SILIBOOST - SOUFREL - Agronomic principles of soil functioning

Effect of SILIBOOST on soil structure

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Soil aeration

Oxygen supply for worms that aerate the soil

- Looser soil,
- Easier to work soil
- Better water circulation
- Better root penetration

Better drained soil has

- greater microbial activity and reduced anaerobic metabolism
- lower denitrification rate (N loss) than poorly drained soil

Maintenance of a soil structure conducive to good yields, natural soil drainage, and reduction of the risk of asphyxia and anaerobiosis

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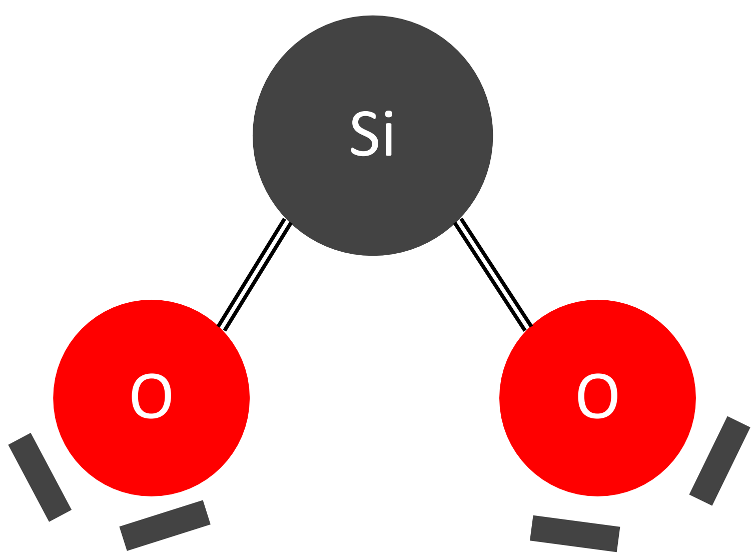
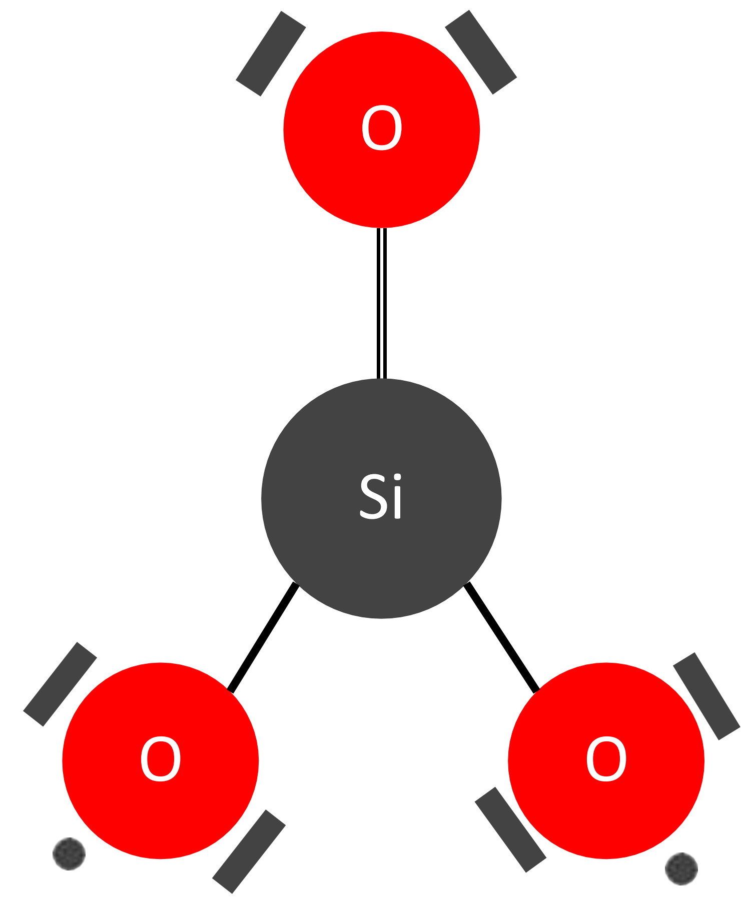
SiO_2 vs SiO_3 $^{2-}$



Amorphous form
SiO_2



Loaded form

$SiO_{3 2-}$

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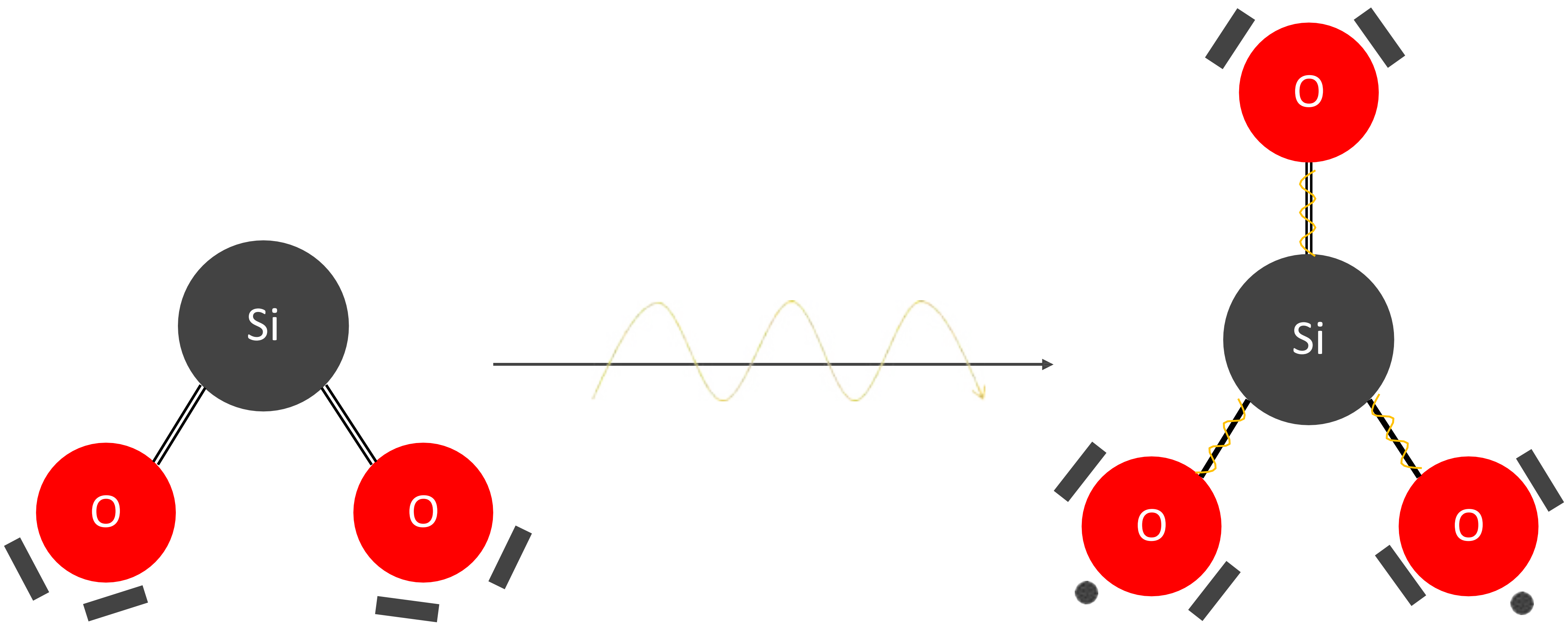
Activation

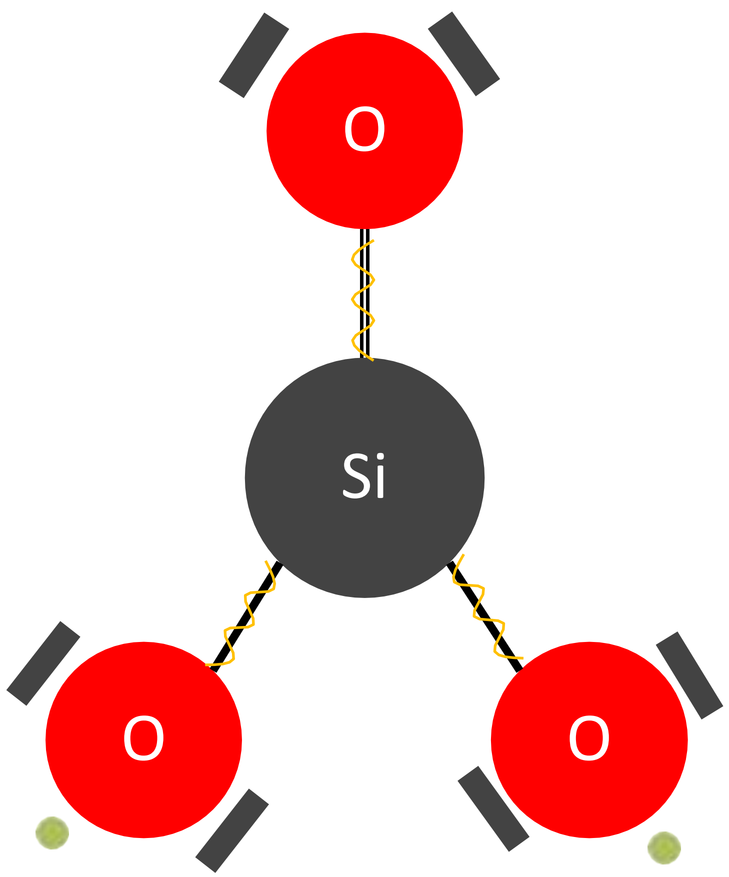


Quartz powder
SiO_2

Loaded form

SiO_{32-}

Creating an imbalance!



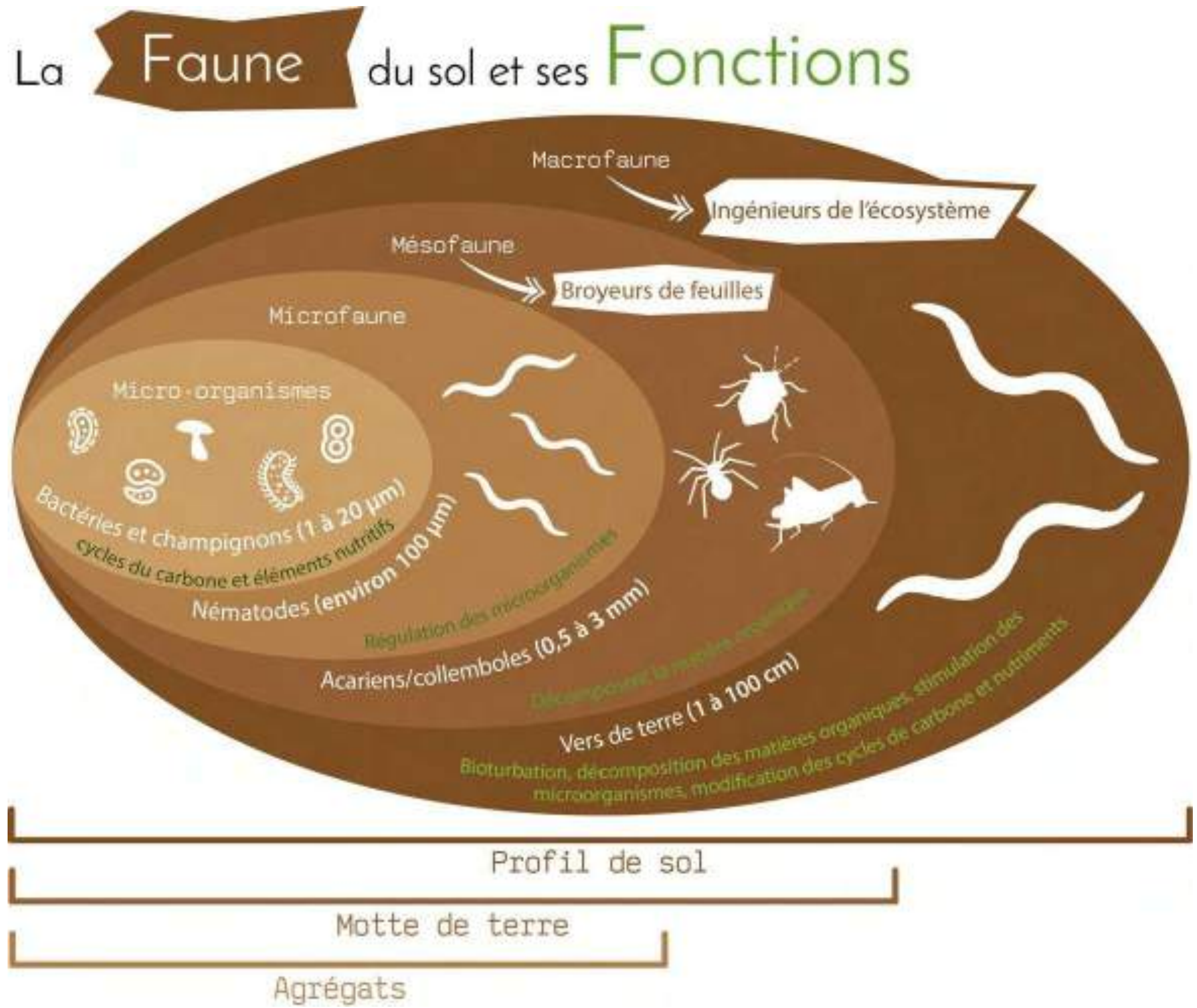
Charged molecule
Imbalance that must be compensated for by ion exchange and chemical reactions

Loaded form

SiO_{32-}

Promoting the action of soil organisms with SILIBOOST

Soil fauna



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Comparative characteristics of fungi and bacteria

	Mushrooms	Bacteria
Breathing - metabolism	Strict aerobic	Optional aerobic or strict anaerobic
Impact of tillage	Sensitive	Stimulation
Non-tillage	Very favorable	Indifferent
Lignin use	Yes	No
Use of cellulose	Yes	Yes
Preferred MO C/N	C/N > 30 up to 500	C/N 6 to 25
Efficiency of recycling original carbon C	40-55% Impossible in anaerobic conditions	5-15% in aerobic conditions 2-3% in anaerobic conditions
P,N excess effect	Inhibition	Stimulation
Effect of compaction	Inhibition	Metabolic change
Effect of hydromorphic soil	Inhibition	Metabolic change
Fungicidal effect	Sensitive	Indifferent
C/N ratio of fabrics	10-25	5-7
Nitrogen requirements	Min 0,2%	Min 2%
preferred pH	5 to 6,8	5 to 8
Mineral and water transport	Up to 15/20 cm	0
Structural improvement	+++	+/-

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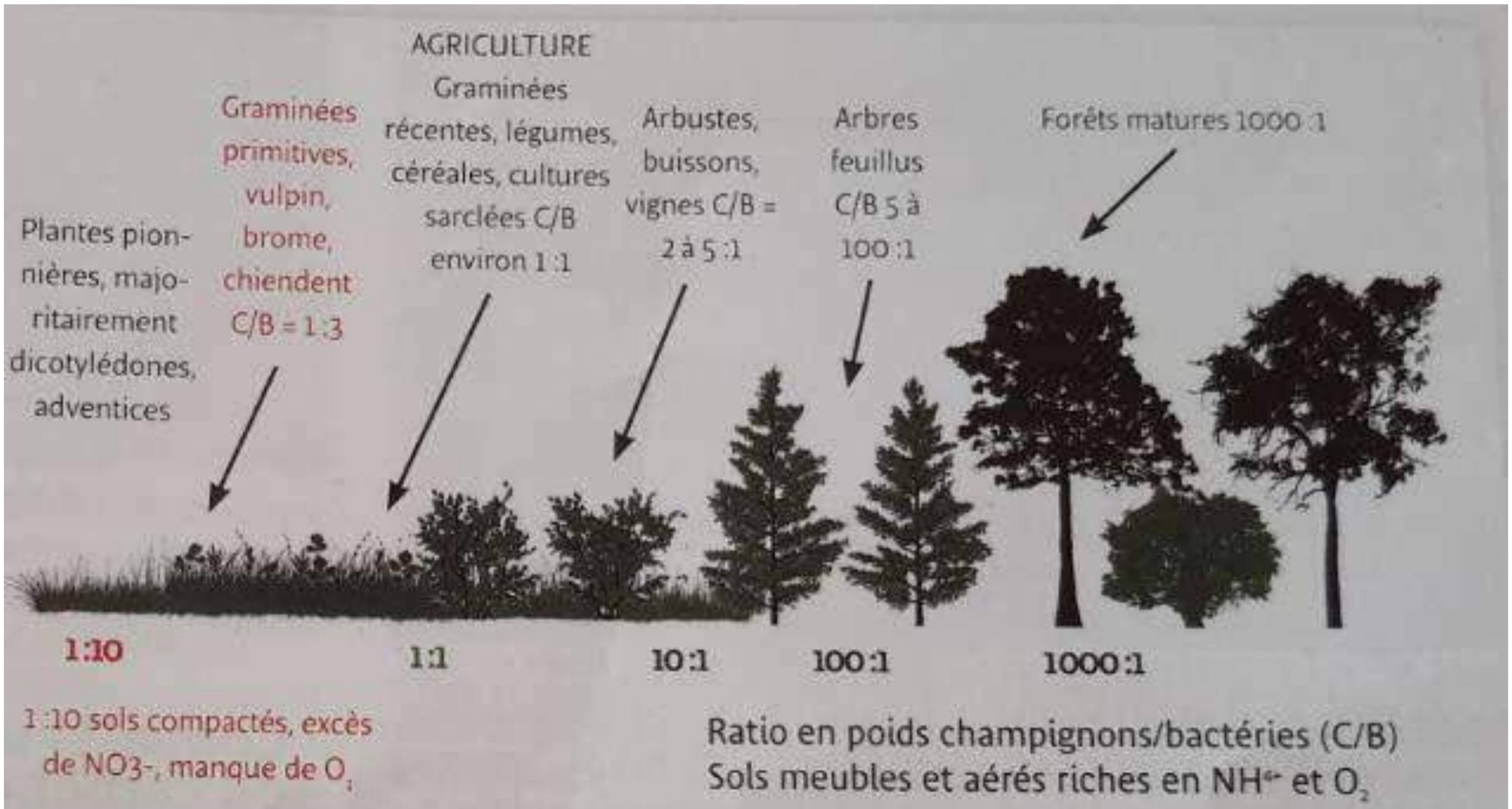
According to Revitalizing Soils, Francis Bucaille, November 2020

Soil Microbiology



Composition de la flore d'un sol en fonction du rapport champignon/bactérie. En cherchant à obtenir un rapport de 1/1 grâce à ses pratiques, l'agriculteur pense avoir résolu un problème de vulpin et de renouée persicaire récurrent dans une parcelle, adventices pionnières favorisées par un ratio de 1/3,5.

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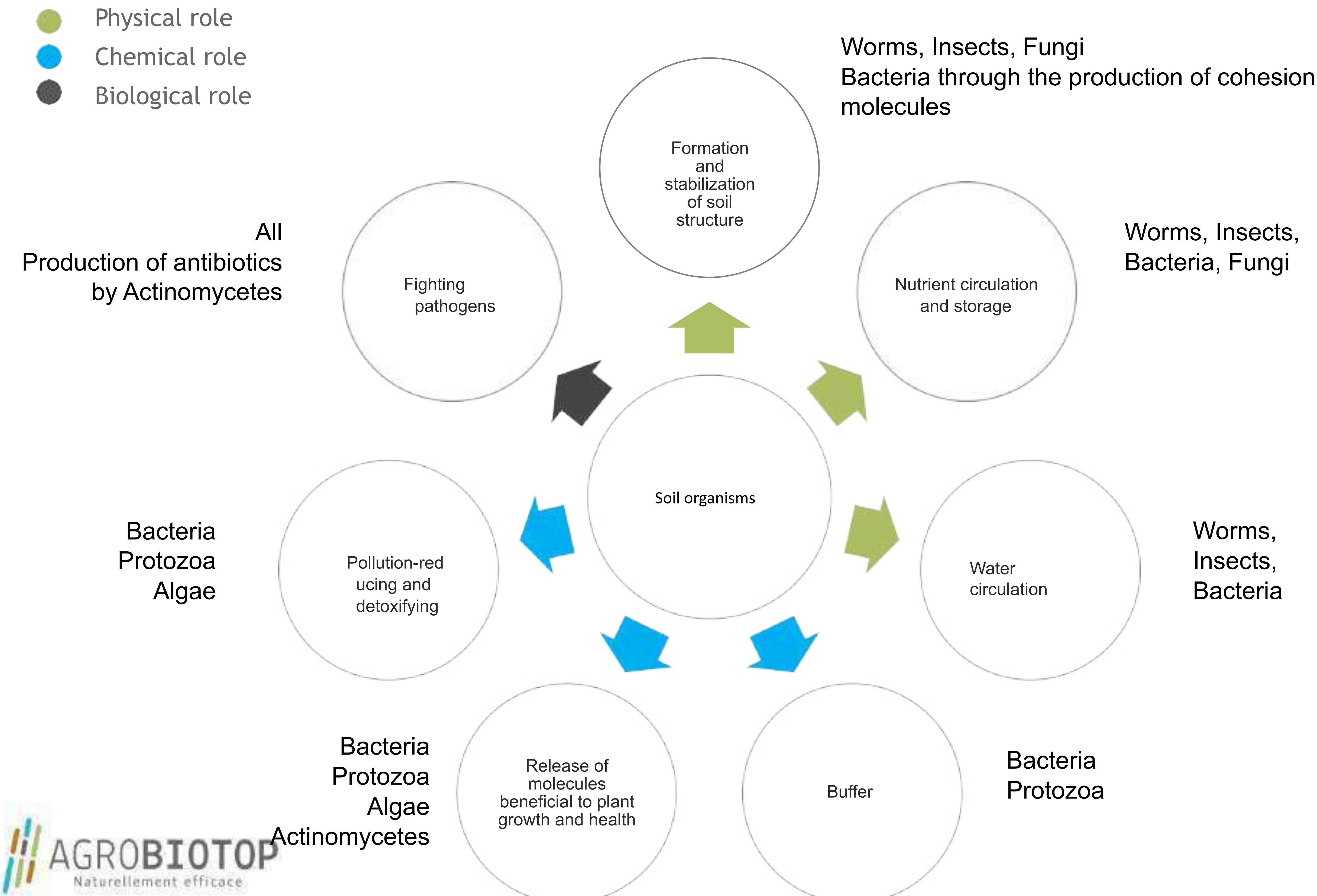
According to Professor Ingham

Roles of Soil Organisms



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Barley after Xynthia: desalination

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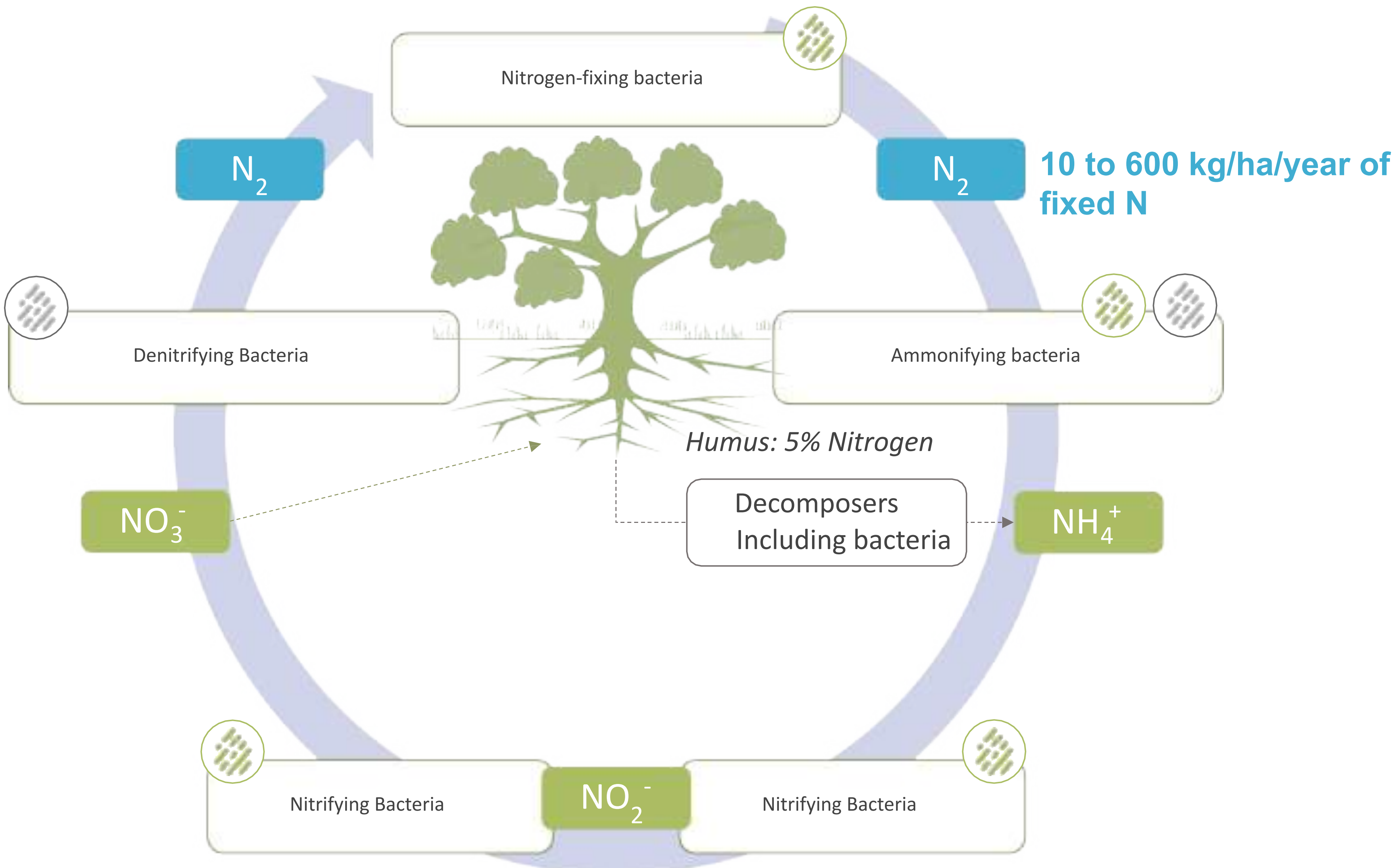
Place in the nitrogen cycle



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Wheat without SILIBOOST

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Wheat with SILIBOOST

- Coating at sowing: 250 g/ha

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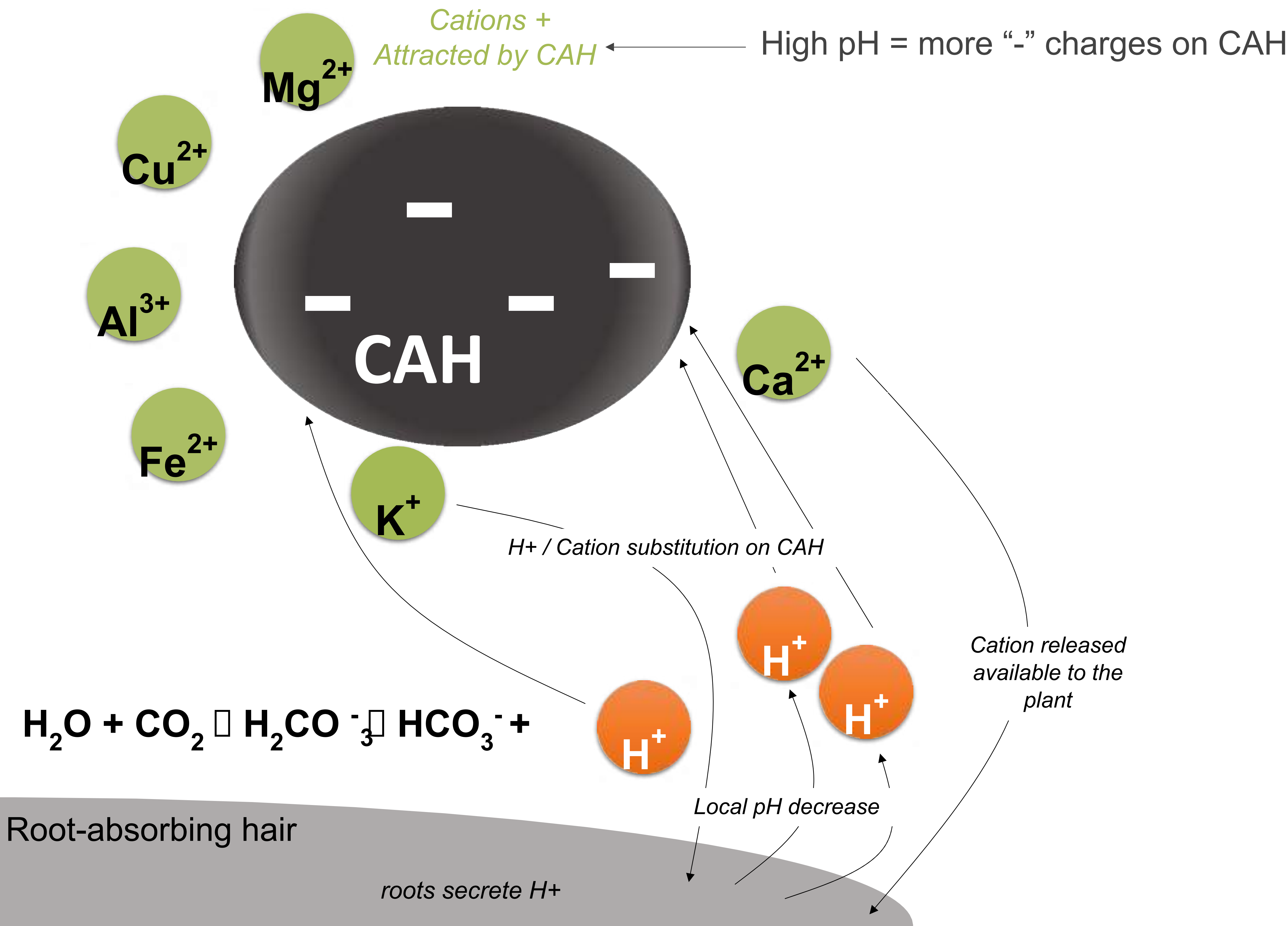
Effects on Trade of SILIBOOST

Cation exchange



Effects on absorption

SILIBOOST

Improvement of CEC Mineral flow regulator
Stimulation of soil biological life

Increased availability of soil minerals, especially K
  and P, through exchange at the CAH level

Regulation of mineral quantities
  Reduces absorption in case of excess P
  Regulates Mg absorption and reduces its toxic effects
  Same for Ca and K

Soil nutrients are more available to the plant, ensuring better mineral nutrition

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Bouzoubaâ Z et al., 2009 ; Velly 1977 ; Bartoli 1978

Effect on soil pH

SILIBOOST

Provides optimal pH

Optimal pH range for beneficial microbial life and for inhibiting the development of pathogenic species

Optimal pH range for crop development

Optimization of soil-plant nutrient exchange, which is pH-dependent

Regulation of soil pH
Improvement in yields and quality of soil organisms Reduction in the need for liming

AGROBIOTOP
Naturellement efficace

Bouzoubaâ Z et al., 2009

Effect on redox potential

SILIBOOST

Provides oxygen

Promotes an oxidizing environment: optimal conditions for soil life

Favorable for soil/plant exchanges dependent on the form of ions present and therefore their oxidized/reduced status

Maintaining a redox potential favorable to plant mineral nutrition

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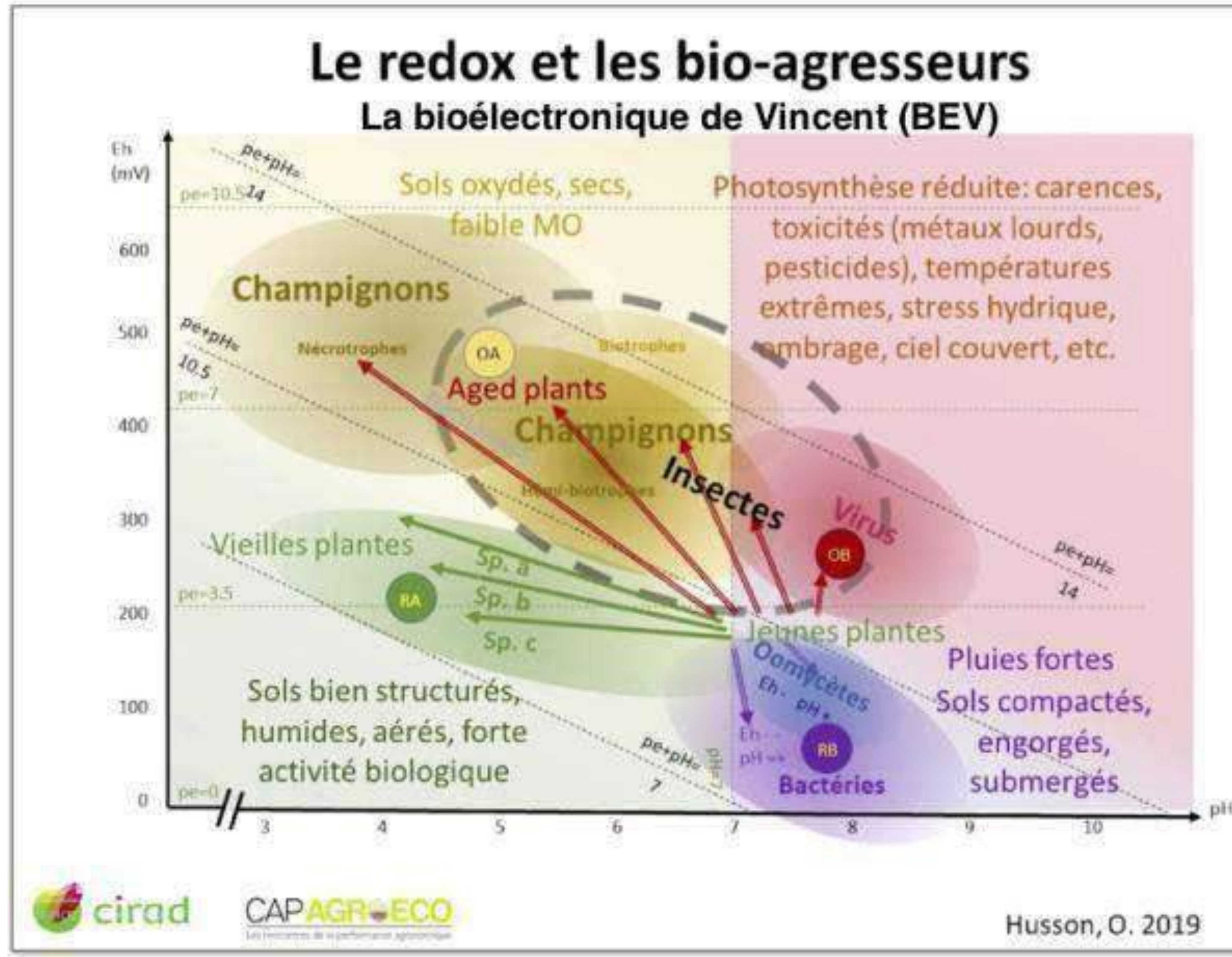
Vizier, 1971

Manganese oxidation and its link to pathogens and diseases

Assimilation of Mn by plants in the form of Mn^{2+} (reduced) and not Mn^{4+}

Pathogen strains (such as *Gaeumannomyces graminis, responsible for scald)* piétin

- ability to oxidise manganese to the Mn4+ form, which cannot be assimilated by crops
    - reduction in crops' resistance to these pathogens



SILIBOOST

Maintenance of a redox potential favourable to the Mn2+ form and unfavourable to pathogens

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John Kempf, 2020

Biotic stress, oxidation and plant polarity

Pest attack = Stress

↓

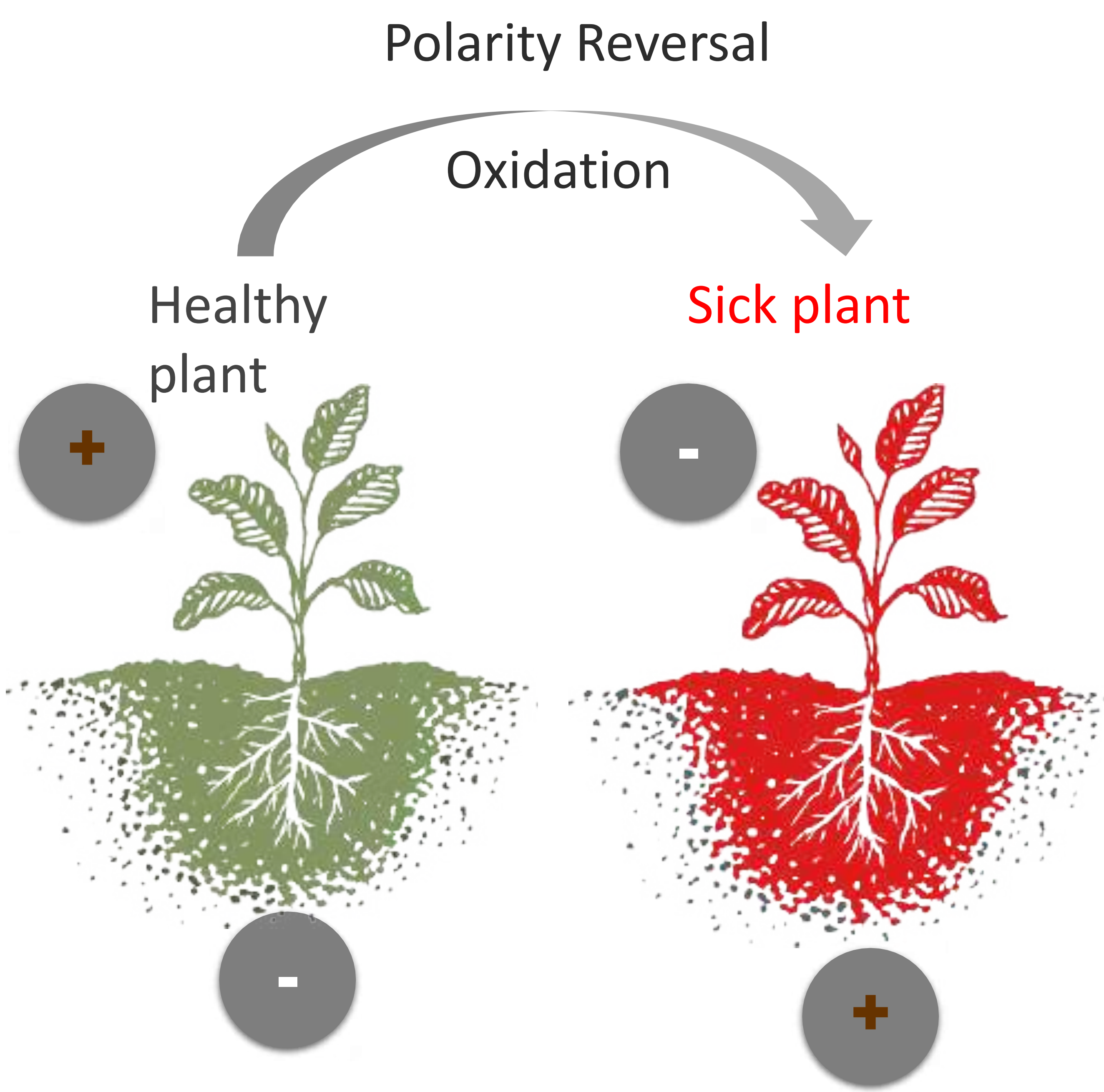
Oxidation

↓

Oxidation Propagation

↓

Reversal of cell polarity and plant polarity



Direct action on the plant of SILIBOOST

Effects on the plant endoderm

SILIBOOST

Strengthens the plant's endoderm, providing mechanical resistance to damage

Reinforced endoderm

Mechanical barrier against pathogens, insects, fungi and parasites

The plant's natural defences against biological aggressors are reinforced by physical protection

Bouzoubaâ Z et al., 2009 ; Bartoli 1978

Wheat after frost

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Effects on growth

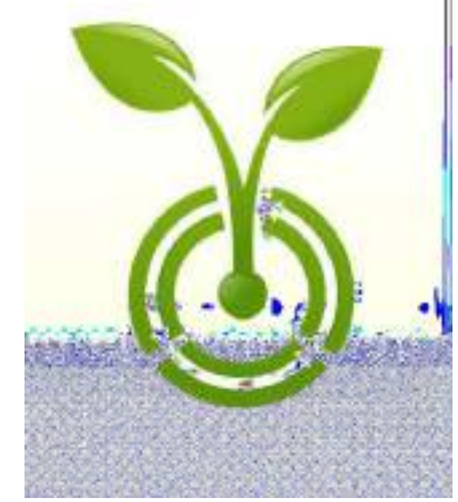
SILIBOOST

Increases photosynthesis capacity and mineral absorption

Reinforced endoderm that allows the leaves to stand upright

The surface area exposed to sunlight is increased

Increased photosynthetic activity, the plant produces more sugars



Root growth in length and diameter

Increased absorption surface area in the soil, resulting in better absorption of water and minerals, linked to the soil's exchange capacity

Plant growth is promoted by increased sugar synthesis and optimal absorption of water and minerals through a denser root network

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Bouzoubaâ Z et al., 2009 ; Velly 1977

Water saving

SILIBOOST

Less water loss

Reinforced endoderm that enables the plant to better withstand water stress and reduce water loss through transpiration, which the roots would be unable to compensate for

Reduced water requirements
Improved soil moisture levels at root level

The plant loses less water, so it is more resistant to difficult water conditions: thermal and water shocks

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Bouzoubaâ Z et al., 2009 ; Velly 1977 : Bartoli 1978

Mandarin trees in Morocco

•

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Naturellement efficace

Carrots

Irrigated carrots without SILIBOOST

Non-irrigated carrots with SILIBOOST at 2 x 250g/ha

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SILIBOOST FIELD DATA

Essay on Wheat

- These trials were conducted on a private group's experimental farm. Nineteen tests were carried out, including seven with competing products.

- Location: Baignes (16) – France – Soft winter wheat – Harvested in July 2013

- SILIBOOST : 200 g/ha at sowing + 200 g at the end of tillering.

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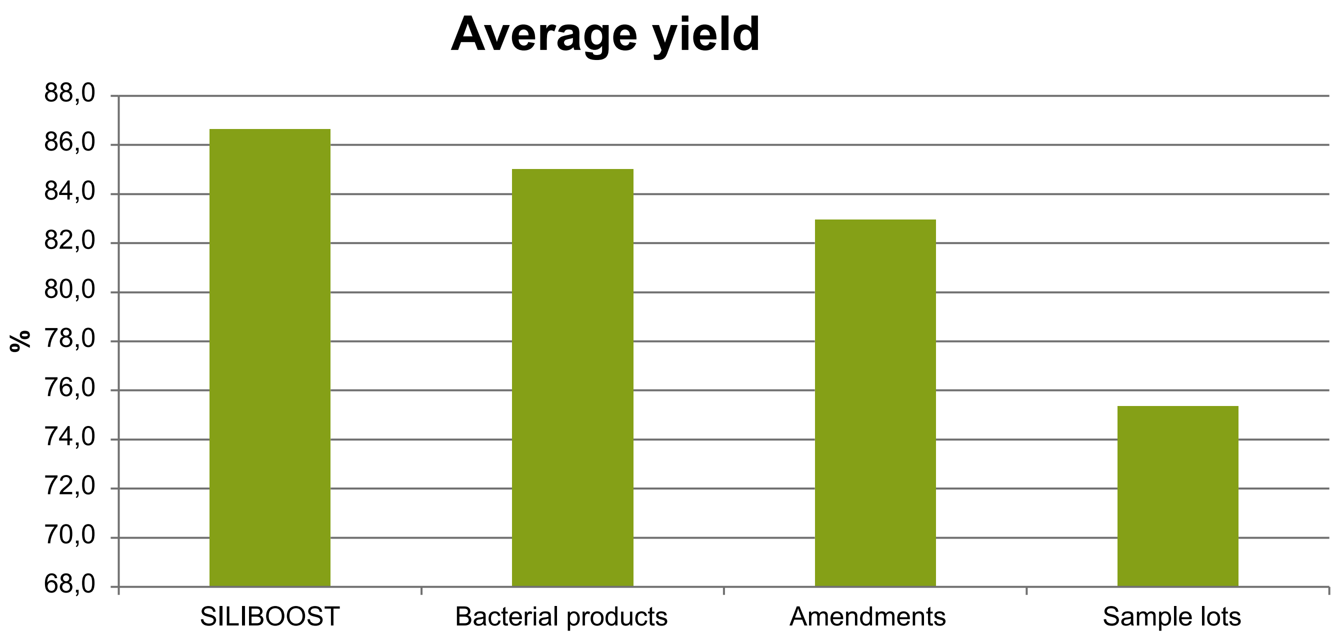
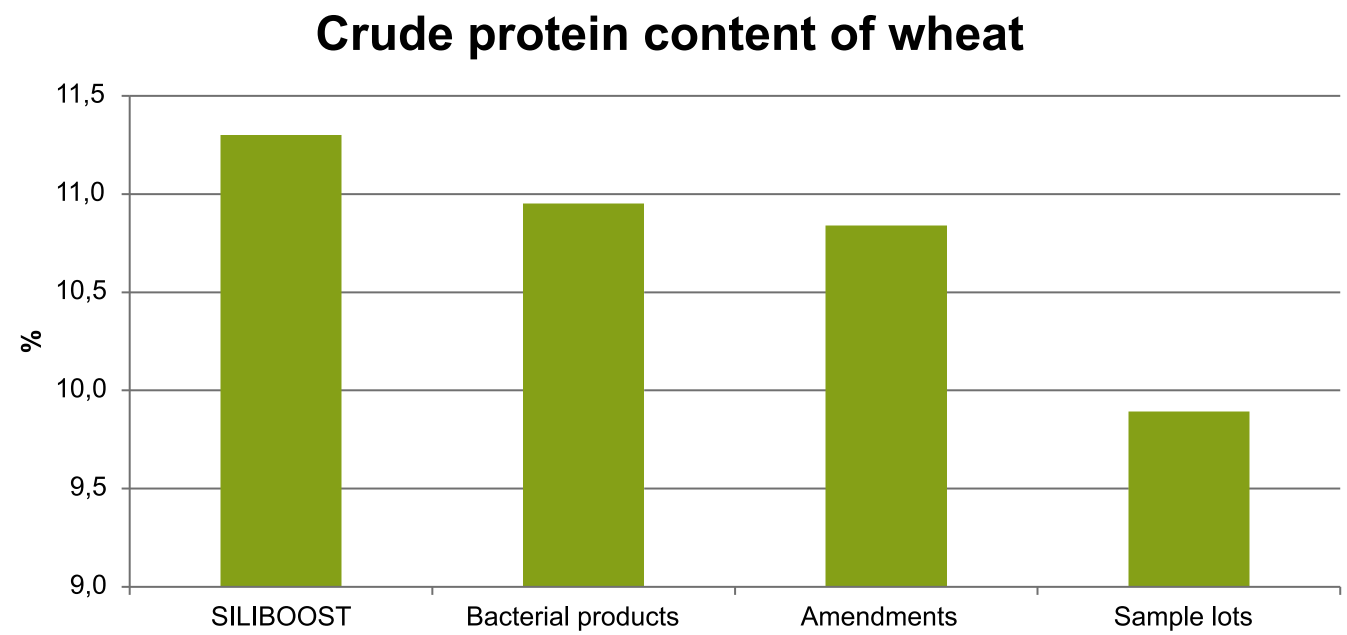
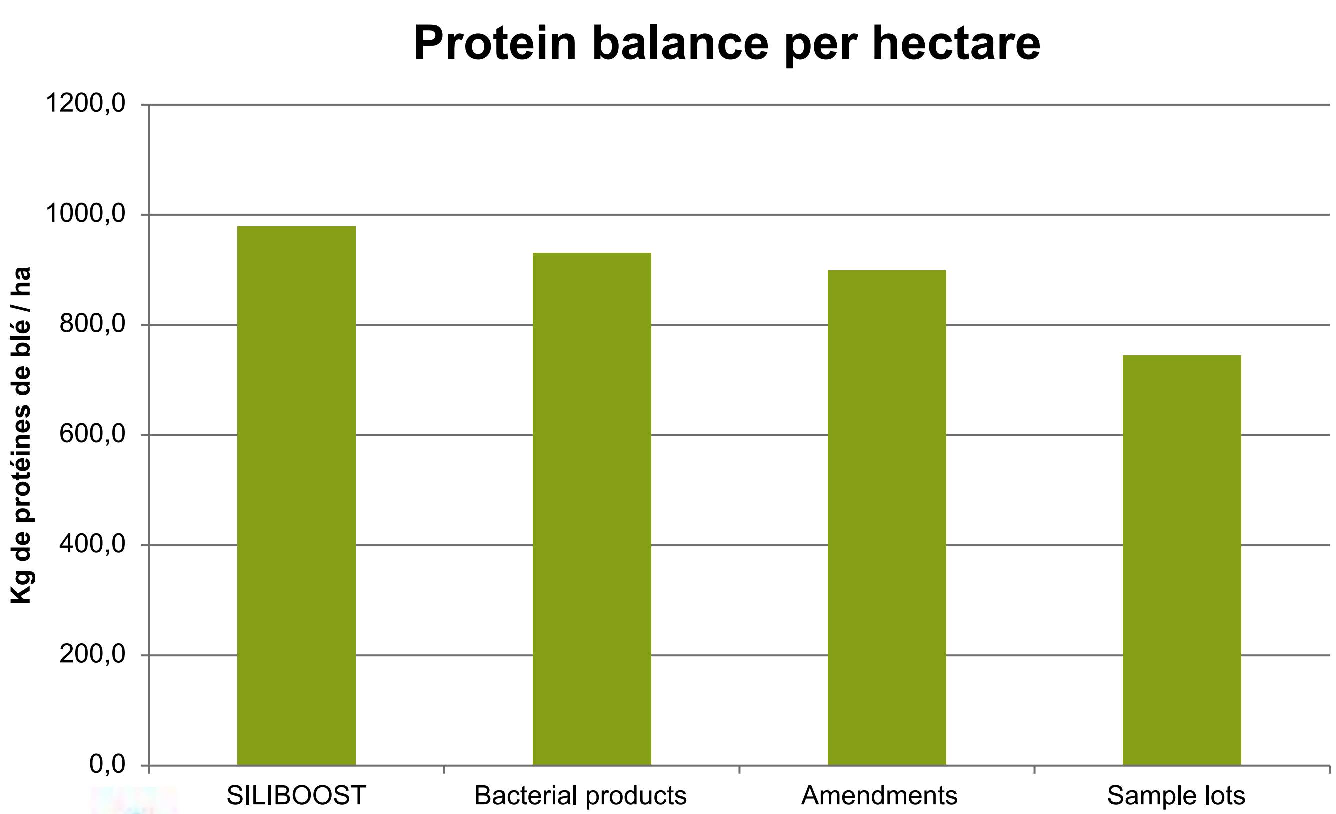
Essay on Wheat







- average return*: +8.2%
- +171.1 kg of protein/ha *
- Average increase in protein balance per hectare*: +21%

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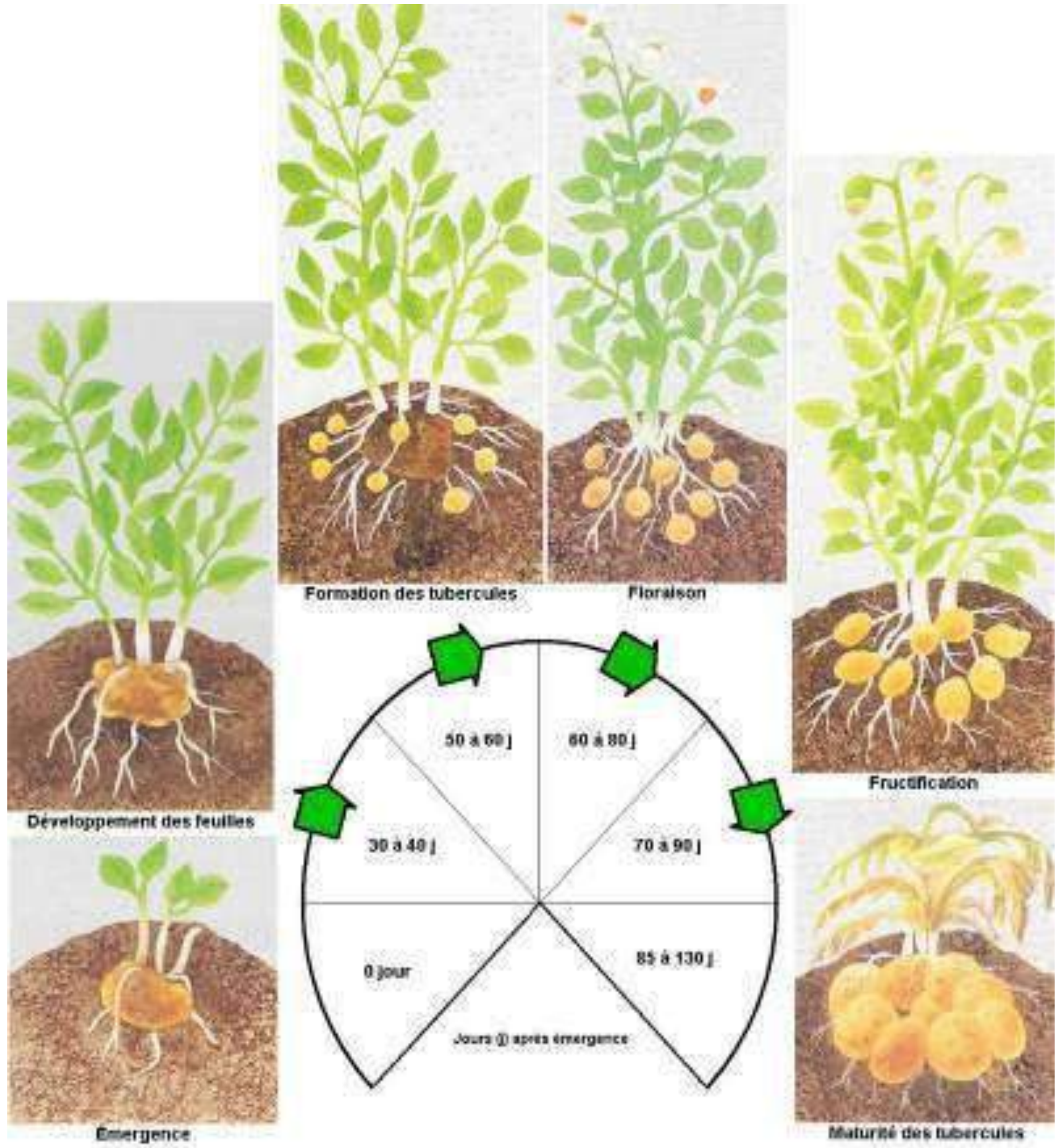
*compared to all batches: 2 bacterial products, 5 soil improvers, 11 conventional fertilisers

Essay on Potatoes

- Field trial

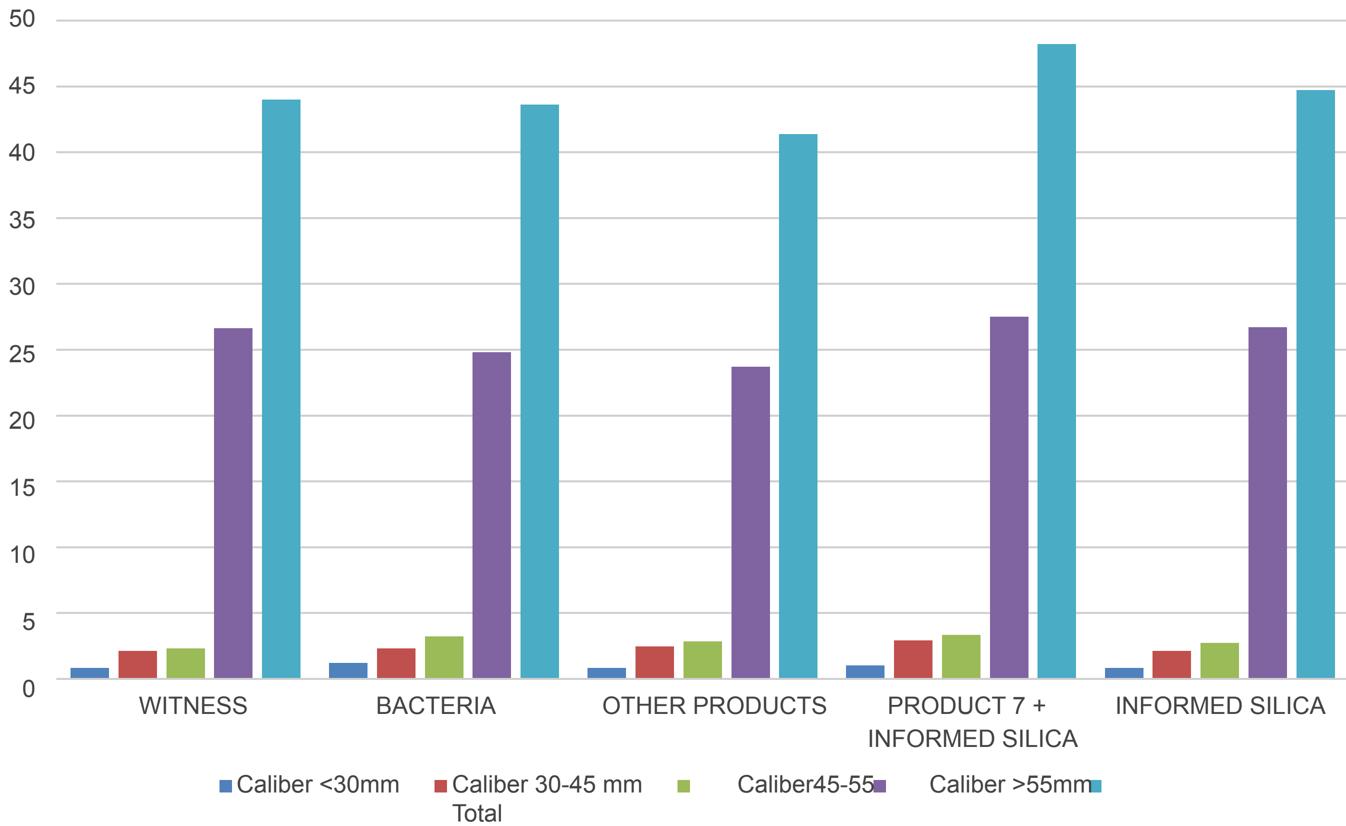
  - Study of the benefits of various foliar nutrition products and SILIBOOST

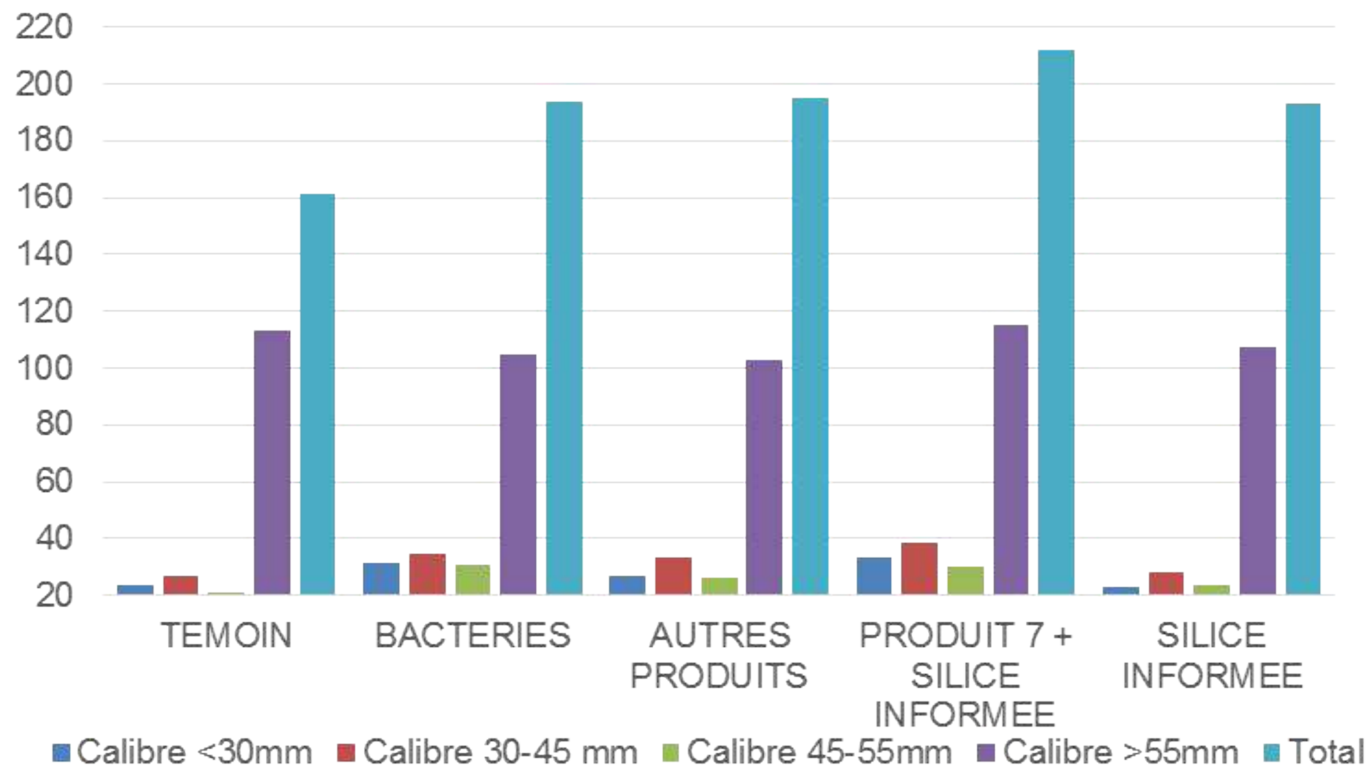
- SILIBOOST : Application of 250 g/ha at sowing. The application programme normally recommends two applications.



+31% with SILIBOOST + Product 7 combination

Increased yield





- Vs the Witness: +20% with SILIBOOST alone
  +31% with SILIBOOST + Product 7 combination

- Compared to other products: +9% with SILIBOOST alone
  +16% with SILIBOOST + Product 7 combination

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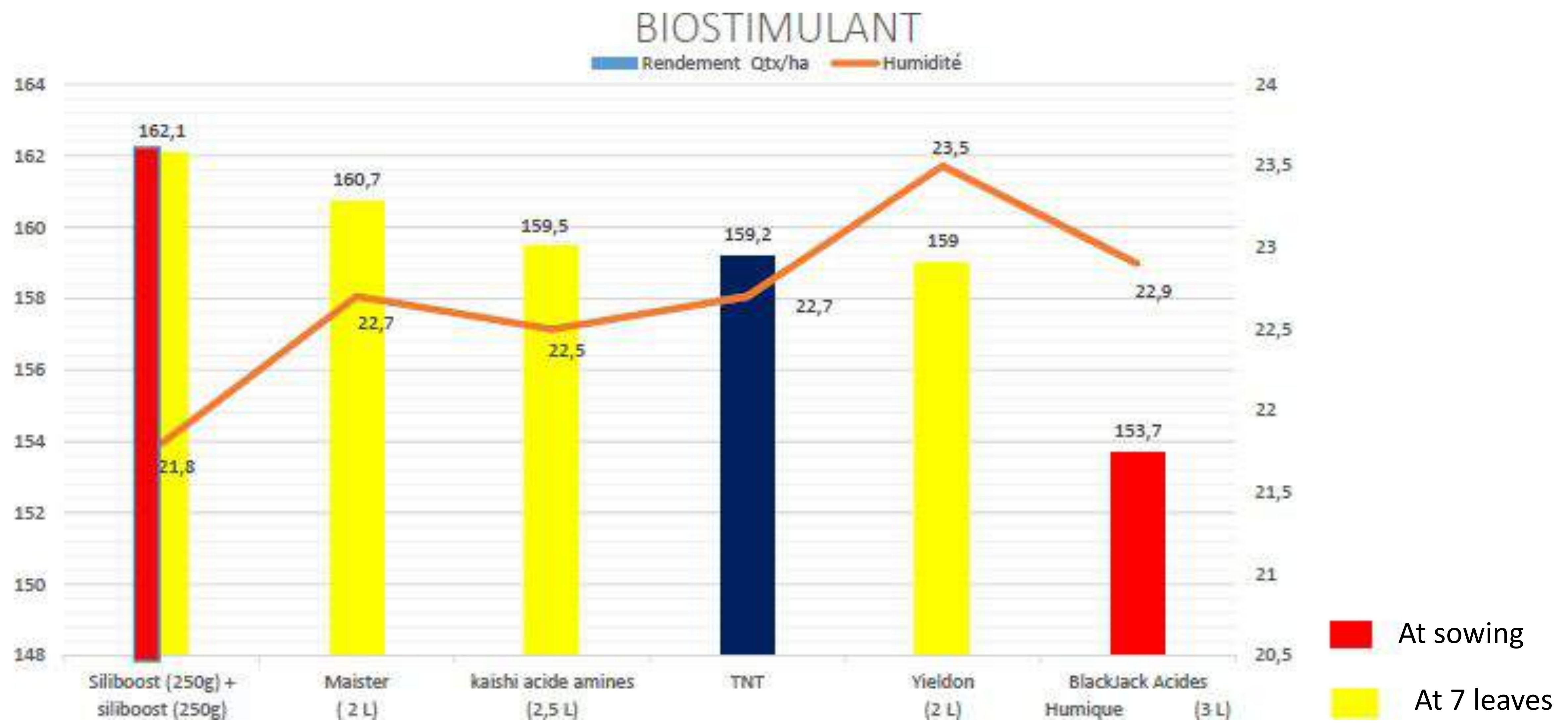
Another Essay on Corn

- Charentes Region Trial (Mansle)
- Siliboost applications at sowing and BBCH stage 16-18 at 250g/ha
- 2020 season (sowing on 15/04 and harvest on 09/10)
- Variety dkc 5141 at 88,000g/ha

T1: AU SEMIS												
MICRO-INSECTICIDE		EN LOCALISE		EN PLEIN				T2: BBCH 16-18				Classement
PRODUIT	DOSE	PRODUIT	DOSE			PRODUIT	DOSE	PRODUIT	DOSE	Humidité	Rendement	Statistique
		18/46+ AVAIL FERTISURE	150 KG							21,6	148,5	a
				SILLIBOOST	250 G			SILLIBOOST	250 G	21,8	144,2	a
		12-40+25 SO3+Zn	150 KG							21,6	143,1	a
		18/46	150 KG							21,5	141,4	a
DAXOL	12 KG	18/46	150 KG							21	139,8	a
		NERGETIC C PRO	150 KG							22,2	139,3	a
				BACTIPI	20 L					22,3	139,1	a
				14/48	150 L	73 CSP.6.18	0,75 L			22	138,5	a
				18/46	150 KG					21,7	136,5	a
								KAISHI	2 L	22,3	136,4	a
		14-30-0-15 Zn (HUMIPHOS)	150 KG							22,2	134,2	a
TRIKA XPERT	15 KG									21,8	133,9	a
				BACTIPI	50 L					21,9	133,5	a
				14/48	150 L					21,5	132,1	a
DAXOL	12 KG									22,1	130,8	a
SOLIEA PROTEO	10 KG									22,4	130,1	a
TEMOIN										22,3	129,0	a
										21,9	137,1	

Another Essay on Corn

- Charentes Region Trial (Mansle)
- Siliboost applications at sowing and at the 7-leaf stage at 250g/ha



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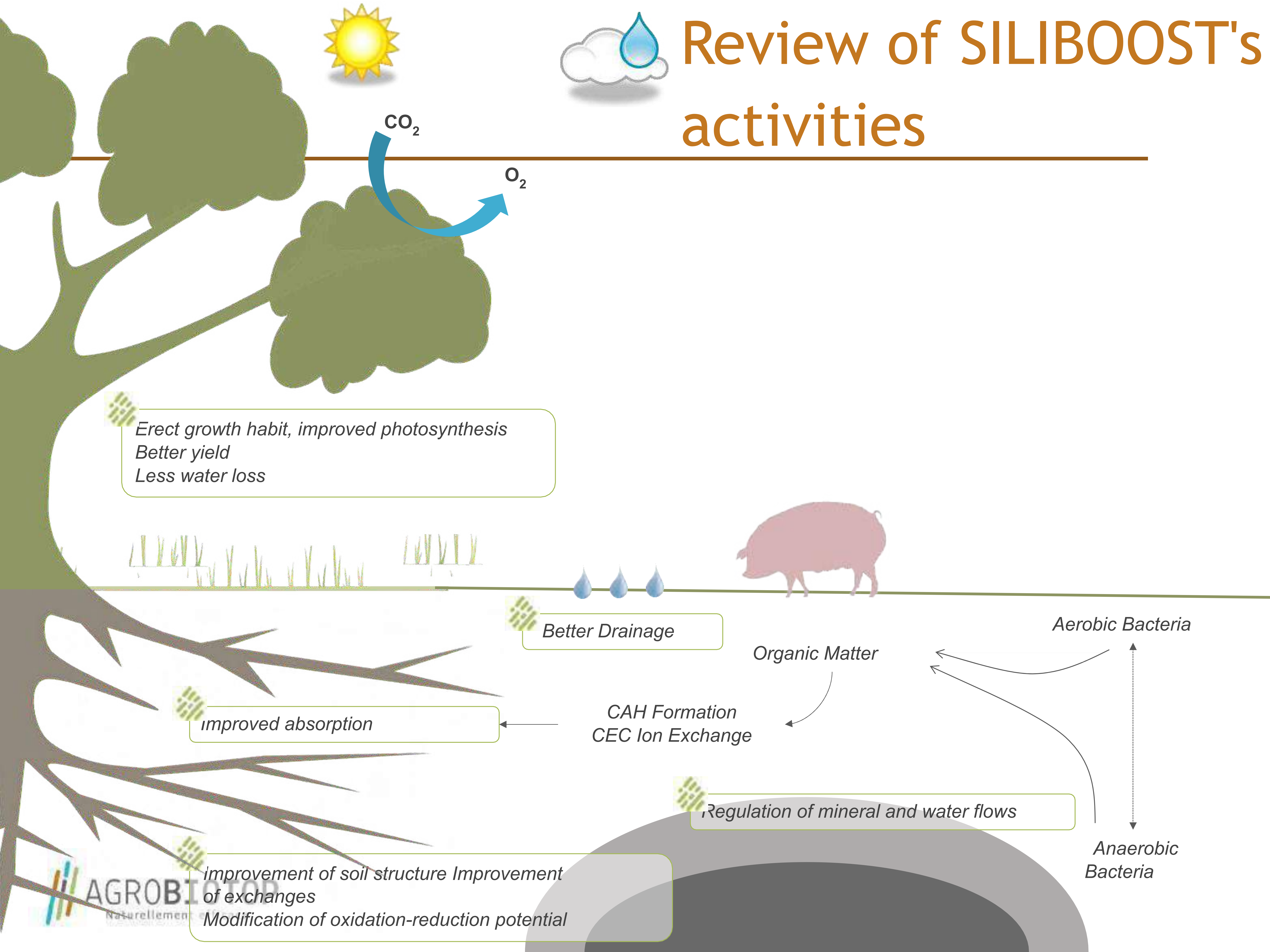
SILIBOOST Action Review

Review of SILIBOOST's activities

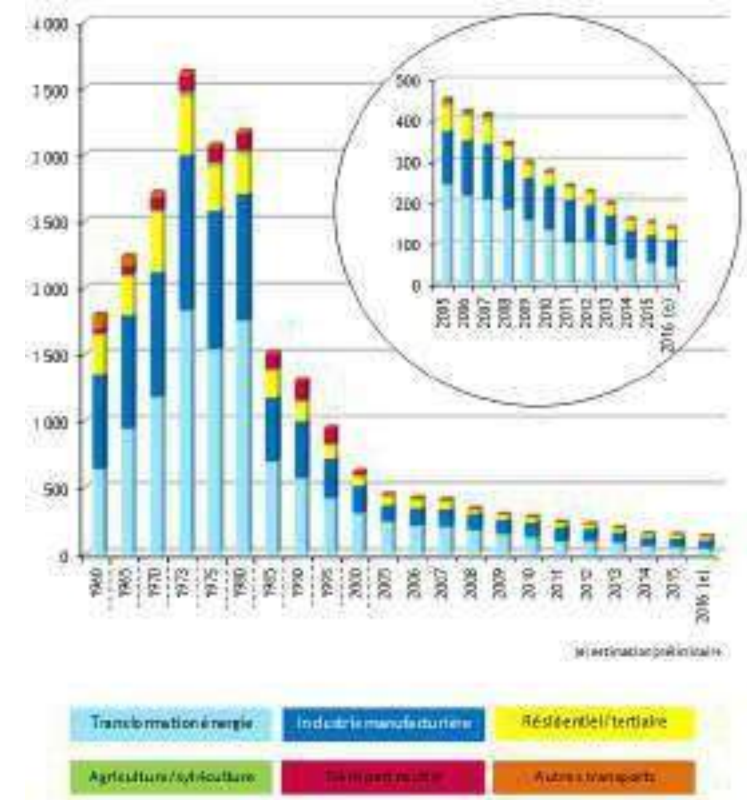


SOUFREL

The issue of sulphur in today's agricultural world

- Replacement of sulphur-containing fertilisers with high-dose NPK fertilisers that no longer contain sulphur
  - Superphosphate, ammonium sulphate replaced by urea, triple superphosphate, ammonium nitrate and ammonium phosphates
- Environmental measures to improve air quality

  Reduction in atmospheric fallout of Sulphur



Atmospheric emissions of SO2 by sector in mainland France in kt

- Increased crop yields and quality
  - Increase in exports and sulphur requirements for crops

⇒ S deficiency since the 1980s

⇒ Regain d'intérêt pour le Soufre en fertilisation

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Source: CITEPA / Format: SECTEN – April 2017

Sulphur in the soil

Sulphur element in the soil

- Sulphur content of soil
  - 20 to 2000 mg S/kg (European soils) *– Freney et Williams, 1983*

- Forms of sulphur in the soil
  - S mineral
    - Function of redox potential:
      - Hydrogen sulphide H_2S or S^{2-}
      - Elemental sulphur S
      - Thiosulphate $S_2O_3^{2-}$
      - Sulphite H_2SO_3 ou SO_3^{2-}
      - Sulphate SO_4^{2-}
  - Organic S (amino acids, proteins)
    - 60 to 95% of S
    - Humus, crop residues, microbial biomass

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Roles of sulphur in soil

- Contains humic substances and CAH

- Enriches the soil with organic matter

  Soil fertility

- C/N/S ratio in the soil = 100/10/1

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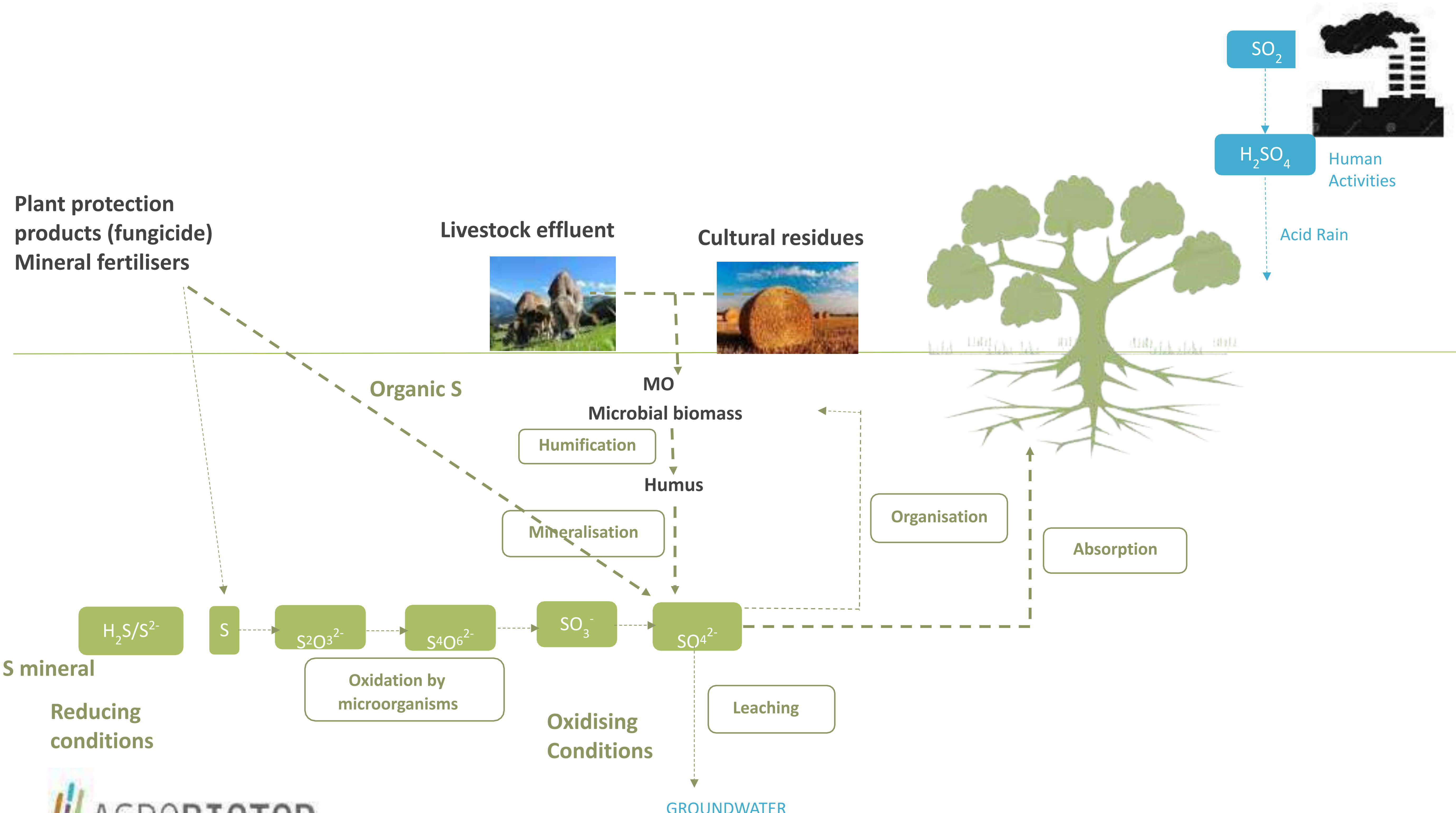
Sulphur cycle in agriculture



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Sulphur in plants

Sulphur in plants

- Sulphur content in plants
  - 0,1 – 0,5%
  - Ranked quantitatively in plants just after N, P, K

- S absorption by plants
  - Only in the form of sulphates SO_4^{2-}

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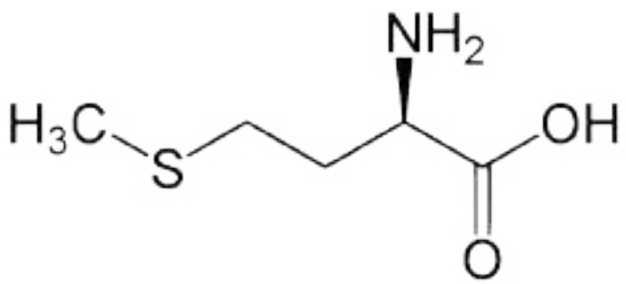
Roles of sulphur for plants

- Synthèse des protéines (constituant des Acides Aminés Soufrés)
  - Methionine
  - Cystine
  - Methionine



Methionine

- Chlorophyll formation
  - Therefore essential for photosynthesis

- Enzyme and vitamin formation (biotin, thiamine, glutathione)

- Activation of enzymes involved in the metabolic processes of fatty acid energy

- Formation of nodules in legumes

- Involved in plant protection mechanisms
  - Present in glucosinolates and alliin
  - Volatile sulphur compounds emitted by leaves with fungicidal effects

Crop sulphur requirements

Requirements	Crops	Elemental S requirements in kg/ha	Equivalent in kg SO3/ha
Strong	Rapeseed, cabbage, mustard, garlic, onion, alfalfa, clover, forage grasses	40 to 80	200 to 100
Medium to Strong	Orchard Vineyard	40	80
Medium	Straw cereals, maize, potatoes, sugar beet and fodder beet	20 to 40	100 to 50
Low	All others	8 to 20	50 to 20

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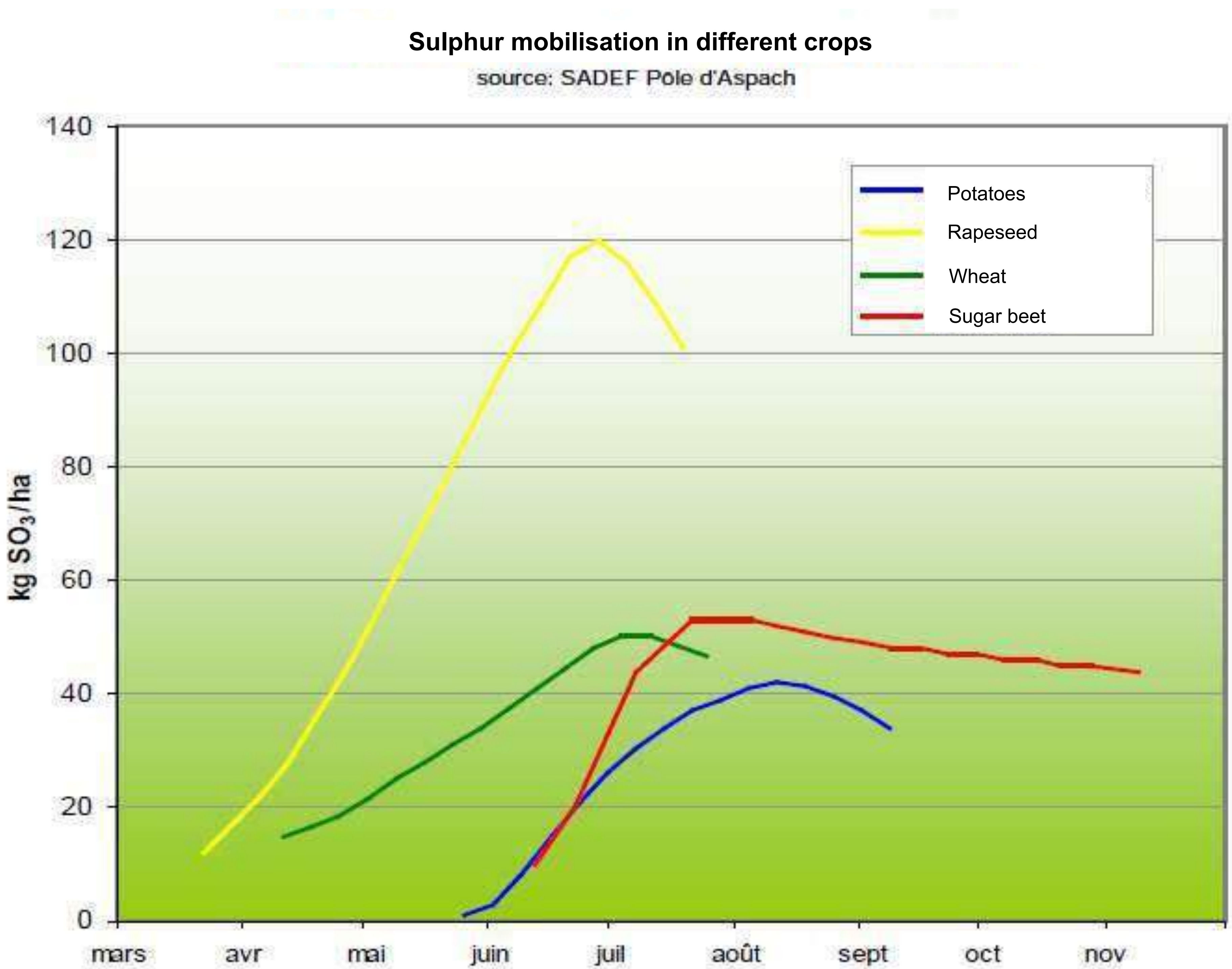
Source : COMIFER

Sulphur mobilisation in crops



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Source : COMIFER

Types of sulphur fertilisers

The main forms of sulphur on the market

- K sulphates, Mg sulphates
- Single superphosphates

- Sulphur-based nitrogen fertilisers
  - Sulphated ammonium nitrate
  - Ammonium sulphates

- Ammonium sulphates
  - Slow assimilation

- Manure
  - 1 to 3 kg/tonne of sulphur depending on the animal origin of the manure
  - Slow assimilation

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Soufrel : elementary S
interest and use

Benefits of sulphur supplementation Elementary

- Sulphate
  - Directly assimilable by plant roots
  - Highly leachable in soils
  - Groundwater pollution, especially in conditions of heavy rainfall
  - Sulphate fertiliser application:

    More than 50% of sulphate-form S application is organised (converted by microorganisms into organic S) within 1 week

- Elemental sulphur
  - Requires oxidation by soil microorganisms
  - Slower action than sulphates
  - Acidifying effect optimising root pH

  Sulphur (S) + Oxygen (2/3 O_2) + Water (H_2O) > (microorganisms) > H_2SO_4

   Long-term sulphur fertilisation strategy

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Use of Soufrel

- Use between 20 and 60 kg/ha at sowing (localised or otherwise)
- To be mixed in the seed drill hopper, micro-granulator or fertiliser distributor
- Product presentation and packaging:

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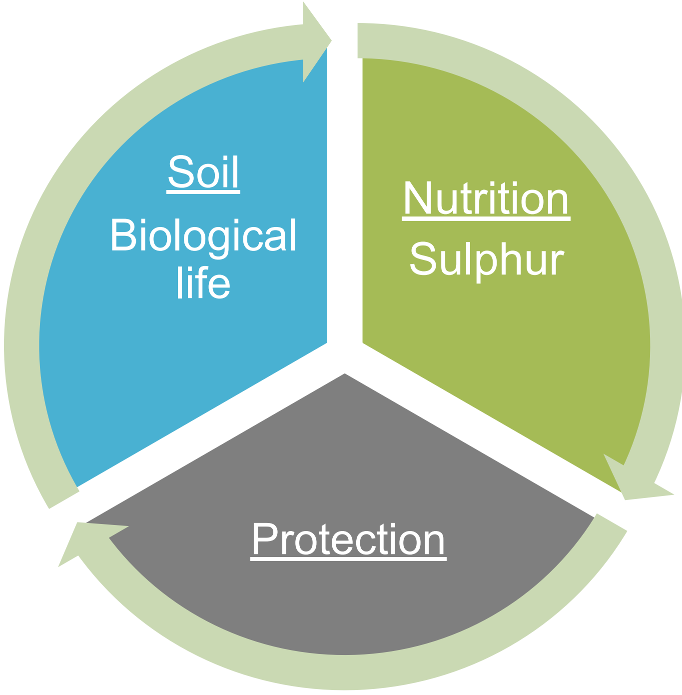
The synergy between Soufrel and Siliboost

- SILIBOOST : enhances the effect of SOUFREL
  - Stimulates biological activity in the soil
    - Stimulates bacteria that convert elemental sulphur into sulphate that can be absorbed by plants



And other complementary products...

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FUNDAMENTAL AGRONOMIC PRINCIPLES OF SOIL FUNCTIONING

Ideal Soil Objective

25% air / 25% water

- Biological Activity

<u>To achieve this objective:</u>

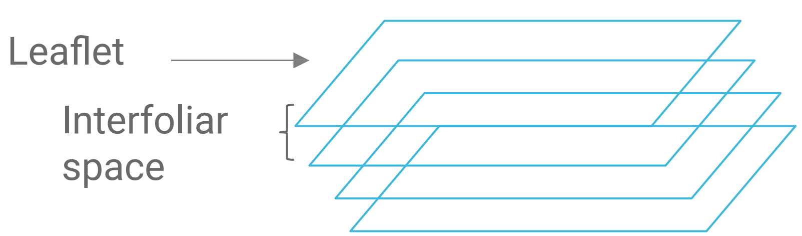
Quality of habitat for microorganisms

1st lever

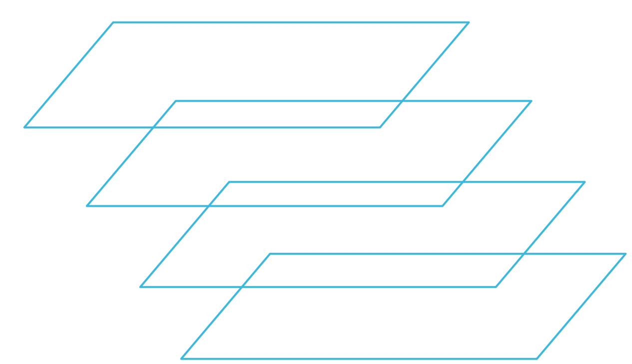
- **Minerals and balance (distribution) of cations on CEC**

Controlling the behaviour of clays

Cohesive effect



Loose effect



Ideal proportions of cations in CEC: 68% Ca^{2+}, 12% Mg^{2+}, 4% K^{+}, 1.5% Na^{+}, 10% H^{+}

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Based on the work of William Albrecht

The Ca/Mg ratio in the CEC

Ideal :
68:12

$\frac{Ca}{Mg}$

Flexibility / Ventilation

'Sticky' / Retains water

$\frac{Ca}{Mg}$

Porosity

Retained water

$\frac{Ca}{Mg}$

Porosity

Retained water

- **To be adjusted according to the CEC (soil type) while maintaining Ca^{2+} + Mg^{2+} = 80% of the CEC:**

Light soils

Clay soils

CEC (meq/100g)	<5,4	8,31 - 19	>45,01
Ratio %Ca/%Mg	60/20	68/12	70/10

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Based on the work of William Albrecht

Soil analysis

Analyse de terre

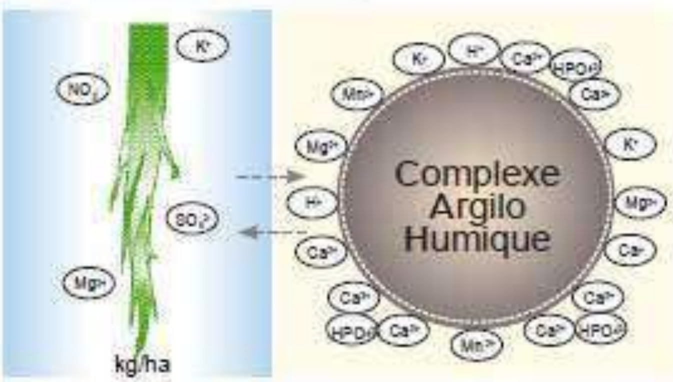
AGRI ANALYSE

ANALYSE RÉALISÉE POUR :
LEROUX DIDIER
10 RUE RIMBERTOT
76930 CAUVILLE
N° échantillon: 26573732

DISTRIBUTEUR :
ETS DUMESNIL
1 BIS ROUTE DE ROUMARE
76150 SAINT JEAN DU CARDONNAY

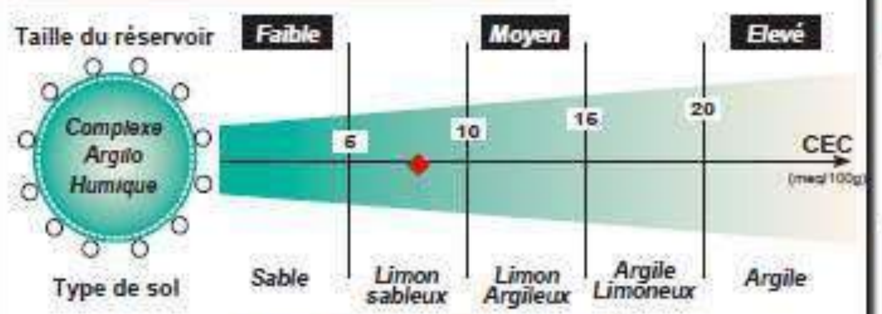
Parcelle : COLZA (7.5ha)
N° échantillon : 26573732 N° îlot :
Reçu le : 12/11/2021 Expédié le : 25/11/2021
Technicien : Régis CHAMPION

Equilibre chimique



L'**équilibre chimique** permet de vérifier si les proportions d'éléments nutritifs (% Ca^{2+}, % K^{+}, % Mg^{2+}) sont optimum sur le complexe argilo-humique (voir tableau ci-contre).

Capacité d'Échange en Cations (CEC)



CEC = 8.4 meq/100g

EQUILIBRE CHIMIQUE		H^+	Ca^{++}	K^+	Mg^{++}	Na^+	Taux de saturation
Répartition des cations en % de la CEC	Actuelle	0	91.7	4.5	4.1	1	>100
	Optimum	0 à 5	90.6	4.3	5.1	<=5	

MO et activité biologique

Azote Total (%): 0.12

	Résultats	Valeur souhaitable	Faible	Moyen	Elevé
MO %	2.3	2.3			
IAB	15 / 20	> 15/20			
C/N	11.1	8 à 10			

Le taux de matière organique est satisfaisant (%MO = 2.3). Veillez à maintenir ce capital organique afin de préserver les propriétés physiques du sol (stabilité structurale, réserve en eau...).

La CEC correspond à la taille du complexe argilo-humique, réservoir en éléments nutritifs du sol. Elle est déterminée par la teneur et la qualité des argiles et de la matière organique.
Le **taux de saturation** correspond au niveau de remplissage de la CEC.
Il est obtenu en faisant la différence "100 - % H^+".
H^+ (taux d'hydrogène) représente l'acidité de réserve (en sol acide).
En sol alcalin, le taux de saturation est généralement supérieur à 100 %.

Analyse chimique

(1) exprimés en ppm pour tous les éléments nutritifs

	Résultats (1)	Normes (2)	très faible	faible	un peu faible	moyen	élevé	très élevé	excessif
BILAN ACIDE BASE									
pH eau	7.2								
pHKcl	6.3								
Calcaire total (%)	0.1								
Calcium (CaO)	2157	2130							
ÉLÉMENTS MAJEURS									
Phosphore (P_2O_5 Joret Hébert)	55	50 / 80							
Phosphore (P_2O_5 Olsen)									
Potasse (K_2O)	175	170 / 250							
Magnésie (MgO)	69	85 / 125							
Sodium (Na_2O)	25	<130							
OLIGO-ÉLÉMENTS									
Zinc (Zn)	1.9	3.5							
Manganèse (Mn)	56	14							
Cuivre (Cu)	1.9	1.8							
Fer (Fe)	79.5	10.8							
Bore (B)	0.22	0.4							

Assimilabilité des réserves :
- faible (risque de blocage élevé)
- moyenne (risque de blocage moyen)
- élevée (risque de blocage faible)

	Assimilabilité	Facteur de blocage
P	élevée	/
K	élevée	/
Mg	élevée	/

	Assimilabilité	Facteur de blocage
Zn	élevée	/
Mn	élevée	/
Cu	élevée	/
Fe	élevée	/
B	élevée	/

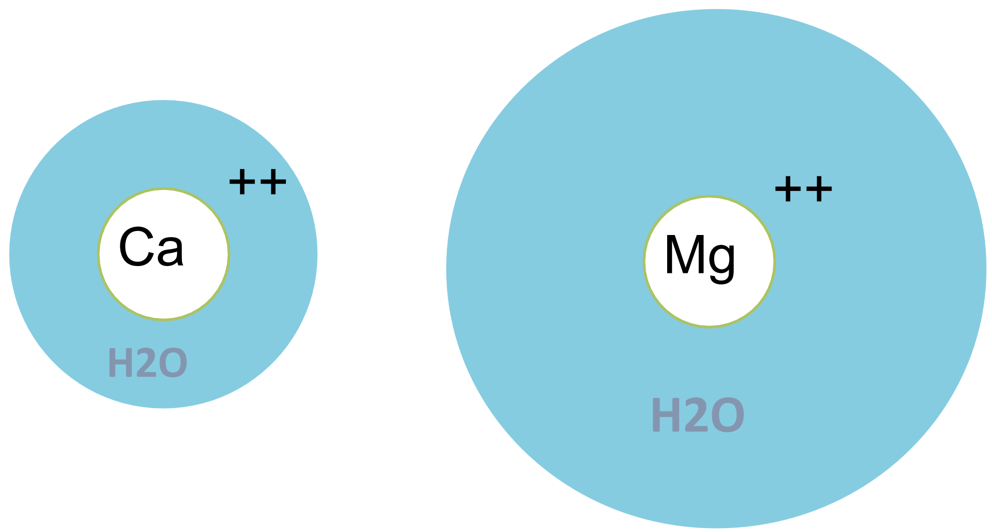
Bilan acide base :

Le pH ainsi que la teneur en CaO sont satisfaisants. Le statut acido-basique du sol est donc optimum.

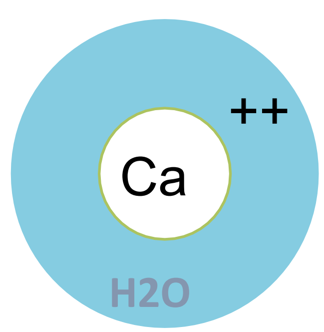
Ratios d'équilibre

	Résultats	Valeur souhaitable	Trop faible	Normal	Trop élevé
K_2O/MgO	2.5	2			
CaO/MgO	31.3	25.1			
Cu/MO	0.83	0.80			
P_2O_5/Zn	28.8	14.3		Non significatif	

Why Ca^{2+} and Mg^{2+}? And what is the difference between the two?



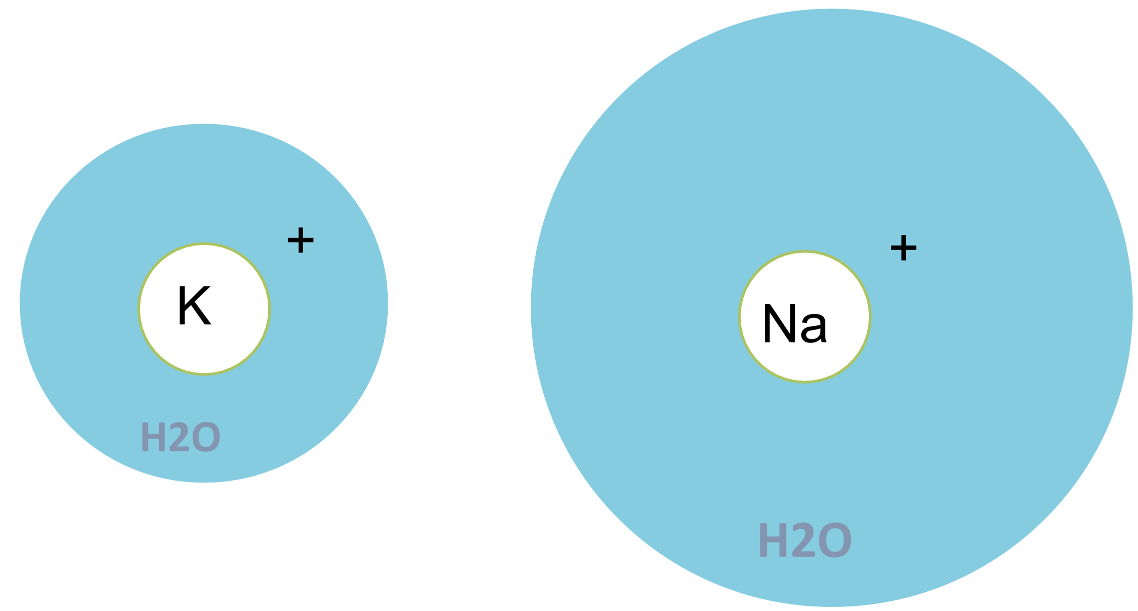
- **Divalent cations = 2 charges +**
  = flocculation / binds humus and clay together
  = structuring role for the soil



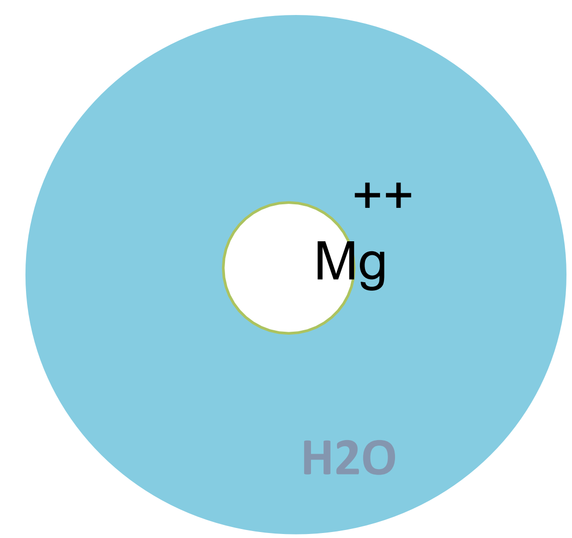
- **Thin layer of water when hydrated**

= low water retention capacity

= reserves maximum space for air in the soil



- **Monovalent cations = 1 charge +**
  = dispersants



- **Significant water layer when hydrated**
  = capacity to store water

BUT if excessive: compaction, hydromorphism

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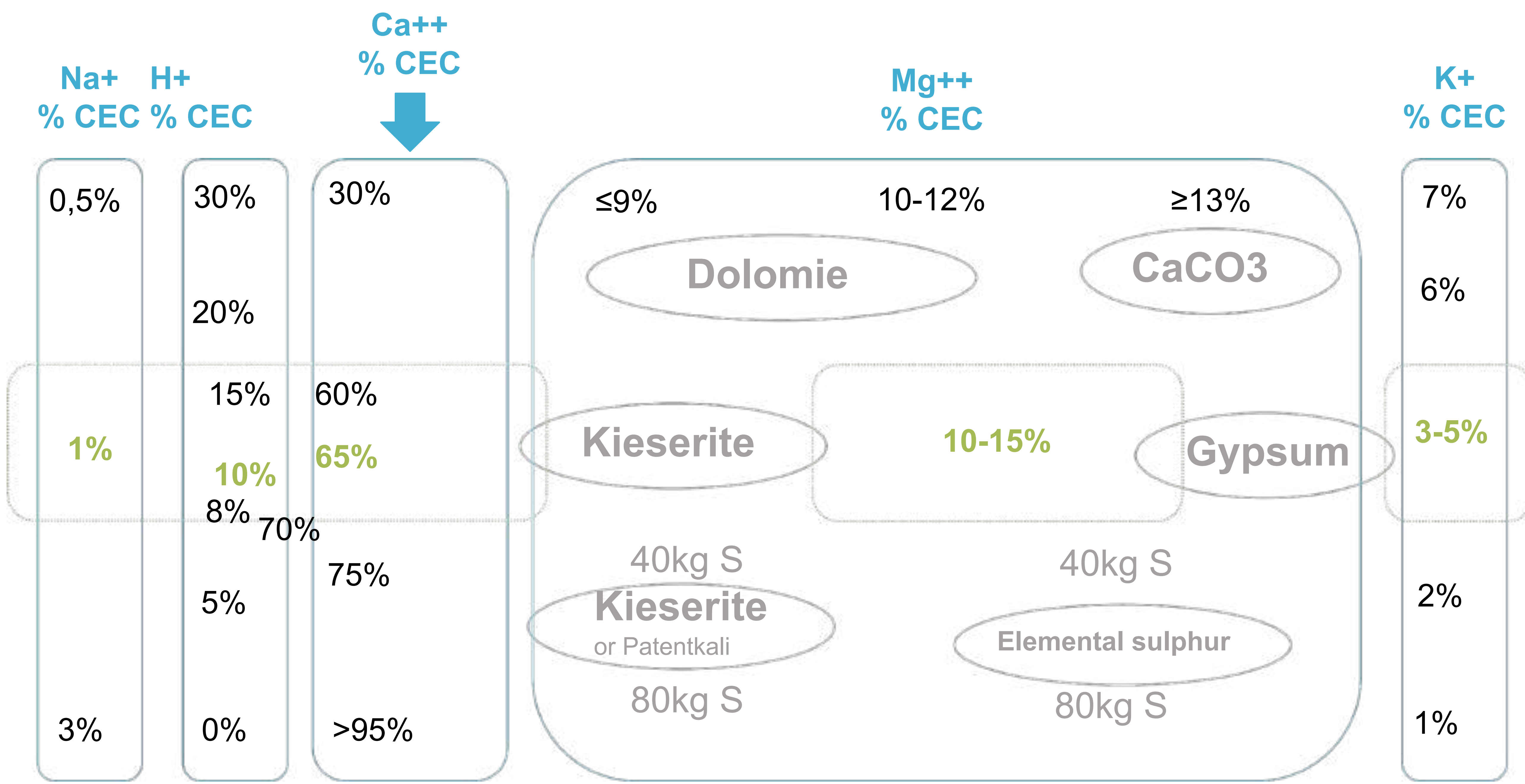
Management of calcium amendments based on the distribution of cations in the soil's CEC



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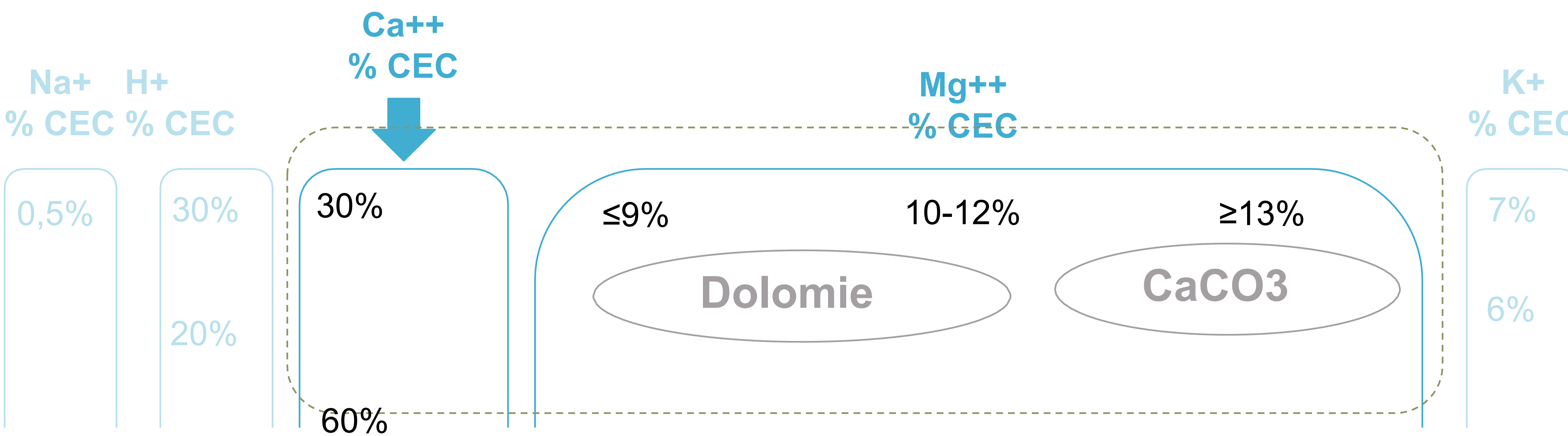
According to the work of William Albrecht

In case of Ca deficiency



- Dolomie : if CEC deficient in Ca and Mg
- Calcium carbonate: if CEC deficient only in Ca
- Gypsum: only when CEC saturation in Ca exceeds 60%
- Lime: not to be used

3% 0% >95%

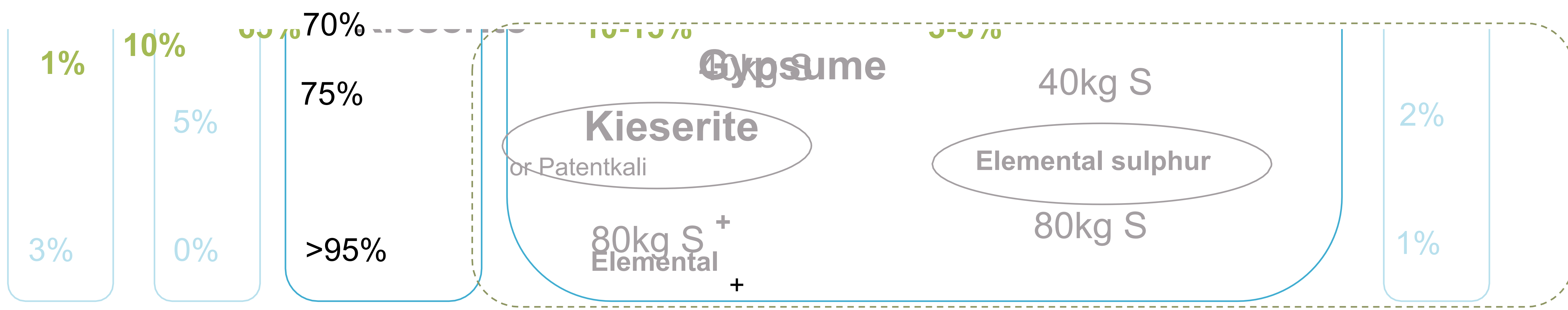
In case of excess Ca

- Method for neutralising excess calcium
  - Mineral chemical method
    - Potassium nitrate: if Mg and K are needed simultaneously
    - Kieserite: if Mg is needed
    - In addition: Elemental sulphur:

Interest of Soufrel

S → SO_2 → SO_3 → SO_4 (sulfobacteria) + Ca^{++} = $CaSO_4$

Soluble salt, stable, no influence on pH, bioavailable, no interference with trace elements



- Biological pathway – soil fungi

Mushrooms → Oxalic acid + Ca^{++} = Calcium oxalate

Insoluble salt, stable, no effect on pH, bioavailable

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SILIBOOST Action Supplement

- On the mushroom/bacteria ratio:
    Promotes the formation of calcium oxalate to neutralise excess calcium
- On the action of sulphobacteria transforming S into SO4:
    - Promotes the formation of calcium sulphate to neutralise excess calcium
- Reduces surface acidity that can be caused in TCS or semi-direct by the addition of S
- Regulates mineral flows
    - Reduces the absorption of excess P, Mg and Ca
- Increases the availability of soil minerals through exchange at the CAH level
- Complementary effect on soil structure
    - Promotes soil aeration
- Regulation of soil pH and redox potential

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Loss of N efficiency and antagonisms

- Impact of excess Mg on CEC on the loss of N efficiency

Excess/ideal Mg calculated (Mg/CEC)	Additional N consumption for the same yield
Mg/CEC +1	+18%
Mg/CEC +3	+35%
Mg/CEC +5	+45%

- Heavy soil with Mg/CEC>18%: the amount of N required will be 50% higher

- N interactions:
  - Excess N = poor assimilation of Cu, Mn, K, Zn, Ca

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Other examples of interactions between nutrients

- P interactions
  - Role of mycorrhizae in P absorption
    Antagonism with Na: possible P deficiency when Na/CEC >5%
  - Zinc-phosphorus antagonism: very strong
    - Zn:P ratio not to be exceeded: 1:25 (P Dyer) or 1:10 (P Olsen) (Zn<50ppm)

- K interactions
  - Above 5% K/CEC (annual crops) and 7% K/CEC (perennial plants, fruit trees, vines): competition for Ca and Mg absorption
  - Importance of K/Ca antagonism for plants that havequalitative requirements in terms of appearance, preservation and taste

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And now…

- … Interpret your soil analyses according to these principles, rather than solely based on plant requirements
- … Apply the necessary nutrients to the soil, not to the plants

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