Greenhouse Trials of Hydrothermally Modified Syenite Rocks: A Climate-Smart Potassium Source for Soybean on Depleted Tropical Soils.

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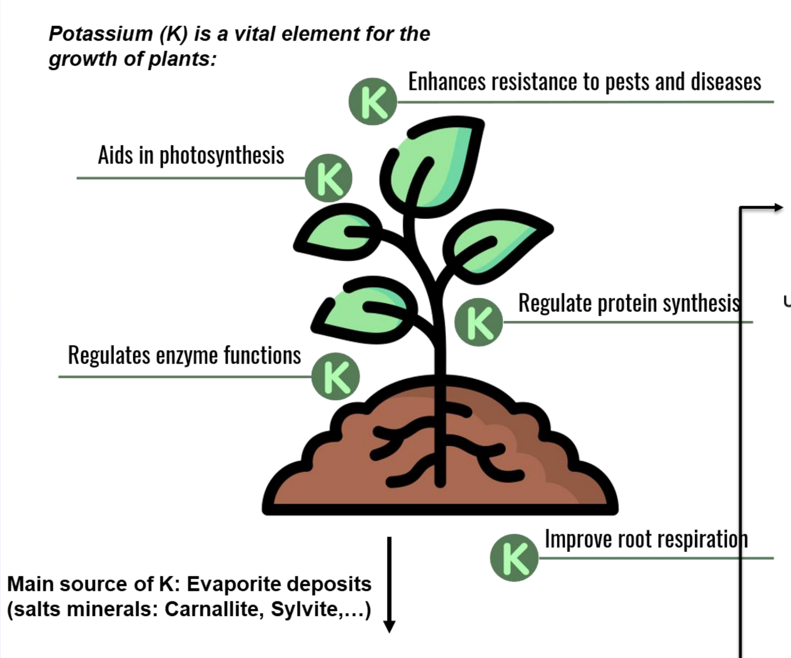
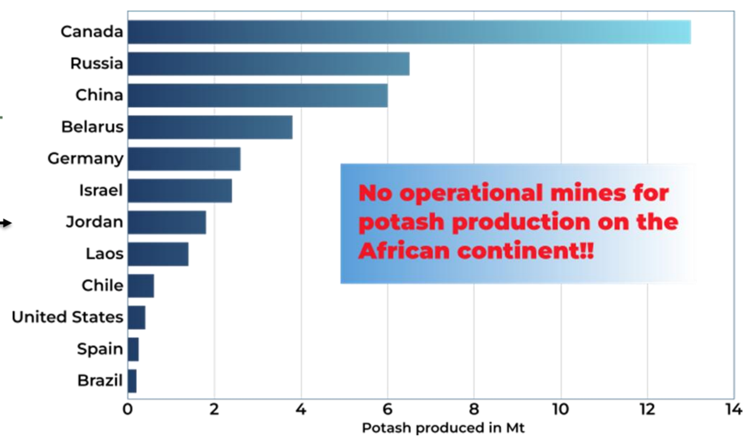
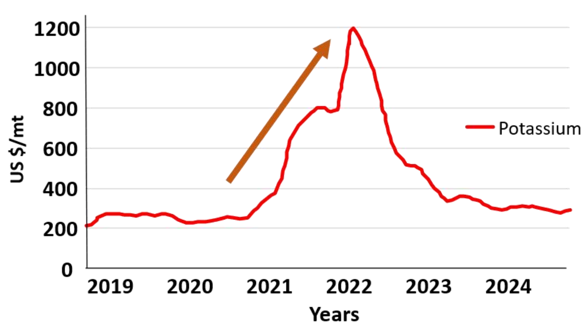
1. Problem statement



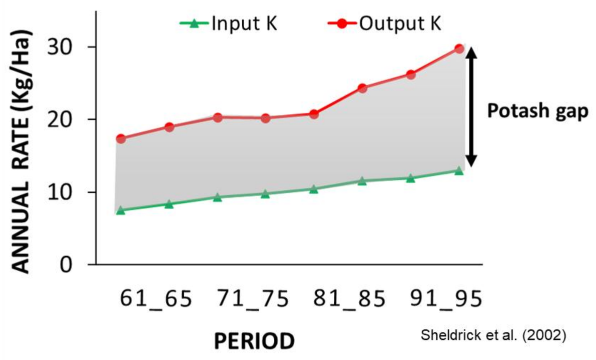


- ✓ Unfair potash distribution
- ✓ 5 countries hold more than 80% of potash reserves
- ✓ High solubility (KCl, K_2SO_4)
- ✓ No mine for potash production in Africa
- ✓ Source of Cl
- ✓ Unstable prices



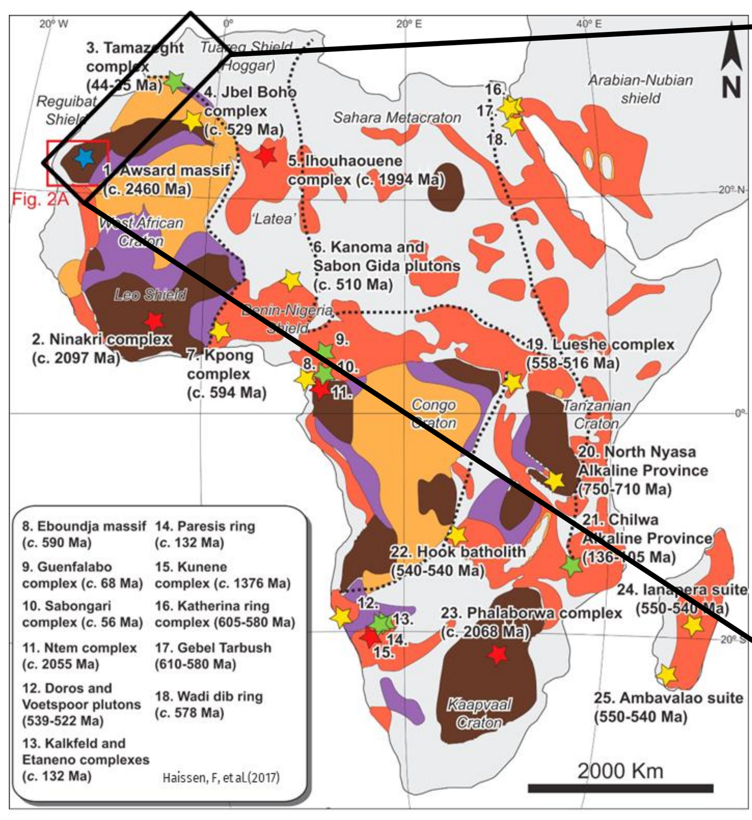
mt = metric ton. Last observation is December

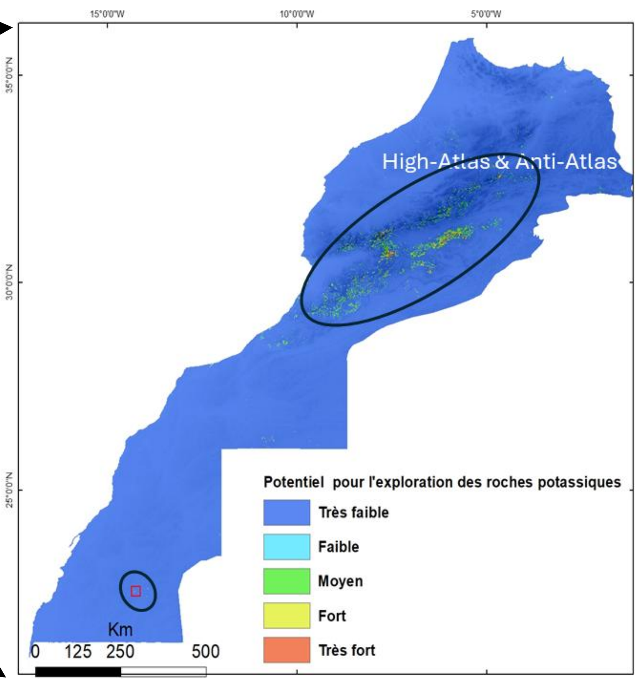
Potash prices peaked at a record **US$1,202** per mt in April 2022 because of the **Russia-Ukraine war.**



2. Problem solution

- About **90%** of K occurrences are found in **igneous rocks and clays.**
- **About 25 alkaline deposits in Africa are constituted of K silicate rocks**
- The common rocks are **Syenite and Trachyte**; they are mainly composed of **K-feldspar, K-phyllosilicates, others….**



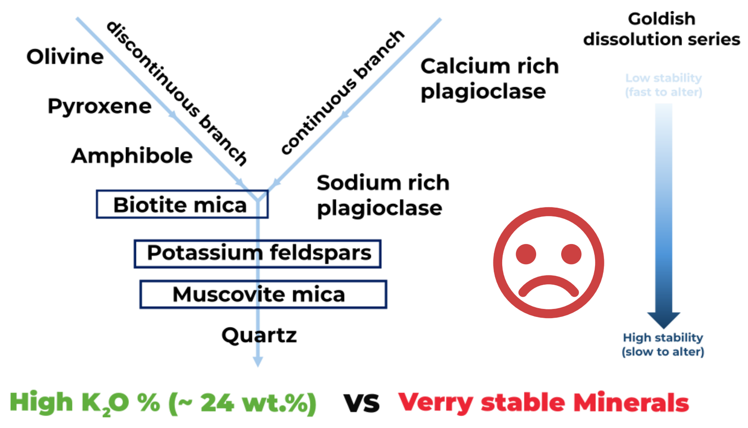


K-rocks distribution in Morocco

7 wt.% < K_2O < 19 wt.%

- Syenites offer both promise and difficulty. On the positive side, minerals such as **kalsilite**, **leucite**, and **K-feldspars** are exceptionally rich in potassium, containing up to **24 % K_2O**.
- However, these same minerals are **highly stable** and **resistant to weathering**, as described by the **Goldich dissolution series**. They hold plenty of potassium, but it's **locked tightly within their crystal structures**.

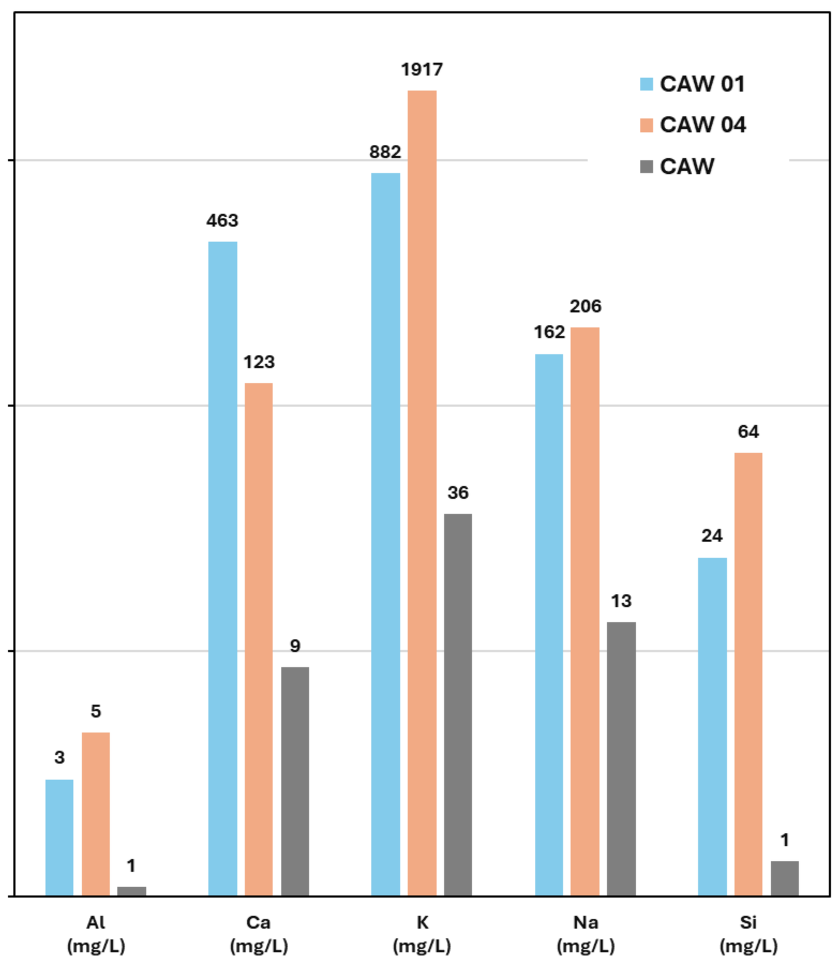
Mineral	Chemical formula	K content (wt.%)
Kalsilite	$KAlSiO_4$	24.68
Leucite	$KAlSi_2O_6$	17.89
K-Feldspars	$KAlSi_3O_8$	14.03
Nepheline	$(Na,K)AlSiO_4$	13.00
Phlogopite	$K_2Mg_6Si_6Al_2O_{20}(OH)_4$	9.38
Muscovite	$KAl_3Si_3O_{10}(OH)_2$	9.03
Biotite	$K_2Fe_6Si_6Al_2O_{20}(OH)_4$	7.62



This research aims to **unlock this bound potassium** and develop methods to make syenitic rocks **agronomically viable as natural fertilizers.**

4. Primary results

Elements release: Water leaching



Among all elements, **Potassium (K)** and **Silicon (Si)** exhibit the **most significant enhancement**, reflecting the strong effect of the treatment on mineral dissolution.

•**Potassium (K):**

CAW 04 = 1917 mg/L ≫ CAW 01 = 882 mg/L ≫ CAW = 36 mg/L

→ **Major increase in K leaching**, confirming effective activation of K-bearing minerals.

•**Silicon (Si):**

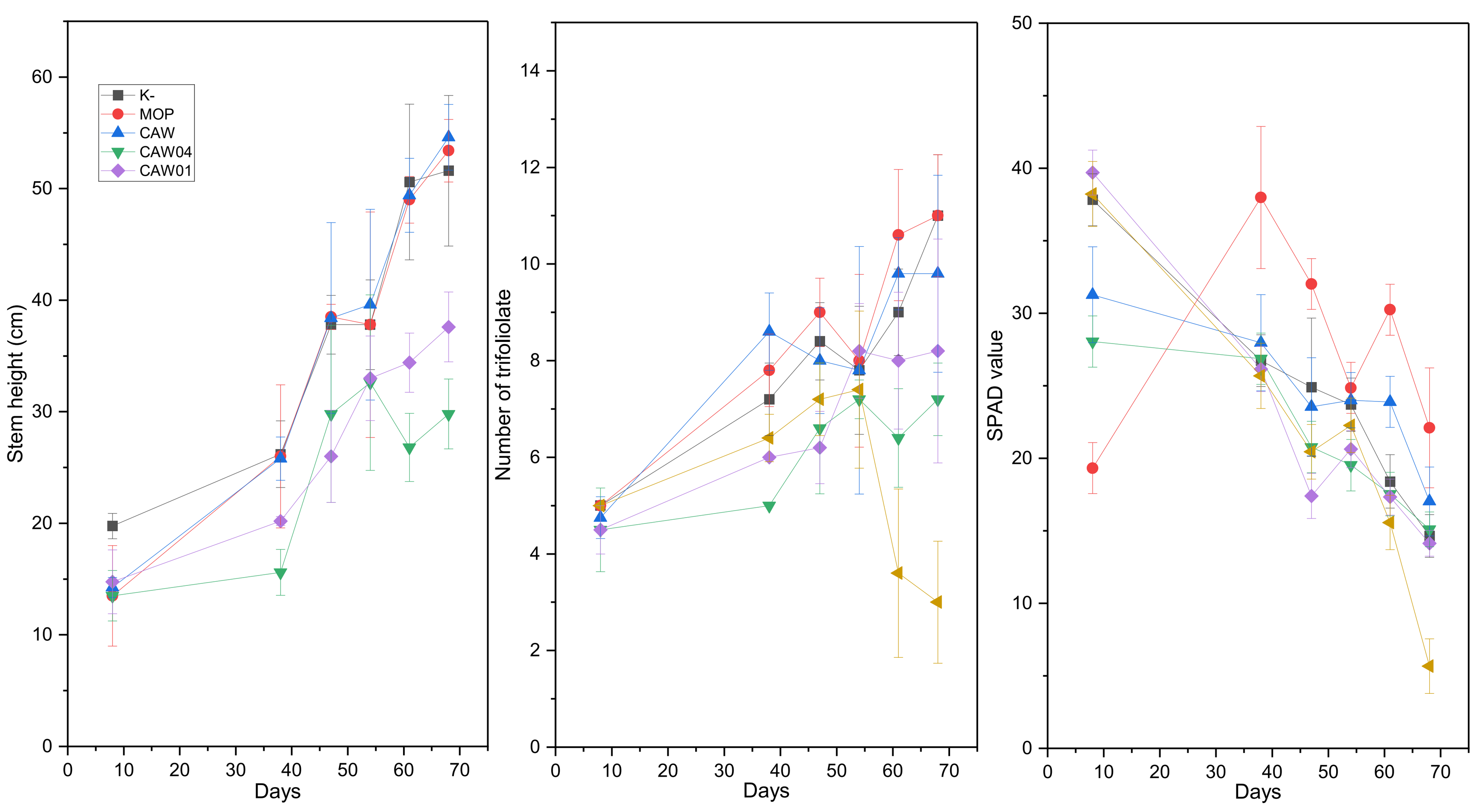
CAW 04 = 64 ≫ CAW 01 = 24 mg/L ≫ CAW = 1 mg/L

→ **Enhanced silicate breakdown**, indicating improved weathering potential.

Other elements (Al, Ca, Na) also show moderate increases in the treated samples,

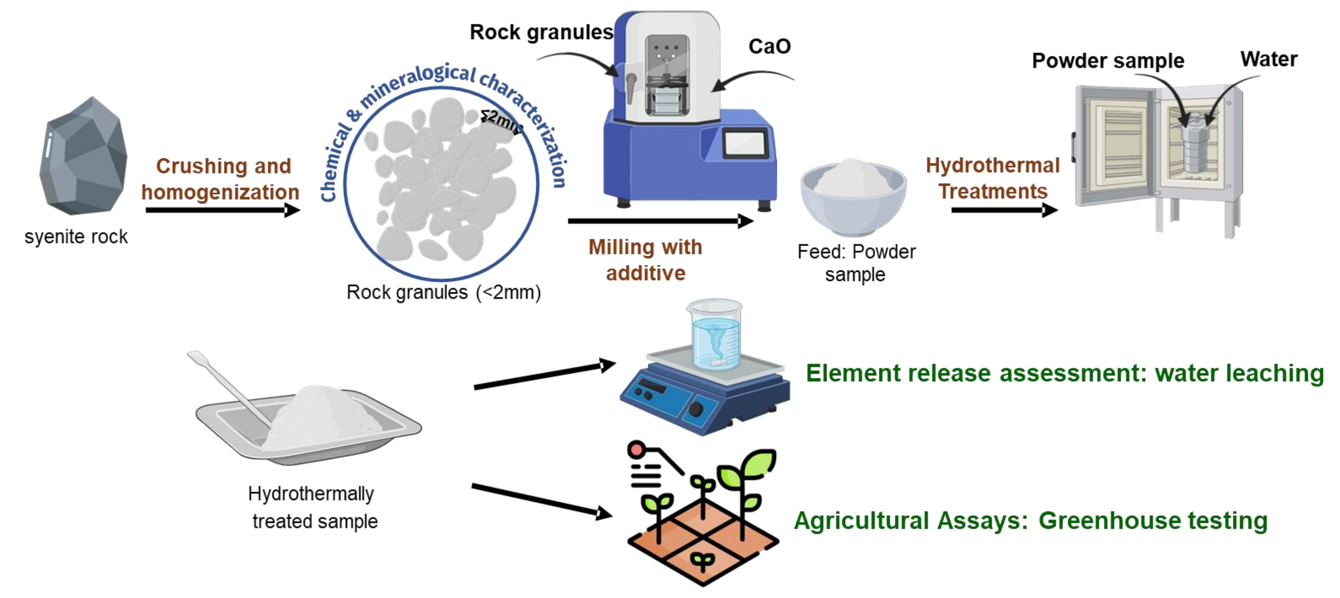
Overall, **CAW 04** demonstrates the **highest leaching efficiency**, confirming the success of the treatment in promoting nutrient release from K-syenite.

Soybean growth and nutrient uptake in a glasshouse pots



- Treated samples (**CAW 01** and **CAW 04**) showed **significantly comparable stem elongation** and **higher trifoliate leaf numbers** compared to untreated syenite and control, indicating improved vegetative growth.
- **SPAD readings** remained higher in treated plants, suggesting **enhanced chlorophyll content and leaf health**.
- Overall, **CAW 01** demonstrated the best performance compared to CAW 04 that released more potassium in the , This results confirm the positive impact of treated K-syenite on soybean growth dynamics.
- By the end of the experiments, K uptake and yield results are still needed to confirm if the rocks are working well.

3. Methodology



- **Sample Preparation:** Rock samples were crushed, homogenized, and characterized chemically and mineralogically to determine composition and phase distribution. Then, milled with CaO.
- **Hydrothermal Treatment:** Processed powders underwent hydrothermal reactions to promote structural breakdown and potassium release.
- **Leaching Tests:** Element release was assessed through water leaching experiments to evaluate solubility and nutrient availability.
- **Agronomic Evaluation:** Treated materials were tested in greenhouse assays to assess their performance as potential slow-release potassium fertilizers.

Agricultural Assays: Greenhouse testing

The pot tests are carried out in the greenhouse at CENA-USP, Sao Paolo, Brazil. Duration of the experiment about 6 months. A sandy soil depleted in K with pH of 4.2 was used. The vegetable used is Soybean (*Glycine max*). The treatment used were MOP as a (+) control, untreated rock, treated rock CAW 04 and CAW 01. The experiment were conducted with a randomized block design in 5 replicates. Soil and rocks were mixed carefully.

Parameters considered of the soybean: fresh and dry weight, height, number of trifoliate, SPAD, and K uptake.

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