Plant available silicon in bare fallow soils after 90 years of annual supplies of manure, lime and fertilizers

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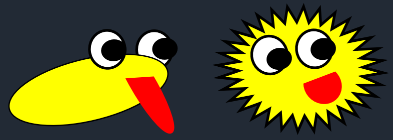
Introduction: The role of silicon in soil-plant systems

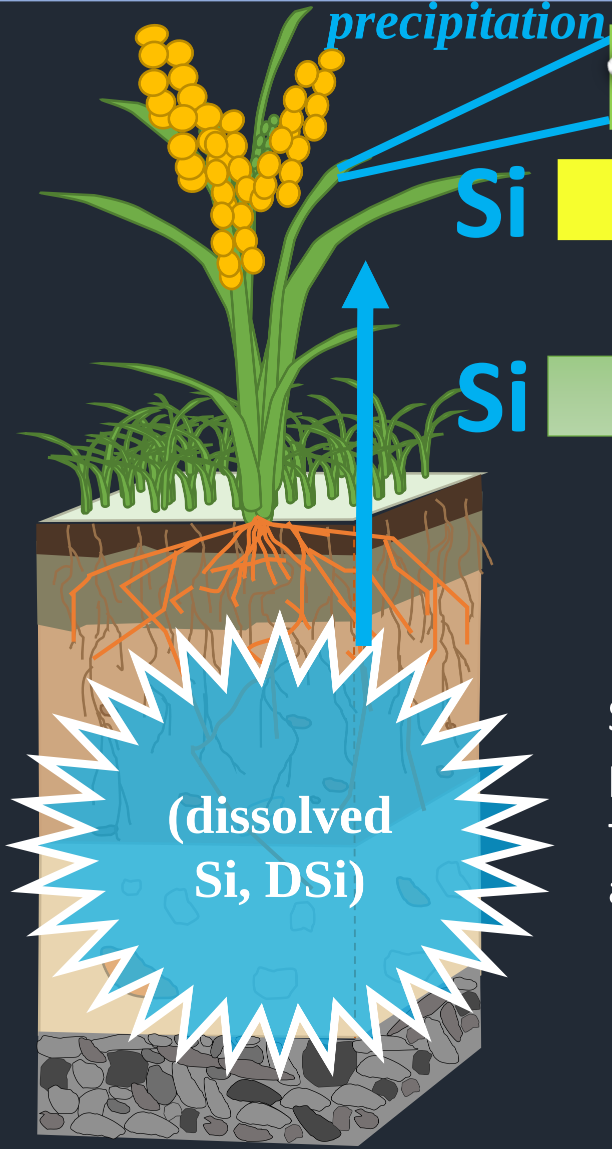


resistance to pests and diseases → Si

alleviates drought and salt stress → Si

coprecipitates with heavy metals (Zn, Cd, Mn, Al, As…) → Si

…decreasing toxicity



Si → **Increases crop biomass and grain yield**

Si → **Promotes photosynthesis and OC storage**

Silicon (Si), non-essential but beneficial to plants, plays a crucial role in maintaining plant functions by alleviating a number of biotic and abiotic stresses.

Applying manure, lime and chemical fertilizers to soils may impact the pool of plant available Si, but their impact over decades to century is unknown.

INRA 42-plot design (Versailles, France)

A silty soil derived from Quaternary loess (Haplic Luvisol), submitted to a long-term bare fallow experiment initiated in 1928 in Versailles (INRA, France).

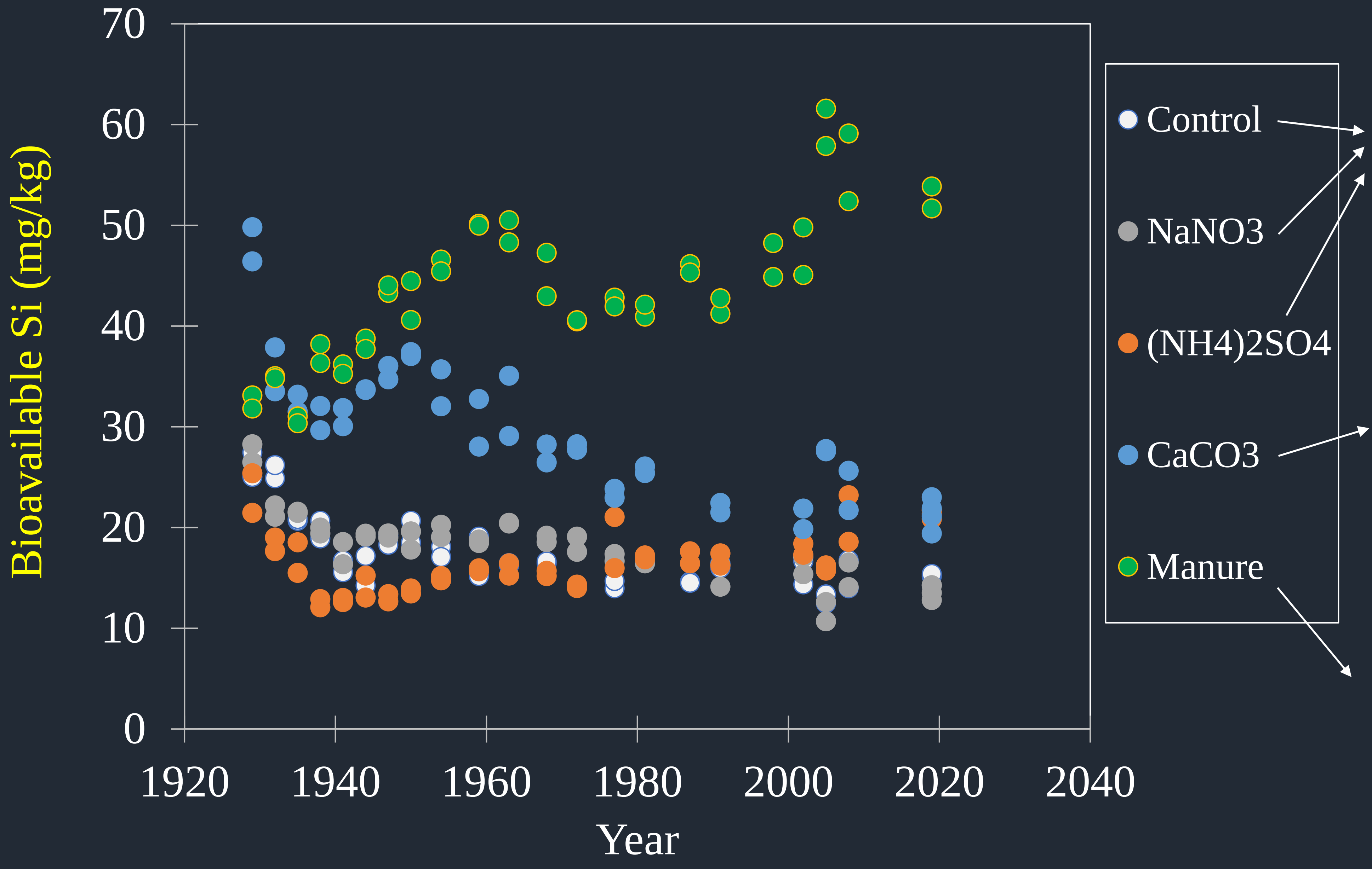
On this bare fallow soil, different treatments were applied annually since 1929, among which, manure, lime ($CaCO_3$), $NaNO_3$ and $(NH_4)_2SO_4$) and compared to control soil.

INRA 42-plot design (Versailles, France)

Photo from Pr. F Van Oort

- Archived soil samples for the period 1929-2019.
- Basic properties: pH, CEC, OC, particle size, TRB (Total Reserve in Bases)… are known.
- We assessed bioavailable Si using 0.01 M $CaCl_2$.

Results and Discussion (bioavailable Si)

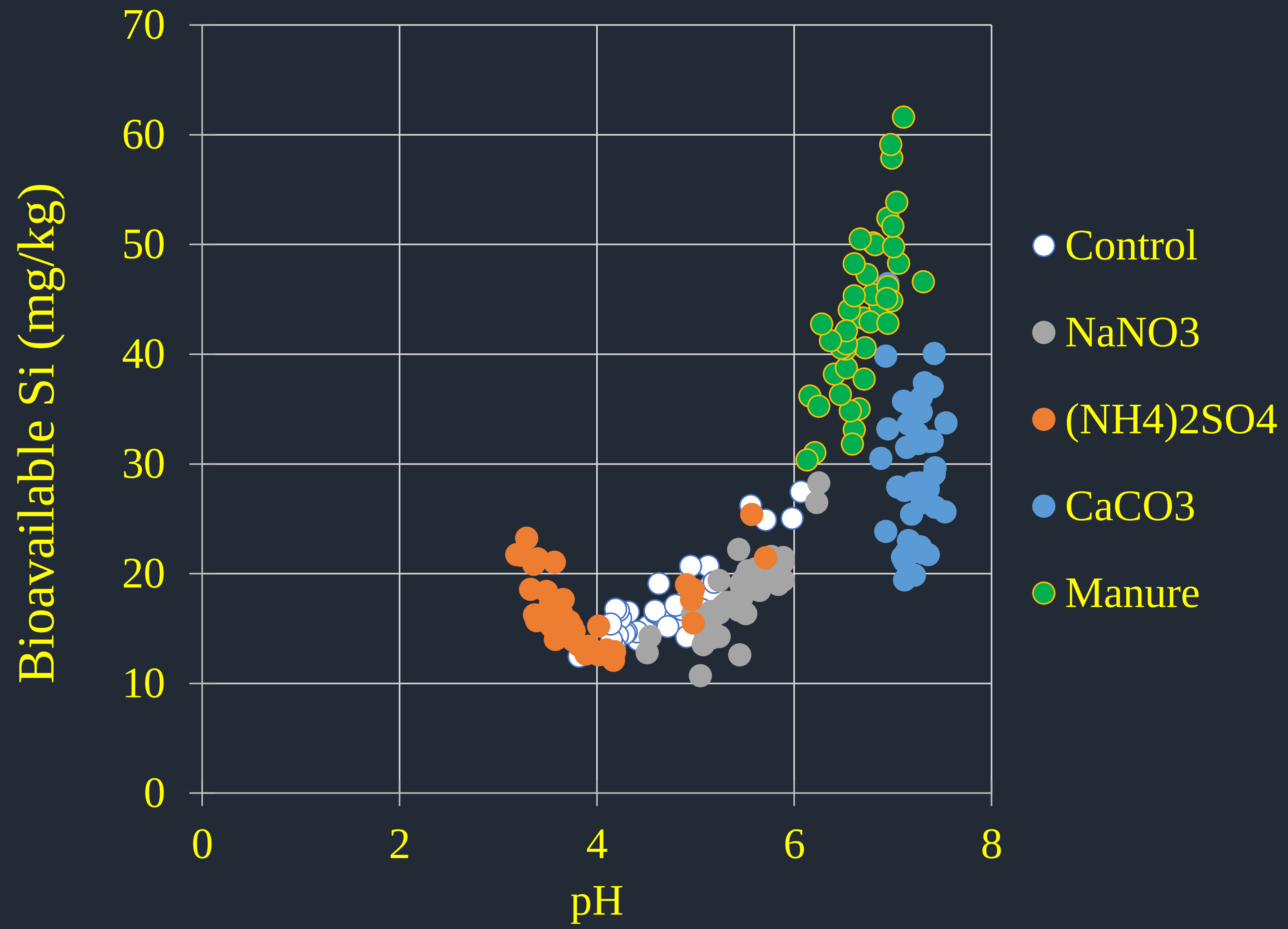


Natural (control, $NaNO_3$) and accelerated net acidification ($(NH_4)_2SO_4$) led to 2-fold decrease in $CaCl_2$-Si from 1929 (25 mg kg^{-1}) to 1941 (13mg kg^{-1}).

Liming induced a sharp decrease in $CaCl_2$-Si from 1929 (50 mg kg^{-1}) to 1941 (30 mg kg^{-1}), followed by an increase from 1941 to 1950, and a further decrease from 1950 to 2019.

Manure application induces a global increase in bioavailable Si from 1929 (32 mg kg^{-1}) to 2019 (54mg kg^{-1}).

Results and Discussion (a significant factor: pH)



In this bare silty soil, Si bioavailability is strongly pH-dependent.

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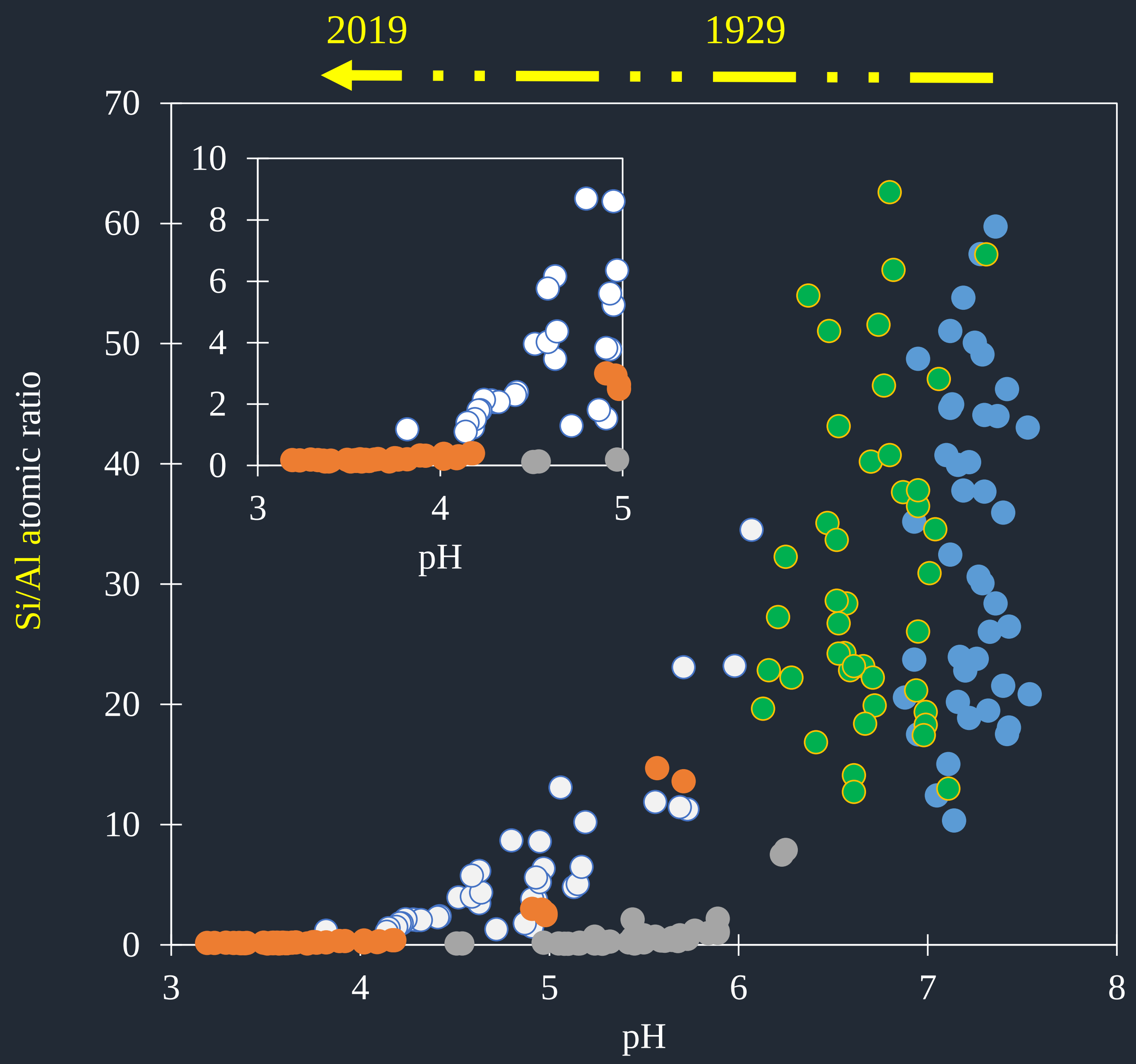

The natural net acidification –control – induces a pH shift from 6 to 3.9 and an increase in aqueous Al

(sharp decrease in Si/Al ratio, from 34 to 1.2).

Accelerated net acidification –$(NH_4)_2SO_4$– enhances this process:
pH decreases from 5.7 to 3.2
(Si/Al decreases from 14 to 0.16) .

In this bare silty soil, $CaCl_2$-extractable Si is likely controlled by the dissolution of clay minerals at pH<4.6 and of silica at pH>6.

Conclusions

The INRA experimental site is remarkable to the study the long term effect of management practices on Si bioavailability in soil and its controlling factors.

Our preliminary results show that in a given soil type, the pool of bioavailable silicon is strongly affected by soil pH and soil components.

Our preliminary data further suggest that the concentration of bioavailable Si might be controlled by phytoliths at pH>6. The stock of phytoliths, however, likely decreases over time in the absence of biomass restitution.

Natural and accelerated net acidification increase the pool of bioavailable Si, which is most likely controlled by the dissolution of clay minerals.

We currently deepen our first interpretations through mineralogical and physico-chemical analyses as well as the quantification of phytoliths.

Many thanks for your attention

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