Evaluation of polyhalite fertilizer for soybean balanced nutrition using a novel root phenotyping system

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SOILS: WHERE FOOD BEGINS

Global Symposium on Soils for Nutrition | 26-29 July 2022

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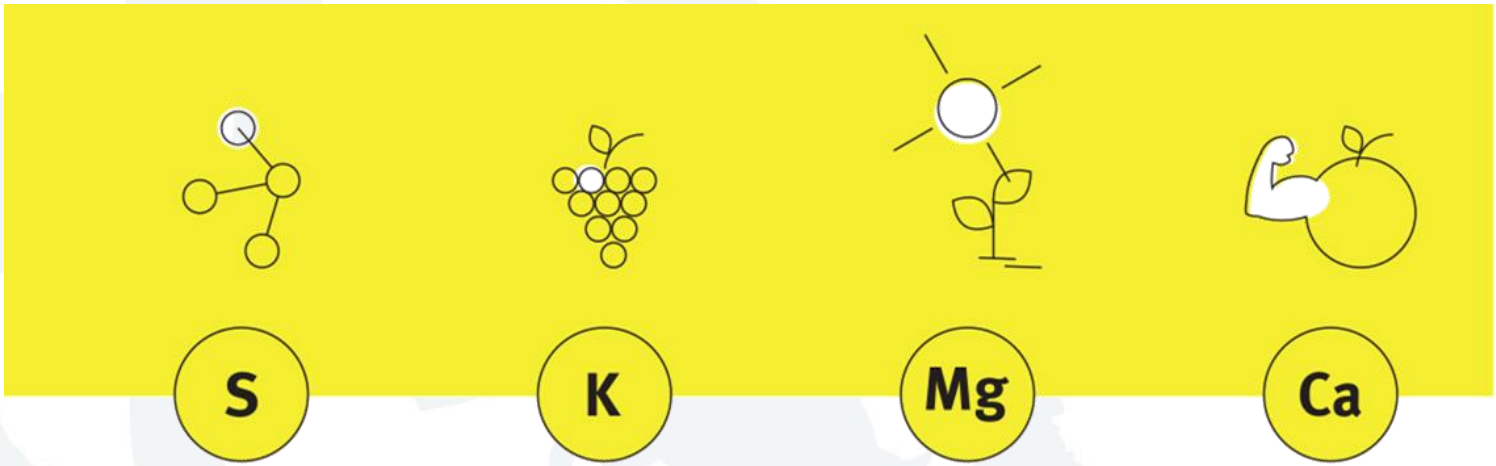
Polyhalite, a new natural fertilizer



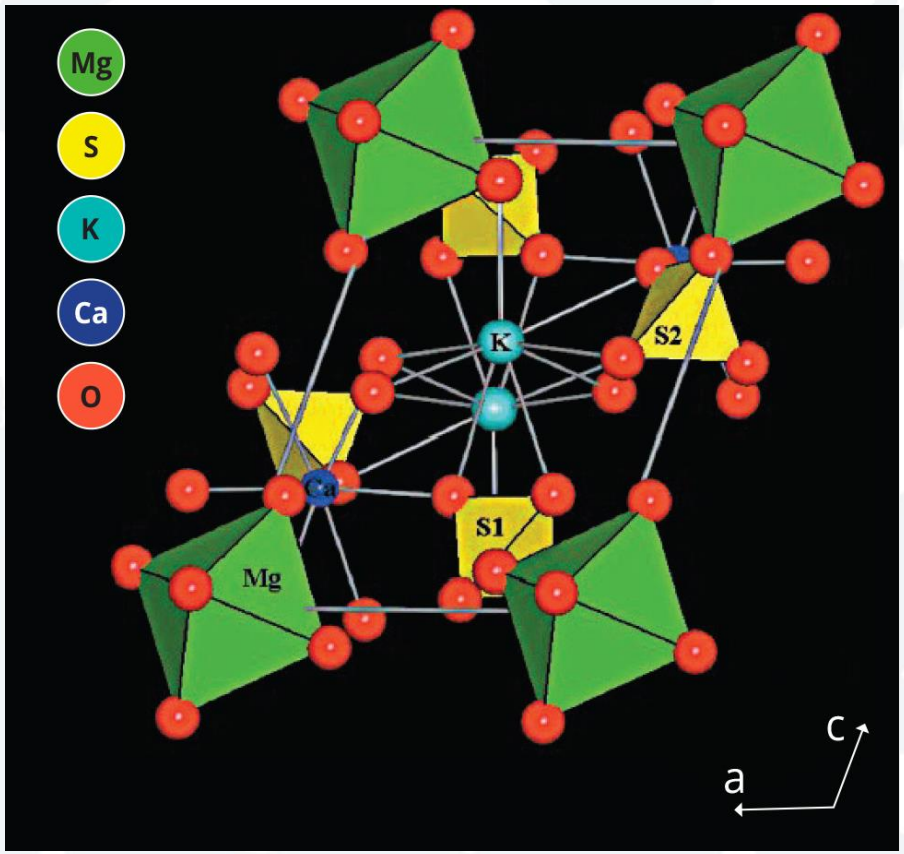
S	K	Mg	Ca
48% SO_3 (19.2% S)	**14% K_2O (11.6% K)**	**6% MgO (3.6% Mg)**	**17% CaO (12.2% Ca)**
As sulphate	As potassium sulphate	As magnesium sulphate	As calcium sulphate
An essential constituent of all proteins	Secures yield and quality	For high photosynthesis	For strong and healthy crop

Where does Polyhalite come from?

- Polyhalite is a natural mineral found over 1000m below the North Sea off the North Yorkshire coast in the UK
- Polyhalite formed during the evaporation of prehistoric seas, 260 million years ago
- Polyhalite is mined, crushed, screened, loaded and shipped worldwide.
- A pure, natural mineral without any added chemicals

Polyshalite is a mineral, not a mixture of salts

The crystal structure of polyhalite



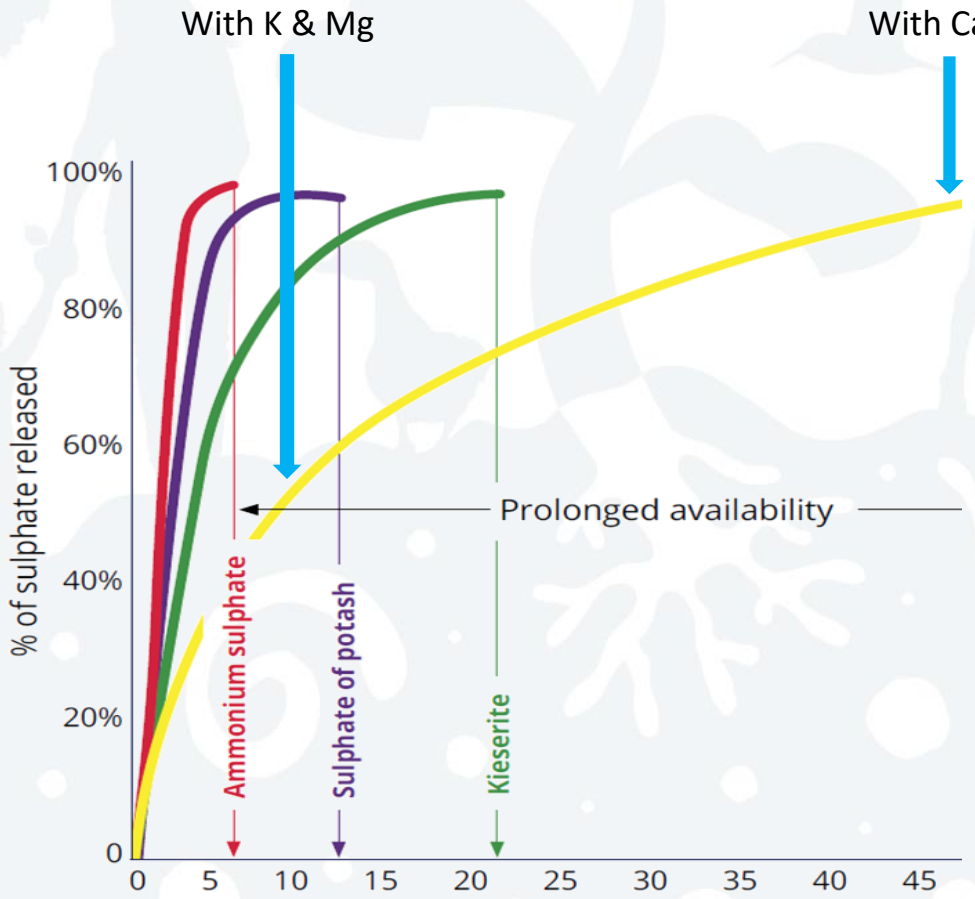
Source: Reinvestigation of polyhalite, $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$. Luca Bindi; Acta Crystallographica Section E Structure Reports Online / ISSN 1600-5368. Editors: W. Clegg and D. G. Watson

$K_2Ca_2Mg(SO_4)_4 \bullet 2(H_2O)$

Polyhalite: ONE single complex crystal

Evidence of gradual release of sulphur from Polyhalite over time

Release of sulphate from Polyhalite vs. other sources (granular grades)



The University of Nottingham

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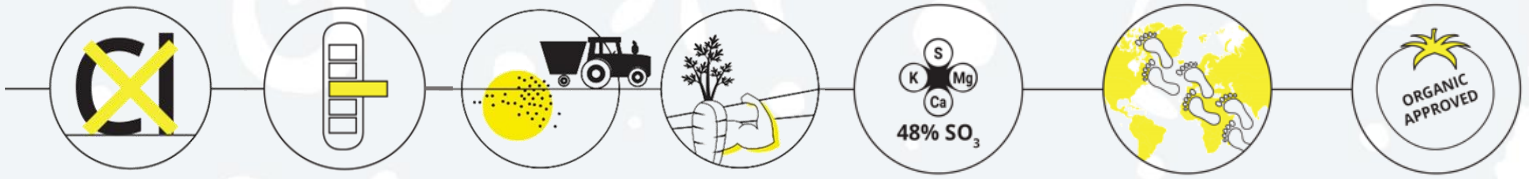
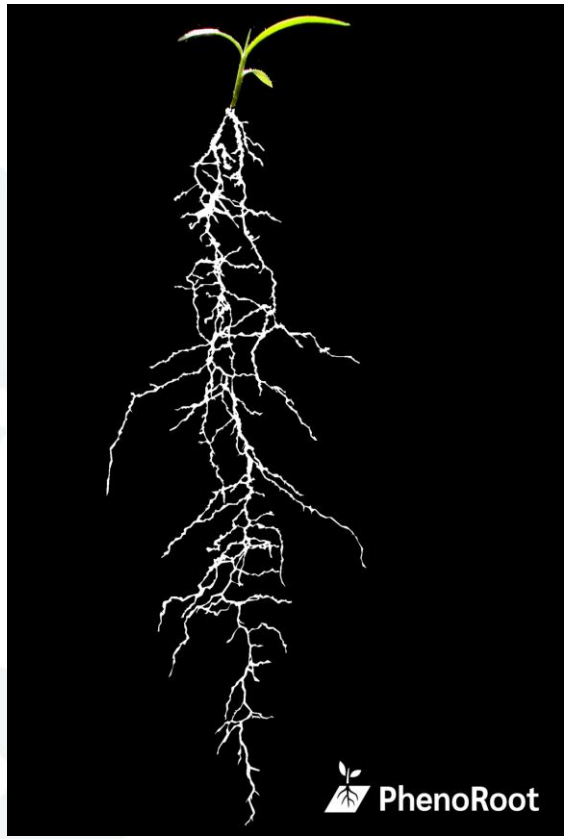
Polyhalite, a new fertilizer

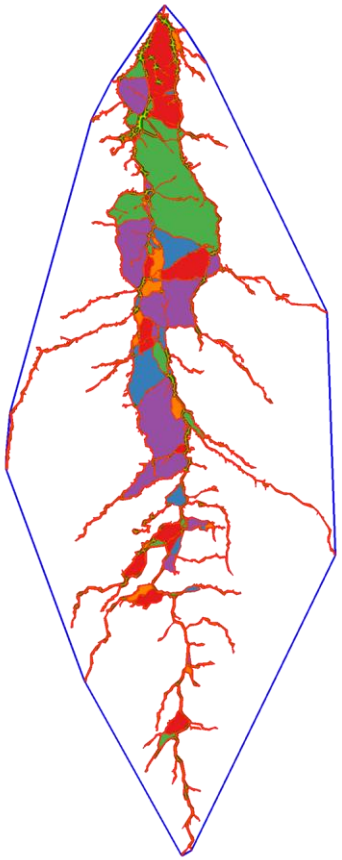
- Very low chloride, ideal for chloride-sensitive crops
- Suits all crops and soil types
- Low salt index and neutral pH
- Fully available nutrients, with gradual release for plant uptake (prolonged availability)
- Better for the environment - less risk of leaching
- Residual effect for next crop
- Approved for use in organic agriculture
- Low carbon footprint



PhenoRoot

- PhenoRoot system tracks and analyzes **roots** development along the plant life-cycle.
- The monitoring and analysis are performed on **soil-grown** plants, thus imitating the real environment of the plant development.
- Non destructive
- Root phenotyping by Computer Vision





Foxtail millet
(Setaria italica)

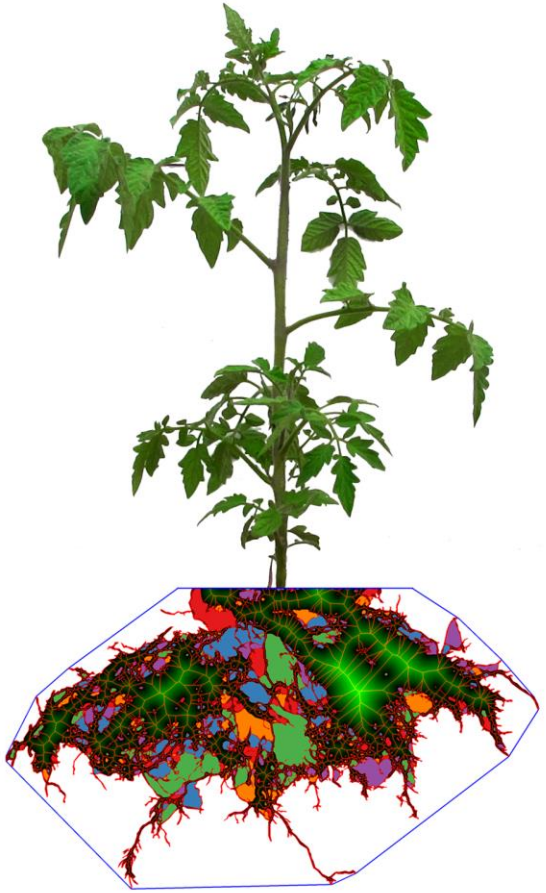
Monitoring and Analysis of Soil-Grown Roots

Soybean roots - One week of development

PhenoRoot

Traits of Root System Architecture (RSA)

- Biomass
- Volume
- Depth
- Width
- Total Root Area
- Network Area
- Convex Area
- Perimeter
- No. of Roots
- No. of Root Tips
- Total Root Length
- Primary Root Length
- Lateral Root Length
- Lateral Root Branches
- Branching Angle
- Root Orientation
- Average Diameter
- Maximum Diameter
- Fine Diameter Frequency
- Medium Diameter Frequency
- Coarse Diameter Frequency
- Shallow Angle Frequency
- Medium Angle Frequency
- Steep Angle Frequency



Objectives

- To investigate the efficiency of Polyhalite as a fertilizer supplying S, K, Mg and Ca relative to equivalent soluble salts
- To investigate the residual effect of Polyhalite on the subsequent crop
- To study the uptake of N, P, S, K, Mg and Ca nutrients by soybean plants when fertilized with Polyhalite
- To study Polyhalite effect on biomass production and different parameters of the root system architecture to get a deep understanding of the effect of Polyhalite on root development

The novelty: Analyzing the underground (roots) parts of plants.

Materials & methods

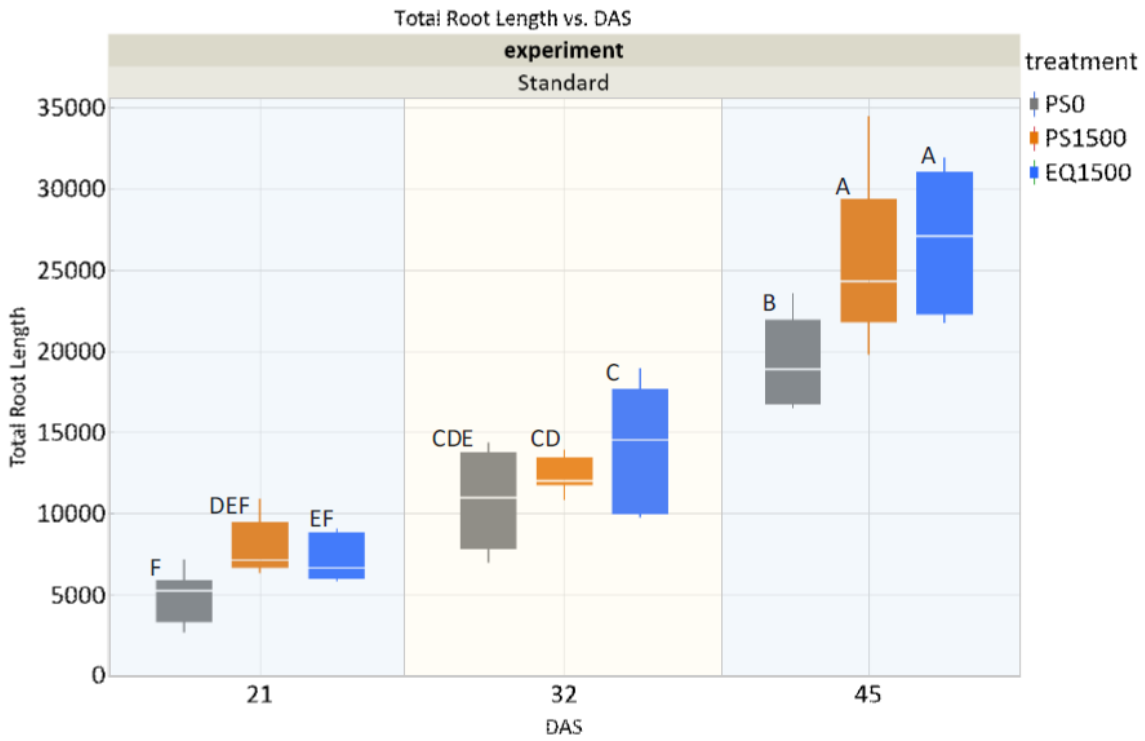
- The experiments were carried out in a nethouse in Givat Brenner, Israel
- Plants were grown in pots filled with sand and irrigated by drippers with irrigation solutions containing macro and micronutrients
- Three treatments were applied on the first set (standard application):
    1. No Polyhalite (negative control) - ”PS0”
    2. Polyhalite at the level of 1500 kg/ha - “PS1500”
    3. Equivalent fertilizers to the PS1500 kg/ha level (positive control) - “EQ1500”
- The second set was composed of pots from a previous experiment (Chickpea and Tomato), without any additional application of Polyhalite or the equivalent fertilizer.
    1. No Polyhalite (negative control) - ”PS0”
    2. Polyhalite at a level of 500 kg/ha - “PS500”
    3. Polyhalite at the level of 1500 kg/ha - “PS1500”
    4. Equivalent fertilizers to the PS1500 kg/ha level (positive control) - “EQ1500”

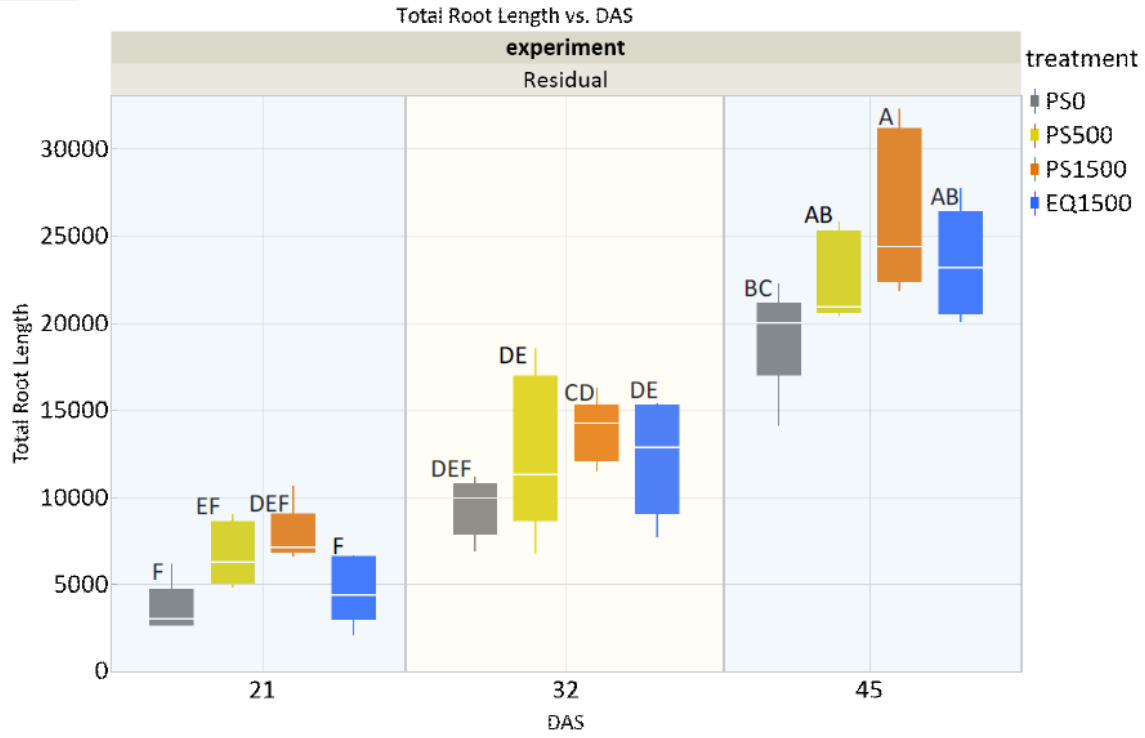
Measurements

- Shoot biomass, root biomass, stem diameter and chlorophyll content
- Root traits were measured using advanced methods of root phenotyping
- Nutrient analysis were performed in plants, leachates and soil

Results

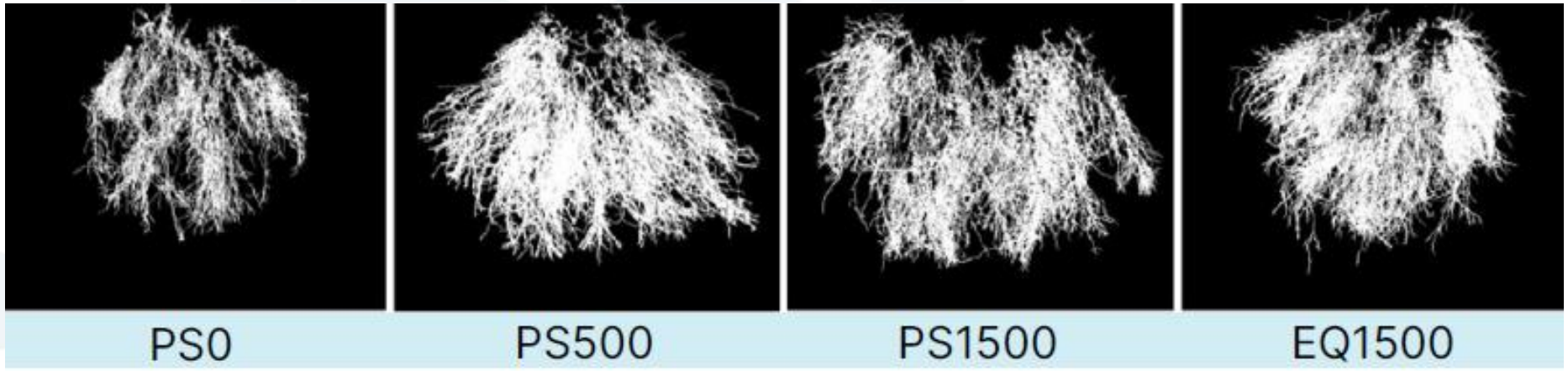
Total root length in four-time points





Results

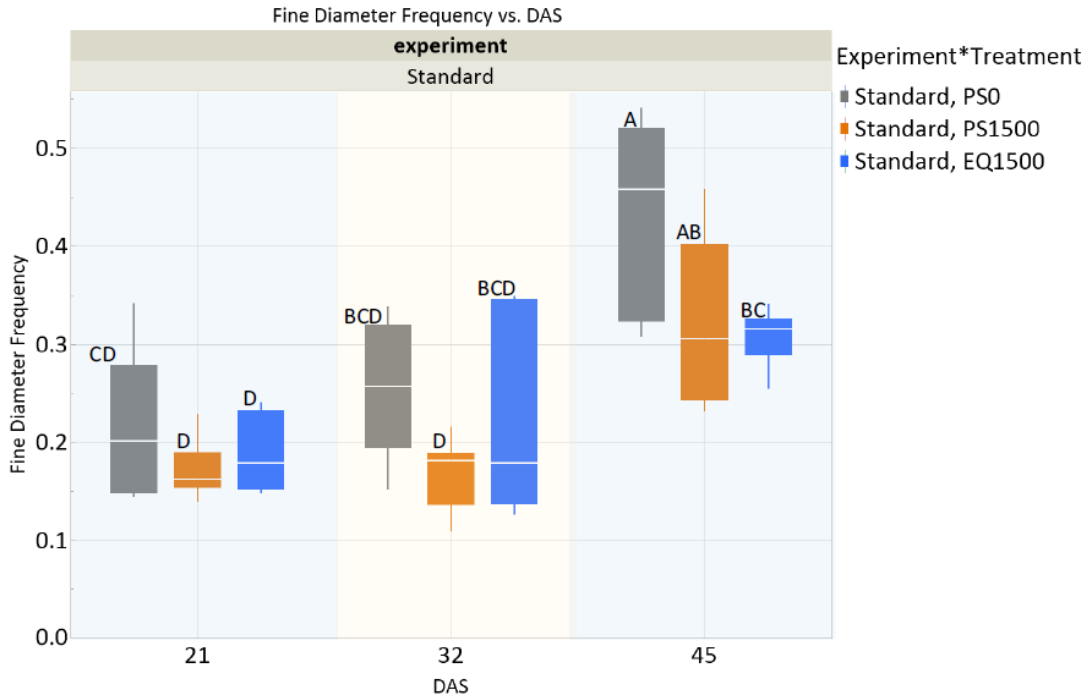
Typical root systems images – measured on 45 DAS (under residual application)



Results

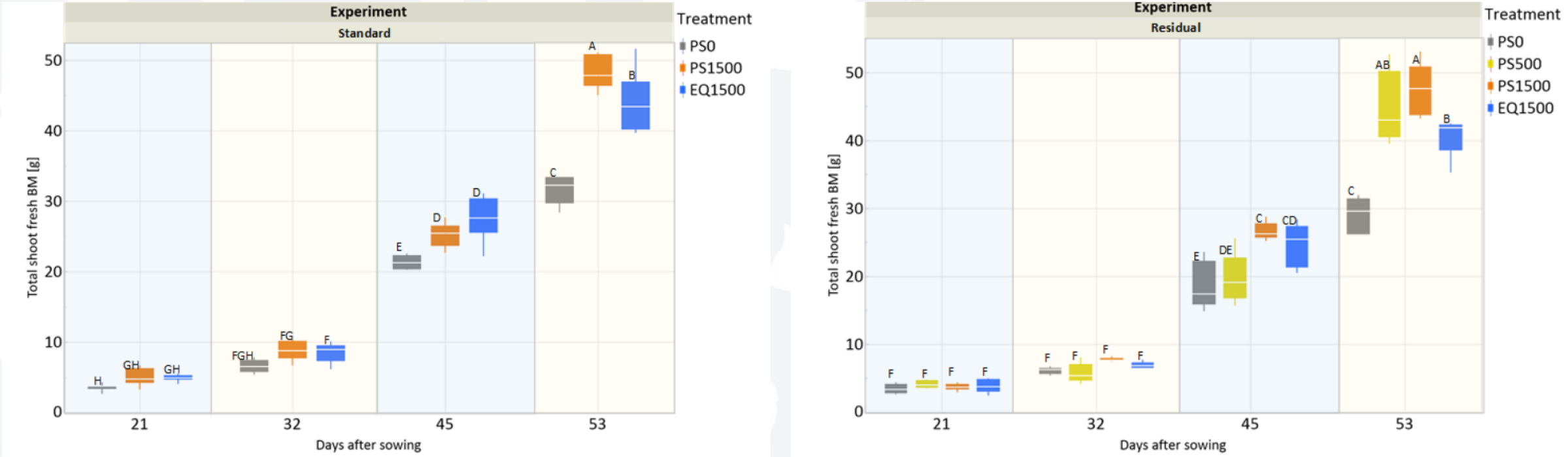
Fine diameter frequency

- The increase in fine diameter frequency is generally to due deficiency of nutrients.
- The roots with fine diameter have strong water and nutrient absorption capacity
- This explains the increase in fine diameter roots since the plant strives to increase the nutrient uptake.



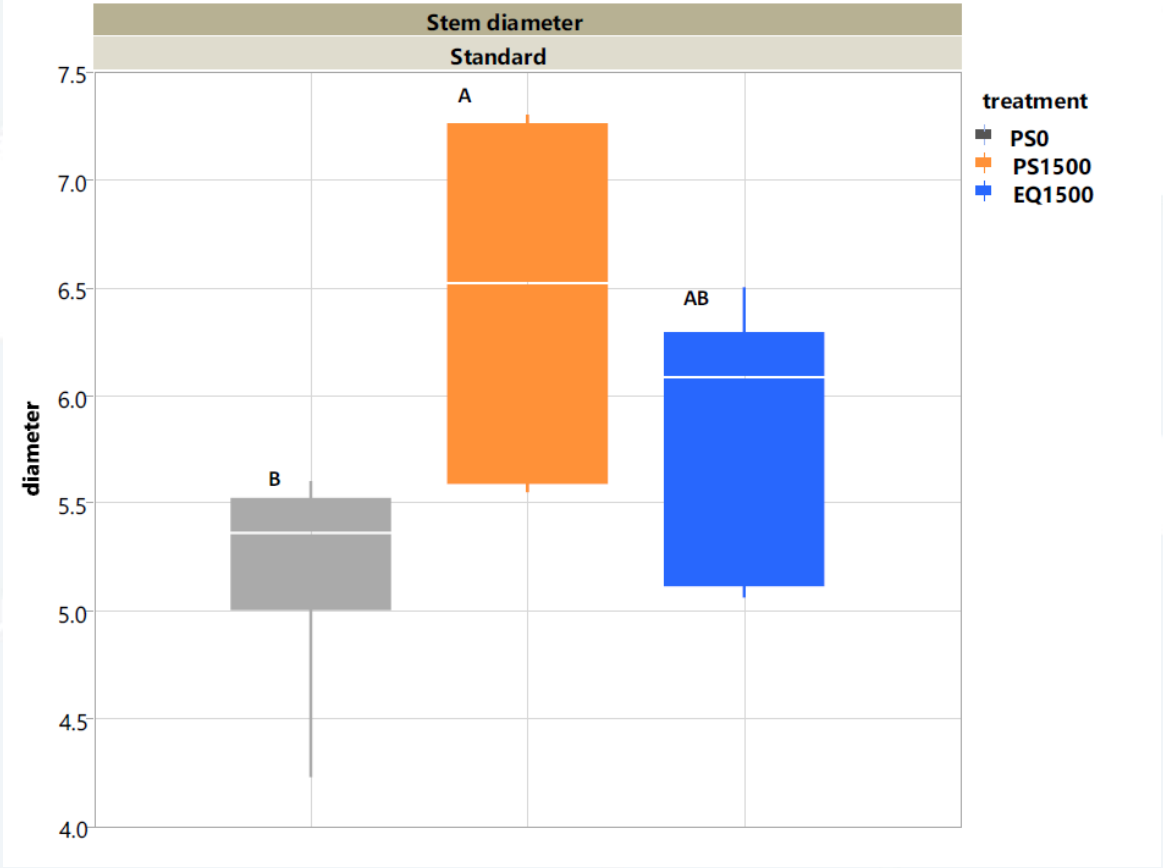
Results

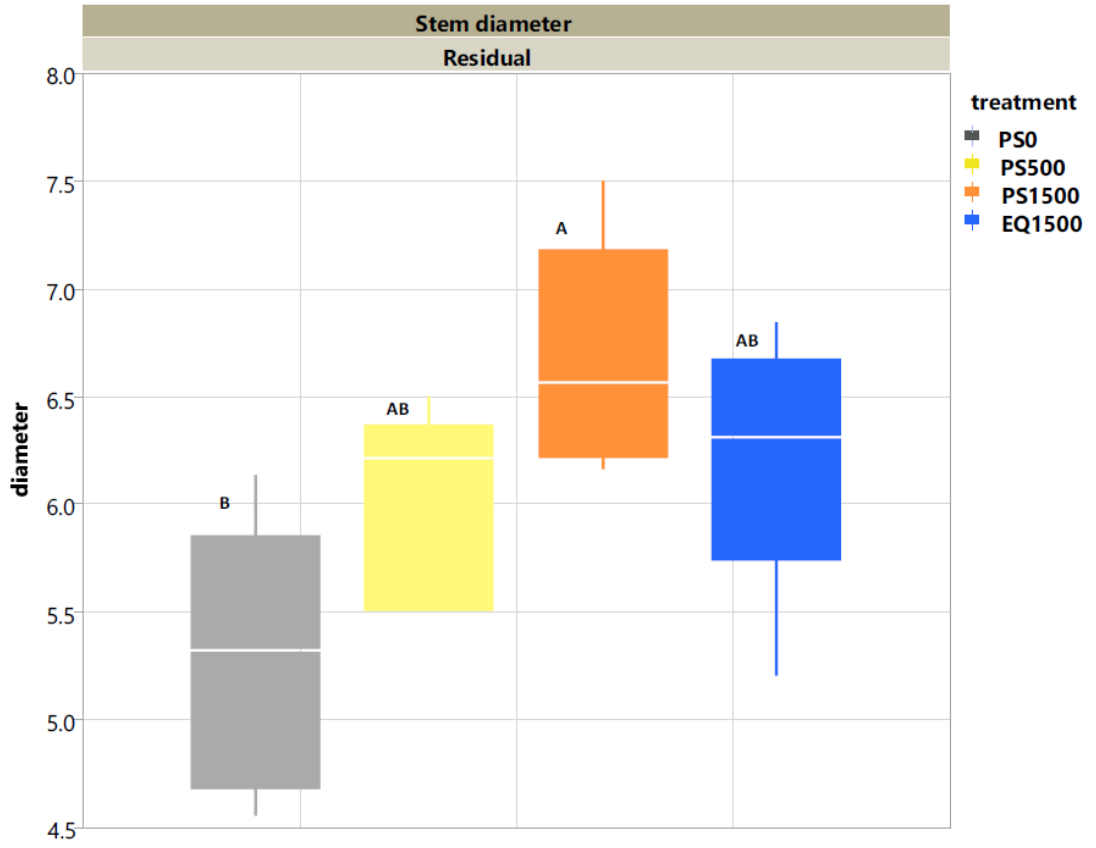
Total shoot fresh biomass



Results

Stem diameter, measured on 52 DAS





Residual experiment

PS 0 PS 500 PS 1500 EQ 1500

Residual experiment

Mg deficiency symptoms (interveinal chlorosis)

PS 0 PS 500 PS 1500 EQ 1500

Results

- Polyhalite performed better that the equivalent fertilizer in accumulation of shoot biomass
- Polyhalite enhanced the vegetative growth of the soybean plants (as was shown in secondary growth of leaves and stem diameter)
- Residual effect: Polyhalite showed better residual effect than the equivalent (a shown in the shoot biomass comparison)
- The PhenoRoot phenotyping technique was successful in detection of mineral deficiency, as was shown in the fine root diameter frequency. The fine root diameter frequency is an indication of the change of the RSA morphology in response to mineral deficiency

Conclusions

- Polyhalite is as effective or more effective than the equivalent fertilizer
- Polyhalite induced more balanced nutrition by supplying the nutrients for extended periods
- Polyhalite is a more sustainable fertilizer with residual effect for the consequent crops


Thank you !
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