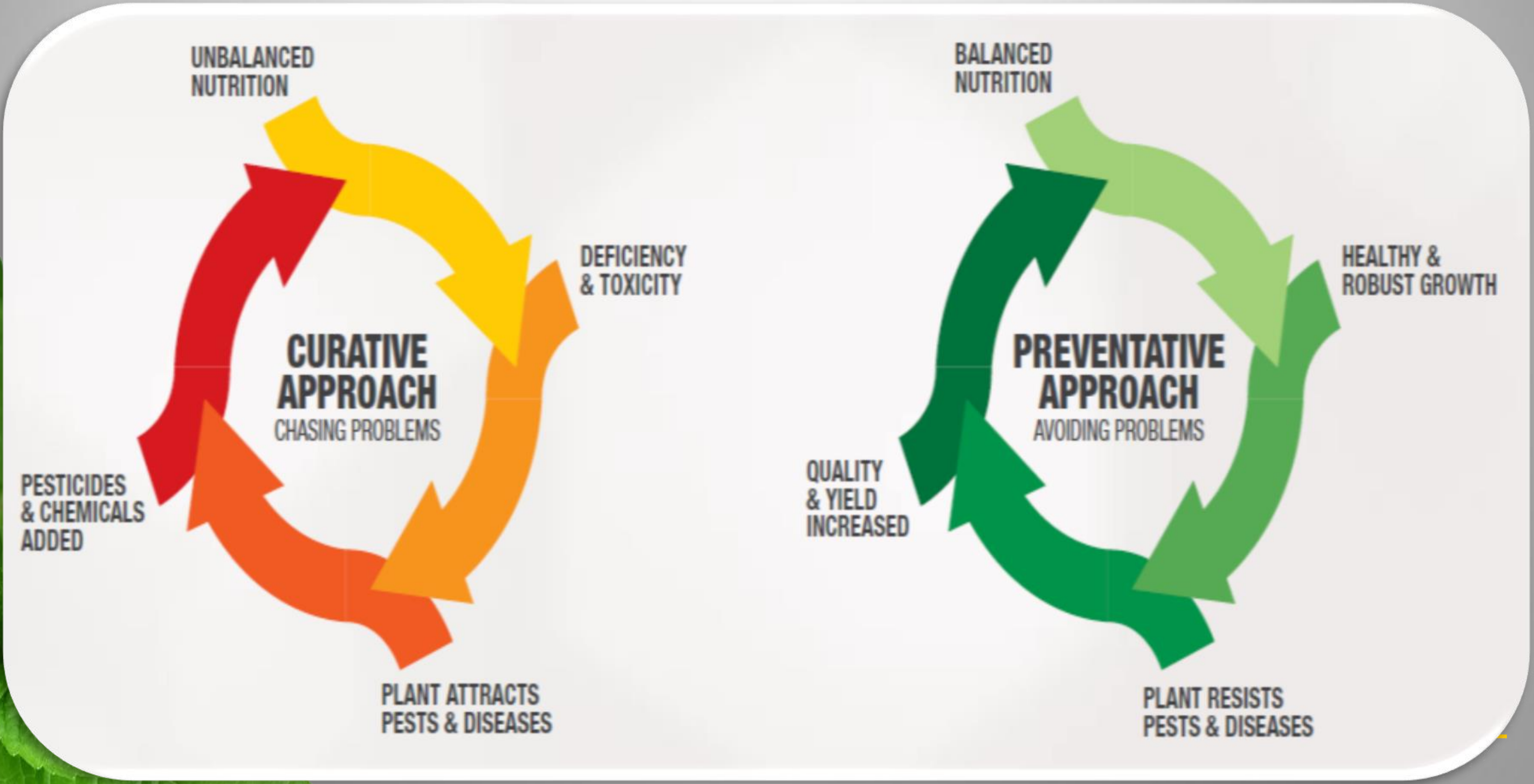
Silicic Acid attributes a silica deposit in the outer epithelial cell membrane of the leaves. It is believed that the silica layer assists in the transpiration of water out of the plant, as well as making a much thicker and larger reservoir to manager transpiration.





SAAT = CropSIL®

CropSIL® adopts a **preventive approach** which makes a plant grow healthier with better quality and higher yield in a natural way.



CropSIL® Seed Germination:

- CropSIL® can be applied to enhance seed germination and protection form fungal attacks.
- Increase Seed Imbibition
- Enhance germination rate of seeds
- Imparts early germination
- Conserves seed vigor for optimal growth
- Boosts plant growth in initial stages
- Imparts immunity in initial stages
- Helps combat abiotic and biotic stress

Effects of Silicic acid

CropSIL vs. Control:

- Increase in leaf and root mass
- More and thicker tillers / more strength of stem
- Larger and more erect leaves together with a higher chlorophyll content

Consequences:

More plant vigor: increase in uptake of nutrients (P, Ca, K, Si and B) and plant defense, water efficacy; better anchoring. Increase of CEC.

RESULT: significant more yield together *with higher quality* in staple foods (rice, sugarcane, potatoes, etc.), vegetables (peppers, tomatoes, carrots, etc.), cereals (wheat, finger-millet, etc.) and other crops.

The application of foliar sprays with stabilized silicic acid

- **CropSIL**: 3% plant available SA
- To be effective as foliar spray solution has to be diluted: (1-2 ml/L)
- Start spraying **early in vegetative stage** (when 3 real leaves have appeared)
- Spray 3-5 times with 2-3 weeks interval
- A Total of **3-4 liters** is all that is needed to treat an entire hectare over the whole growing cycle of crop.

Instructions for spraying

- Use very fine sprays / very fine droplets like a fog or mist
- The use of wetting agent (humectants) is advised
- CropSIL can be mixed with other (micro) nutrients; zinc, selenium, molybdenum, humic acids and others
- After dilution also pesticides, etc. **can** be added


Effect of SAAT as a foliar spray on growth and yield parameters in wetland rice during Kharif 2007

Treatments	Plant height (cm)	No. of panicle	Panicle length (cm)	Grain yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})
T_1 –Control (NPK, Pest.)	91	8	20	5057	7261
T_2 - 2 ml L^{-1} SA (no Pest.)	95	8	21	5932 (+ 17%)	8294
T_3 - 4 ml L^{-1} SA (no Pest.)	97	10	22	6380 (+ 26%)	8929
T_4 - 8 ml L^{-1} SA (no Pest.)	93	7	20	5474 (+ 8%)	7392
T_5 - 2 ml L^{-1} SA + 50% Pesticide	93	8	21	6022 (+ 19%)	8759
T_6 - 4 ml L^{-1} SA + 50% Pesticide	96	9	22	6679 (+ 32%)	9697
T_7 - 8 ml L^{-1} SA 50% Pesticide	93	7	20	5424 (+ 7%)	7326
SEM±	2	1	1	174	99
CD (5 %)	5	2	2	428	244

See: Journal of Plant Nutrition 2011

Effects of SAAT on growth parameters of Grapes (Bangalore blue) – India (09-10)

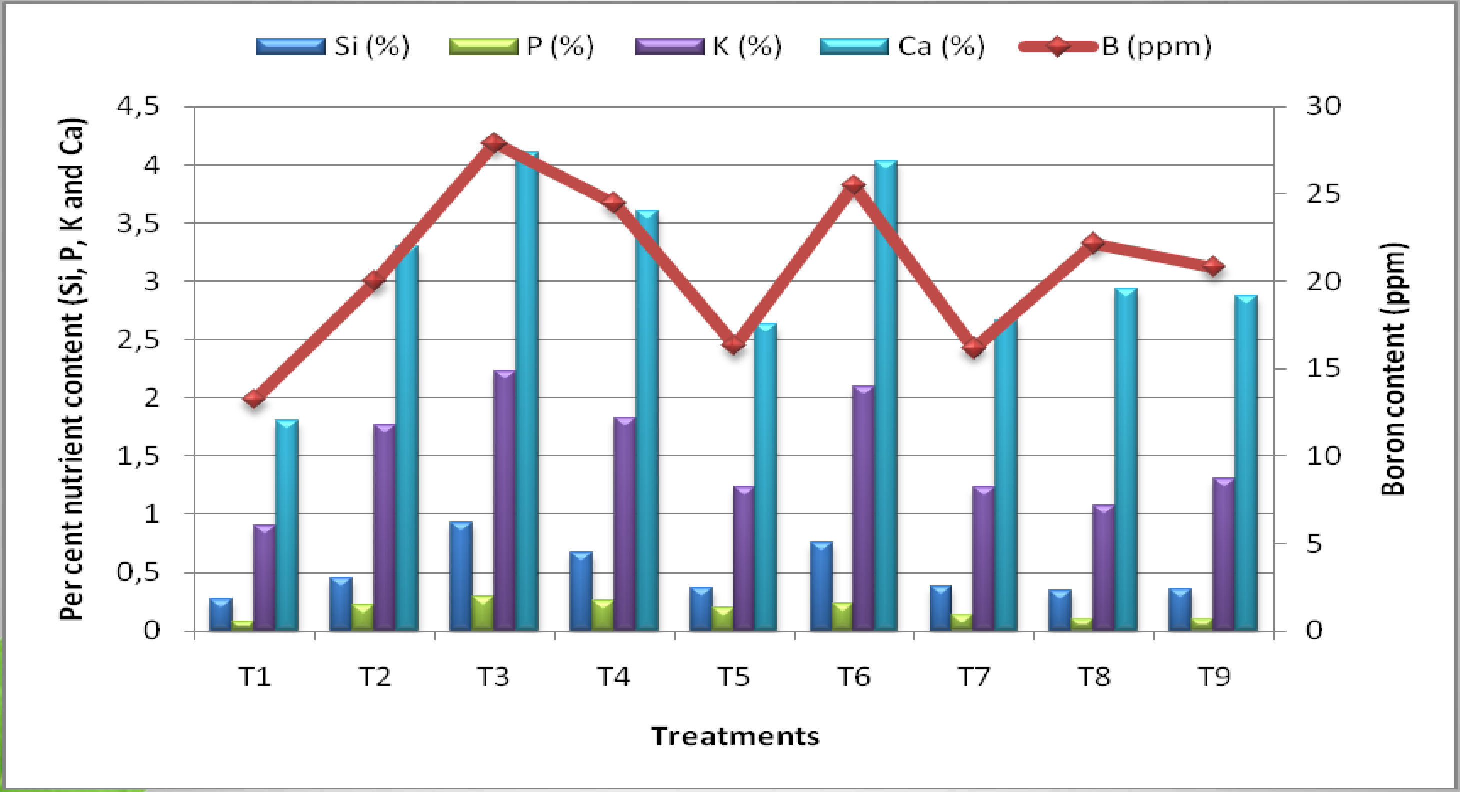
Treatments	Cane length (cm)	Leaf area (cm^2)	Leaf total chlorophyll content (mg g^{-1})
T_1- Control	89.84	155.46	6.93
T_2- SA spray 2ml L^{-1} once in 10 days (6 sprays)	91.13	161.01	10.66
T_3- SA spray 4ml L^{-1} once in 10 days (6 sprays)	110.09	179.44	13.73
T_4- SA spray 6ml L^{-1} once in 10 days (6 sprays)	107.77	176.81	11.41
T_5- SA spray 2ml L^{-1} once in 20 days (3 sprays)	95.15	164.38	8.89
T_6- SA spray 4ml L^{-1} once in 20 days (3 sprays)	98.15	175.90	12.21

Effect of SAAT on yield parameters of Bangalore blue Grapes (India 2009/10)

Treatments	Number of bunches per vine	Yield per vine (Kg)	Yield per hectare (t)
T_1- Control	295.20	26.68	12.01
T_2- SA spray 2ml L^{-1} once in 10 days (6 sprays)	283.27	31.87	14.34
T_3- SA spray 4ml L^{-1} once in 10 days (6 sprays)	325.53	33.87	15.24
T_4- SA spray 6ml L^{-1} once in 10 days (6 sprays)	301.00	37.19 (+39%)	16.74
T_5- SA spray 2ml L^{-1} once in 20 days (3 sprays)	294.00	29.52	13.29
T_6- SA spray 4ml L^{-1} once in 20 days (3 sprays)	298.00	36.14 (+ 35%)	16.26
T_7- SA spray 6ml L^{-1} once in 20 days (3 sprays)	296.60	27.86	12.54

Yield increase: 10 - 39%

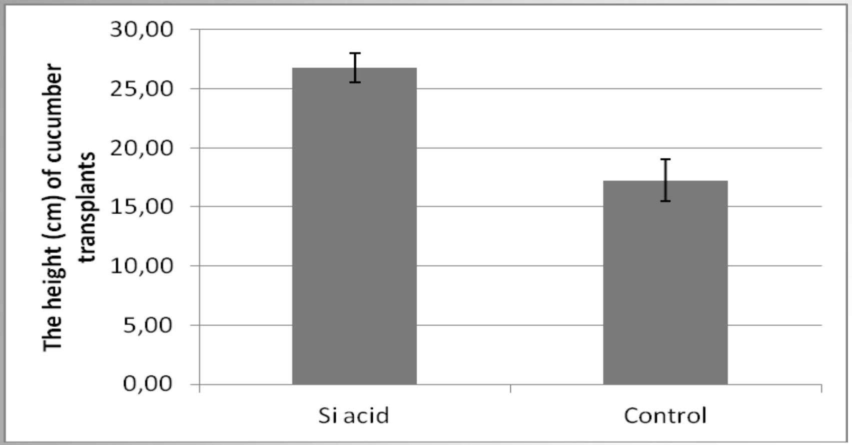
Effect of CropSIL on the uptake of minerals in Grapes

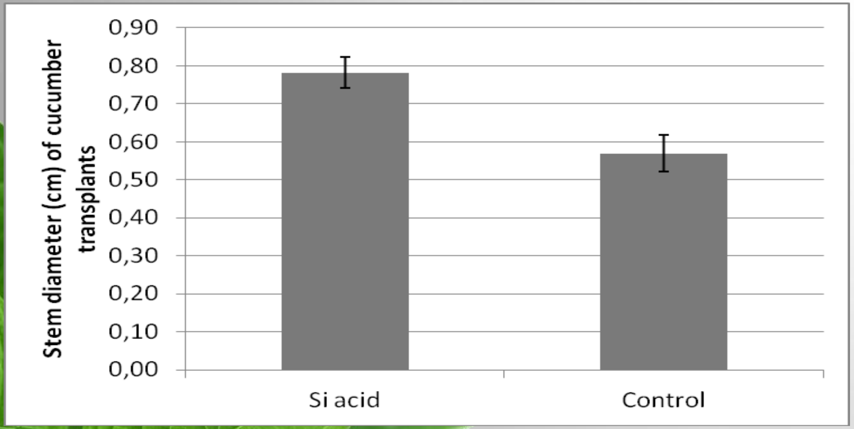


Higher uptake of Si, P, K (> 110 %), Ca (> 200%) and B: higher brix

Less physiological loss & less post harvest losses

Effect of SA on organically grown cucumber transplants Growth and Quality – Margit Olle – Estonian crop Research Institute - 2014





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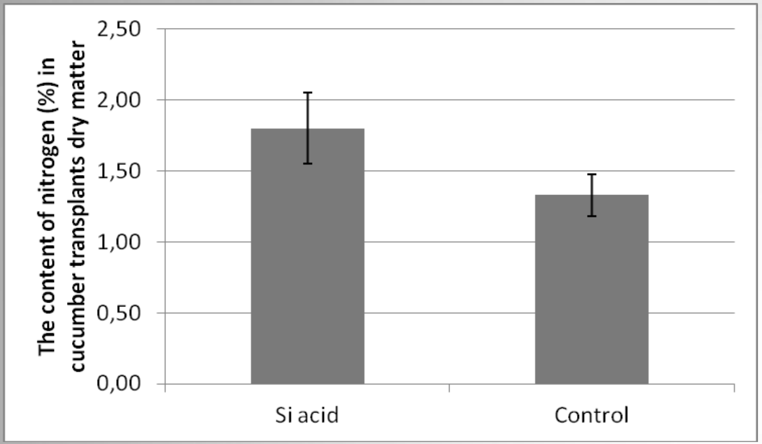
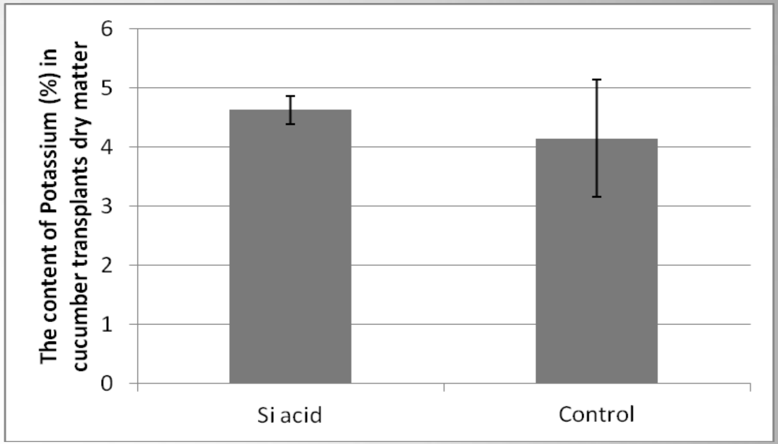
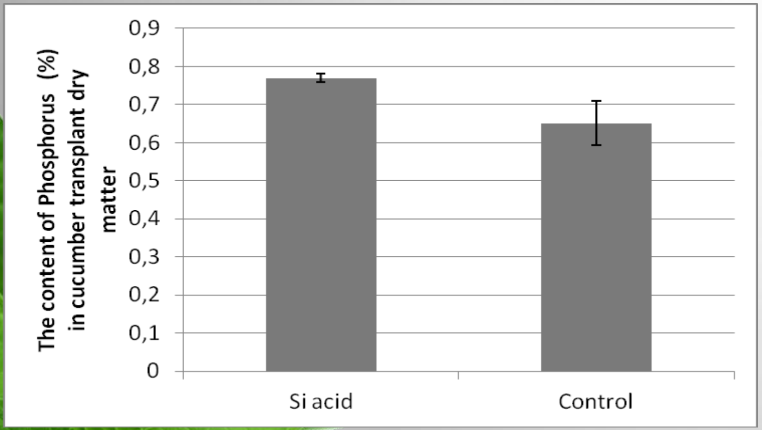
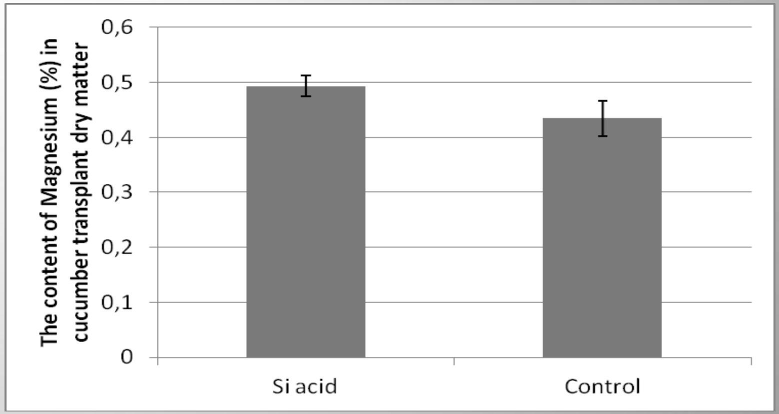








Effect of SAAT on (substrate grown) tomatoes (Greenhouse of 12 ha / 26,5 acres) Analysis of nutrients in petiole

Tomato fruit	Brix value
Silicon added	10
Control	9

Leaf sap analysis	Standard leaves	Leaves from silicon treated plants
Brix	8	9
NH_4	21	50
NO_3	15	13
Ca	97	113
K	182	203
Mg	15	18
SO_4	55	62

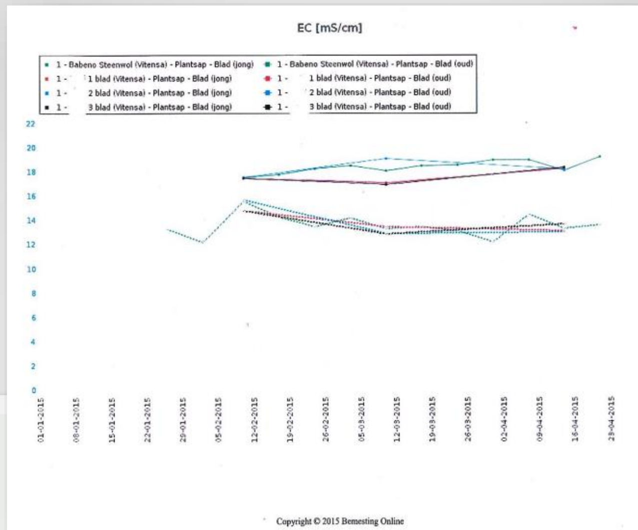
Higher uptake of K, Ca, Mg, etc. - Higher brix

Increase of internal quality & shelf-life

Effects of SAAT on growth of tomatoes

The green lines are untreated and the dotted line are the old leaves and the straight line the young leaves.

Si stabilize the sugar content and increase it. More sugar, more chlorophyll in old leaves

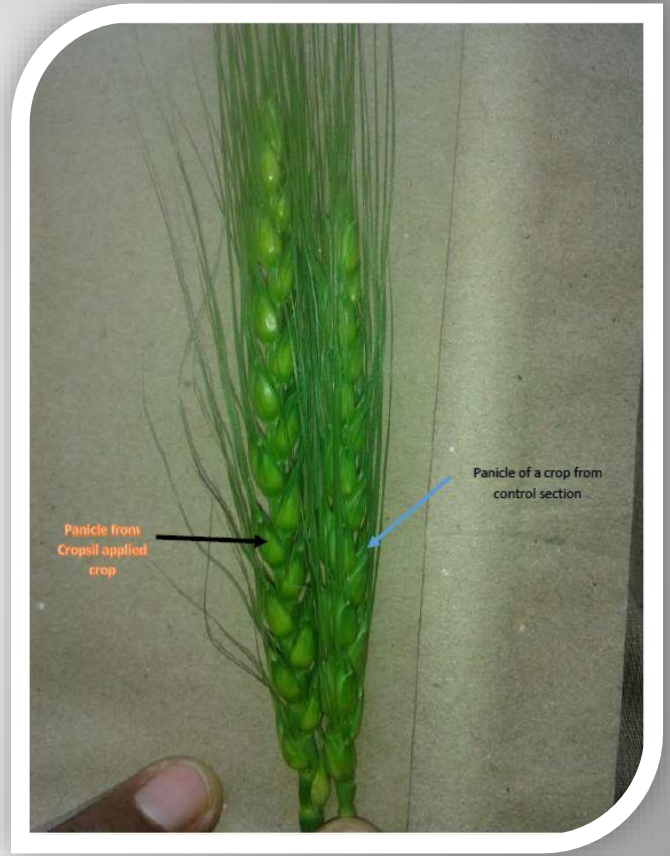


The pH levels are more stable in young and old leaves, (5.6-6.2) perfect for nutrient uptake

The EC level stabilizes in old and young tomato leaves, being slightly higher in the young leaves due to more mineral take up and sugar (sink source)

Effect of SAAT on Monocots

Crop	Year	Country	Yield in %	Remarks
Rice	2005	Panama	+ 19	Shorter crop cycle
Rice	208-12	India	+ 15 – 45	Lower infection rate
Rice	2013	Surinam	+ 37	Lower infection rate
Sugarcane	2010	India	+ 23	NRS: +7%
Sugarcane	2010/11	India	+ 26	Lower stem borer rate
Sugarcane	2011/12	India	+ 28	Higher result in drought c.
Wheat	2008	Pakistan	+ 31	Less water needed
Wheat	2012	Romania	+ 45	Effective in saline soil
Wheat	2013	Romania	+ 20,5	Higher protein content
Wheat	2013	Ukraine	+ 19	Higher protein content
Wheat	2013	Netherlands	+ 6	Higher protein content
Wheat	2014	Algeria	+ 56	Higher resistance to wind
Wheat	2014	India	+ 10-15	



Higher quality and more bulk

Effect of SAAT on Dicots

Crop	Year	Country	Yield in %	Remarks
Tomato	2011	India	**+ 31**	Higher brix; less infections
Tomato	2013	Poland	**+ 29**	Higher brix; less infections
Cauliflower	2013	Surinam	**+ 23**	Lower infection rate
Strawberries	2013	India	**+ 27**	Shorter crop cycle
Strawberries	2007	Netherlands	**+ 19**	Higher brix
Cucumber	201	India	**+ 23**	Less infections
Garlic	2012/13	India	**+ 28**	Higher Allicin content
Grapes	2011	India	**+ 35**	Higher sugar content
Grapes	2012	Romania	**+ 29**	Higher sugar content
Potato	2011	Netherlands	**+ 27**	More uniformity
Watermelon	2013/14	India	**+ 46**	Less infections
Okra	2012	India	**+ 26**	Less infections
Chilli Peppers	2009	India	**+ 15**	Higher quality

Higher quality and improve vigor

Silicic acid as biostimulant

- The sprayed silicic acid induces a top-down mechanism resulting in increase of root system resulting in an increased uptake of nutrients.
- SA should be regarded as *biostimulant* next to silicon's function as *fertilizer*.
- Biostimulants are "substances and materials, with the exception of nutrients and pesticides, which, when applied to plants, have the capacity to modify physiological processes in a way that provides potential benefits to growth, development a/o stress response".

Silicon and Legislation

Governments and industries globally, at all levels, are seeking viable economic solutions to the escalating problems associated with; the environment, food shortage, fresh water and harmful chemicals. Biostimulants and organic inputs are one of the fastest growing sectors of agricultural sciences today.

CropSIL= SAAT, Recognized:

- As a beneficial substance by Association of American Plant Food Control Officials (AAPFCO)
- Recognized as an Organic Input in EU & US
- CropSIL is now recognized and commercially registered as an organic input in Asia, EU & N.A.

‘Silicon’: double action

Key message

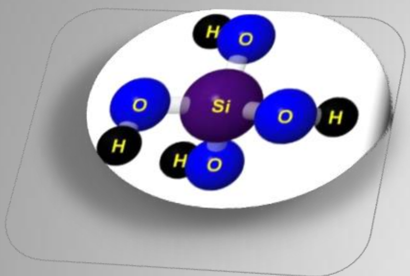
Silicon has a role as a **fertilizer,** especially in monocots like rice, sugarcane, etc. Silica is needed as brick stone for monocot plants: Silicon is an essential or beneficial microelement

Next,

Silicon acts as a **biostimulant**

Very small amounts of stabilized silicic acid induces in a plant, physiological processes (mono- and dicots), aiding and optimizing fertilizers, pesticides and fungicides. Resulting in healthier plants, higher growth, more yield and better quality

CropSIL® Features & Benefits



3% bio-available Silica
- Plant derived Silica
- Delivers to plants 99.99 % Bio Available
- Recognize by Association of American Plant Food Control Officials (AAPFCO)

INPUTS ECOCERT
Approved by Ecocert

Approved for Organic Farming
- By EcoCert, France
- Safe for Organic and conventional farming
- Cleared For Toxicity in Rats and Mice, ROHS Compliant

Registered and recognized by PCT-The International Patent Cooperation Treaty - WIPO
Patents already filed and pending
- USA, EU, Africa and India

CropSIL

ROOT

Better Growth & Uptake

STALK

Better Transport of water & nutrients

LEAF

Better leaf Erectness, Color & Size

FRUIT

Better firmness & Juiciness

SEED

Better Germination

PLANT

Overall Better Plant Health & Enhanced Crop Yield

Conclusion

The CropSIL® Technology attributes 5 unique benefits to Plants known as Pillars. These Pillars together improve the overall production and quality of the plant in different environments:

- Improved Physical Barrier
- Improved Transpiration
- Improved Disease and Pest Management
- Improved Regulation of Plant Processes
- Improved Uptake and Translocation of Plant Essential Elements

THANK YOU!