UTILIZATION OF SILICON IN AGRICULTURA

Helping plants (also the soil & growers) to help themselves

‘Silicon Solutions’

A monograph by Edward Bent (in English)
Fundamental instrument in support of sustainable agriculture

- Silicon is an important antagonist to reactive (soluble aluminium) and to many heavy metals;

- Some 40% of the world’s arable land has already become less productive due to acidity;

- Today, many soils are deficient in Bioactive/Plant available silicon;

- Silicon has a role to play in support of sustainable agriculture, biological and biodynamic production and can also render intensive production more sustainable.
The least understood mineral element in agriculture!

- Silicon science is attractive to pure science because of the huge number of variables in soil-water chemistry, plant nutrition, metabolism and genetics.
- There is no apparent organization to BRIDGE silicon science with commercial production, to educate and distill the science into AGRICULTURAL INNOVATION – led by production, the agro-food industry and distribution.
- Silicon application to crops is problematic because:
  - Many different formulations and methods of application;
  - Effects can be crop-specific, indirect and are preventative (protective and deterrent) rather than curative;
  - Interactions between Silicon and other elements e biostimulants, what substance does what?
  - No known scientific proof that leaves absorb silicon (silicic acid), yet commercial trials show the contrary and growers can gain significant benefits.
- This was a major motivation for writing the book ‘SILICON SOLUTIONS’ (2014).
Positive effects of Silicon on a variety of crops (documented in scientific publications)

Agricultural crops, including:
- rice, barley, maize, wheat, bamboo, beans, peas, potatoes, soyabean.

Fruit & Vegetable crops, including:
- Strawberries, cucumbers, melons, zucchini, tomatoes, apples, pears, apricots, cherries, aubergines, cabbage, carrot, chicory, onion, grapevines.

Ornamental crops including:
- Chrysanthemums, gerberas, Helianthus, orchids, roses, begonia, petunia, poinsettias, saintpaulia, syringa, ornamental grasses.
Bioactive Silicon (BAS)
Plant Available Silicon (PAS)

sand – silicates – clay – diatomaceous earth

mono-silicic acid
Product description / category

Fertilizer? Essential element?

Silicon is considered a **Biostimulant**

**ANTI-STRESS**

Si – Bo – Ca

‘Plant Stress Dynamics’ (dinamica dello stress)
Losses from ABIOTIC stresses are often much higher than losses due to BIOTIC stresses.
Categories of Biostimulants

• Humic acids - organic substances (*often linked to Si*)
• Extracts of algae (*rich in Si*)
• Extracts of *Equisetum* (*rich in Si*)
• Chitin and derivatives (*polysaccharide – synthesis*)
• **SILICON**
• Protein hydrolates e amino acids
• Phosphites
• Microbes – Growth promoting bacteria
• Microbes - Trichoderma
• Microbes – Micorrhyza
• Other (anti-transpirants, microelements, hormones etc.)
The book touches many arguments

Education
If SILICON *indirectly* improves the mineral balance of plants (e.g. up to 30-40% less phosphorus needed) why is Silicon not considered essential alongside N-P-K?

Such a book should be available to students of agronomy and growers.

Experimental trials
Trials should be LED by growers and grower clients (agro-industry) i.e. production, transformation and distribution, in collaboration with agronomists and experimental stations.

Quality of produce
Silicon plays a major role in product quality = EXTERNAL QUALITY (yield, grades, uniformity, appearance).

(+)
INTERNAL QUALITY (post-harvest characteristics: nutritional profile, chemical residues, resistance to handling, storage and transport).

(+)
Contribution to the ENVIRONMENT:
• Circular economy e.g. biodynamic production;
• Sustainable and biological production;
• Longer lasting produce, less waste;
• Improved soil structure & fertility;
• Benefits to human & animal health.
Silicon science v commerciale utilization?

- The functions and effects of silicon in plants are very COMPLEX, creating challenging and fascinating new objectives for scientific research throughout the world;

- Si has a PROTECTIVE function: it does not kill diseases or insect pests but reinforces plants against abiotic and biotic stresses;

- Conflict of interest between: growers/agromists – agrochemical industry – scientific research?

- Need to place GROWERS ‘in the driving seat’ to initiate commercial trials on their land or in their greenhouses, in collaboration with local agronomists, silicon suppliers, experimental stations and universities.

Help growers to help themselves

This is also the mission of the book ‘SILICON SOLUTIONS’ by Edward Bent (Sestante Edizione 2014)
AGGREGATION WITHIN THE AGROCHEMICAL INDUSTRY

- Monsanto and Monsanto Growth Ventures
- Syngenta and Syngenta Ventures
- Archer Daniels Midland Company
- Land O’Lakes
- Cargill and Cargill Ventures
- Dow Chemical Company and Dow Venture Capital
- DuPont and DuPont Ventures
- BASF and BASF Venture Capital
- Bayer and Bayer CropSciences

If the application of silicon reduces plant requirements for: fertilizers, fungicides, insecticides and water, will silicon be wooed (corteggiato) by the agrochemical industry?
Categories of Silicon formulations

Application as foliar spray or soil drench

- Stabilized mono-silicic acid;
- Stabilized mono-silicic acid + other mineral elements e.g. boron, zinc molybdenum, copper, iron chelate, selenium;
- Stabilized mono-silicic acid + amino acids (o chelates of malic/citric acid polymers).
- Phosphite + urea (organic nitrogen) + ethyl silicate;

Potassium silicate, calcium and aluminium silicates, magnesium silicate etc., diatomaceous earth, zeolite, soluble glass, other silicates. There is a need to establish a more holistic and multi-disciplinary approach to commercial trials with silicon amendments, with more than one production cycle and involving the agro-food industry and distribution chain in support of the trials. Some objectives for commercial trials are suggested in the book.

Further knowledge transfer to agronomists and growers is vital and the media together with retail distribution should provide more information to the consumers.

A WORKING GROUP should be established to promote the dissemination of information on the utilization and value of silicon in agriculture.

The bioactive, plant available silicon molecule remains mono-silicic acid
Foliar absorption of mono-silicic acid

- Obstacles faced by BAS/PAS in the soil solution can limit its uptake in the transpiration stream;

- No scientific proof that BAS/PAS is absorbed by the leaf. This contradicts beneficial effects that growers have obtained for many years by applying BAS/PAS as a foliar spray;

- The precise mechanism is not understood. It has a TOP-DOWN effect in the leaf, probably through improved activation of certain genes resulting in a greater synthesis of certain growth hormones in the roots.

- Enhanced photosynthesis and improved water balance also results through the silification of leaf surfaces that also deter the germination of fungal spores and insect herbivory.
Synergic and additive effects

- Synergic and other additive effects have been observed when the application of Silicon is accompanied by other biostimulants: mineral elements such as boron, amino acids, various microbic formulations.

- **Foliar spray** of BAS/PAS on its own or in combination other mineral elements and biostimulants e.g. amino acids) effects a TOP-DOWN beneficial action;

- When BAS/PAS is applied (provided) **to the soil**, on its own or in combination with other biostimulants (including microbial preparations) plants benefit from a BOTTOM-UP action.

- The action of Silicon in plant genetics, metabolism, biochemistry and physiology is complex and all-embracing, not surprising when considering that plants have evolved for millions of years growing in soils most of which have a silicon content (sand/clay).
Convincing arguments
Leaf resistance (Vite)
Fraise: effet sur la conservation

Témoin
Infection fongique après 5 jours

Siliforce
+5 jours de conservation

CRA CNRItaly 2009- Valentini- Metodiche RMI: caratteristiche generali e risultati applicativi sui vegetali
Impact of Actisil treatment of mother plants on yield of pointsettia transplants

- **FM yield [g/plant]**
  - Control: 3.80
  - Actisil 0.1% weekly: 3.90

- **DM yield [g/plant]**
  - Control: 0.63
  - Actisil 0.1% weekly: 0.68
<table>
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<th>STRESS DELLE PIANTE</th>
<th>IMPATTO SULLA PRODUZIONE</th>
<th>POST-RACCOLTA</th>
<th>QUALITY DEI PRODOTTI</th>
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<td><strong>Abiotico</strong></td>
<td>Luce (UV), Temperatura, Umidità relativa, Ozono, Vento, Pioggia/Grandine, Chimici ecc.</td>
<td><strong>COSTITUENTE DELLE PIANTE</strong> - robustezza - fotosintesi</td>
<td><strong>RESA/RACCOLTA</strong></td>
<td>- Peso e volume</td>
<td><strong>AMBIENTE</strong> - Utilizzo ridotto di prodotti chimici sopra suolo - Effetti positivi x insetti (inclusi le api), fauna selvatica ecc.....</td>
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<td><strong>Biotico</strong></td>
<td>Malattie Insetti Erbivora Sopra suolo</td>
<td><strong>BIOSTIMOLANTE</strong> - resistenza alle malattie - deterrenza agli insetti - bilancio di acqua e minerali; metabolismo</td>
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<td>- Apparenza - Uniformità - Standard</td>
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<tr>
<td><strong>Abiotico</strong></td>
<td>Sotto suolo Acqua, Minerali, Salinità, Chimici, pH, Temperatura, Idraulica, Meccanica etc.</td>
<td><strong>AMMENDANTE DEL TERRENO</strong> - struttura e fertilità del terreno</td>
<td><strong>QUALITA’ INTERNA</strong></td>
<td>- Valore nutrizionale - Residui chimici - Trasformazione cibo - Immagazzinamento - Movimentazione e trasporto - Shelf-life</td>
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<td><strong>Biotico</strong></td>
<td>Batteria Micorrize Nematodi Altri insetti Parassitismo</td>
<td><strong>MICRORGANISMI</strong> - aumento numerico - attività maggiore - resistenza x malattie - deterrenza x insetti</td>
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<td><strong>AMBIENTI</strong> - Utilizzo ridotto dei prodotti chimici per il suolo - Lisciviazione ridotta - Depurazione metalli pesanti - Riserva silicio-carbon</td>
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Summary of the benefits of Silicon to plants

- Growth & development of plants (biostimulant against abiotic and biotic stresses);
- Impact on soil structure and fertility and soil microorganisms;
- Reduction in leaching of minerals from the soil and the depuration of heavy metals;
- Improved quality: yield, uniformity and maturation, appearance;
- Better internal quality: nutritional values, lower chemical residues;
- Improved postharvest characteristics: handling, storage, transport, longer-lasting freshness;
- Contribution to human and animal health
Health Benefits

- Important role, together with Calcium in the maintenance of healthy bones (osteoporosis);
- Reinforcement of connective and mucous tissues, arteries, tendons, skin, hair, nails;
- Constrasts the effect of reactive (soluble) aluminium, implicated in various neurodegenerative diseases;
- Increases the content of vitamins, minerals and anti-oxidants in fresh fruit and vegetables.

Some silicon supplements on the market: Rexana, Silidyn, Biosil, diatomaceous earth, Equisetum extracts/tea etc.

Questions:
- Will the nutritional values and the length of conservation of potatoes increase when plants are treated with silicon during production?
- Will this improvement provide an economic return to the grower and/or to the food industry?
THE CHALLENGE
To promote utilization of Silicon in sustainable agriculture, horticulture, biological and biodynamic productions

Commercial trials: growers, grower consortia and cooperatives;

AGRONOMY: agricultural colleges, universities and other Institutes (education, design and monitoring of trials);

Suppliers of SILICON products and amendments for agriculture;
Companies that transform agricultural products for the food industry.

The book ‘Silicon Solutions’ (and similar);
Agricultural Associations: Coldiretti, Confagricoltura etc;
MEDIA, Professional and trade publications;
Conferences and trade exhibitions.

Wholesale distributors for agricultural produce, fruit & vegetables;
Volume retail (Grande Distribuzione)
Consumer associations (health and silicon supplements)
“SILICON SOLUTIONS”

Introduction

Questions & Answers

PART I: AGRICULTURE
• Plant Stress Dynamics
• Mineral Balance
• Silicon (fertilizers)

POTATO TRIALS (BELGIUM)

PART II: FUNCTIONS OF SILICON
• Anti-stress effects
• Plant metabolism
• Silicon cycle

TECHNICAL APPLICATION INFORMATION

PART III: HORTICULTURE
• Food quality & nutrition
• Benefits of Silicon

TECHNICAL APPLICATION INFORMATION

PART IV: FLORICULTURE
• Container environment
• Plant growth & development

Annex

Glossary

Bibliography

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Some reviews of the book ‘Silicon Solutions’

"Un notevole resoconto di ricerche, prove sperimentali, conferenze scientifiche e idee illuminanti. Il libro risponde a un bisogno reale. Con forte convinzione mette insieme prove, esperienze e intuizioni scientifiche, evidenziando anche aspetti che non sono stati ancora adeguatamente esplorati".

"C'è una grande quantità di ricerca scientifica e conoscenza sui benefici per le piante di un'adeguata fornitura di silicio, ma pochi libri (se ci sono) hanno tentato di trasformare le risultanti informazioni accademiche in una forma più accessibile agli interessi e ai bisogni pratici di coltivatori. Come tale è il primo del suo tipo".
Dr. N.B. Prakash, Professore associato, Dipartimento di scienze del suolo e chimica agraria, Università di scienze agrarie, GKVK, Bangalore, India.

"Ora è apparso un libro con un'indagine completa su quasi tutti gli aspetti dell'uso del silicio nell'agricoltura e nell'orticoltura. Alla fine! Utilizzando questo libro l'agricoltore può ottenere rese elevate con una qualità superiore, secondo pratiche agricole sicure e sostenibili. 'Silicon Solutions' dovrebbe essere un MUST per quasi tutti i contadini".
Dr. Henk-Maarten Laane, medico ed ex ricercatore, direttore R & D di Rexil-Agro BV, Paesi Bassi.

(19)
SPECIAL OFFER

Summary:
• Title: Silicon Solutions
• Author: Edward Bent
• Publisher: Sestanti Edizioni (Bergamo)
• ISBN: 978-88-6642-151-1
• Format: Paperback 17 x 24cm
• Pages: 184 plus cover (12 chapters, 40 tables, graphs/diagrams, 46 full colour illustrations.
• Cover price: €29,00

- €29 each book
- (discount for quantity)
Up-date and translations?

The book project included the eventual sponsorization of an edition in the Spanish, Italian and French languages.

There is a need to update the content of the book and prepare the ground for new books of this type.

Despite substantial efforts, there has been no interest or support from the the Italian agricultural institutes contacted so far (MiPAAF, CREA, Association for Biodynamic Agriculture).
SILICON DAY (Agriproject Bologna 2008/2009)

- Az. Agr. Ponterosa: uva da tavola;
- Az. Agr. Passalacqua: zucchini, cetriolo, peperoni;
- Consorzio Agrario Forli-Cesena-Rimini: fragole, albicocco, patata;
- Az. Agr. Veronesi / Fondazione Edmund Mach, Ist. Agrario di San Michele all’Adige (Tn) : melo, uva;
- CRA Tor Mancina, Monterotondo, Roma: RMI per pomodoro, fragole, kiwi.

It is now time to repropose and redouble efforts to promote the utilization of silicon in agriculture to protect and improve production.
7th International Conference on Silicon in Agriculture
24-28 October 2017, UAS, Bengaluru, India

Programme Schedule
University of Agricultural Sciences, Bengaluru
Indian Society of Soil Science, Bangalore Chapter
The International Society for Silicon in Agriculture & Related Disciplines (ISSAG)

www.silicon2017.com
For further information:
HORTCOM (Blog) theme: bioactive silicon.

Edward Bent

www.hortcom.wordpress.com

International Society for Silicon in Agriculture and related Disciplines

www.issag.org
CONCLUSION

There is a need to establish a more holistic and multi-disciplinary approach to commercial trials with silicon emendments, with more than one production cycle and involving the agro-food industry and distribution chain in support of the trials. Some objectives for commercial trials are suggested in the book.

The EXPO at Bologna 1° May – 31 October 2019 for horticulture and ornamental nursery stock has themes: GROW GREEN, EAT GREEN & LIVE GREEN. This should be a great opportunity for promoting the use of Si, also addressing the consumer.

Further knowledge transfer to agronomists and growers is vital and the media together with retail distribution should provide more information to the consumers.

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help plants, soil and growers to help themselves