Science Societies

Polyhalite best management practices

A multi-nutrient approach to system efficiency and soil function

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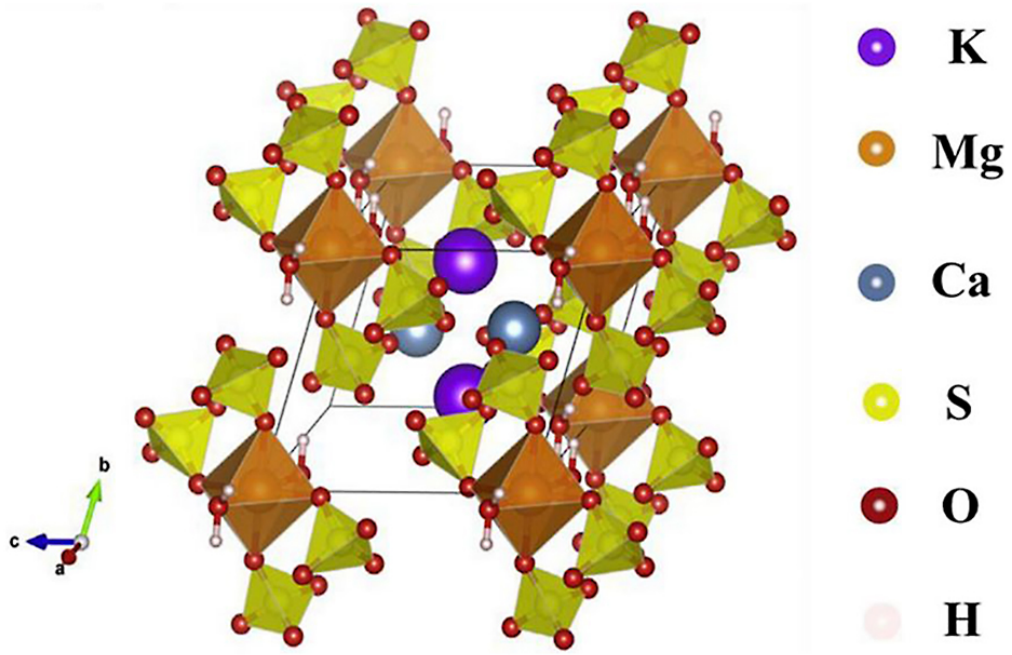

Polyhalite is a naturally occurring evaporite mineral composed of potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) in sulfate form [K?Ca?Mg(SO?)?·2H?O].

This article explores how polyhalite, a natural multi-nutrient fertilizer, supports crop performance and soil health through a sulfur-driven, slow-release nutrient system. It highlights practical management strategies and real-world benefits, from improving nutrient use efficiency to enhancing operational and environmental outcomes across diverse farming systems.

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Polyhalite is a naturally occurring evaporite mineral composed of potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) in sulfate form [K□Ca□Mg(SO□)□·2H□O]. Commercially available from ICL as **Polysulphate**, it is mined, crushed, and screened without chemical processing, preserving its mineral integrity and contributing to a low production carbon footprint.

Unlike highly soluble single-nutrient fertilizers, polyhalite dissolves gradually in response to soil moisture. This dissolution pattern provides a season-long supply of

sulfate-S along with accompanying base cations. As a result, polyhalite functions as a **natural slow-release, multi-nutrient fertilizer** suited to improving whole-system nutrient efficiency.

Field and commercial experience indicates particularly strong performance in:

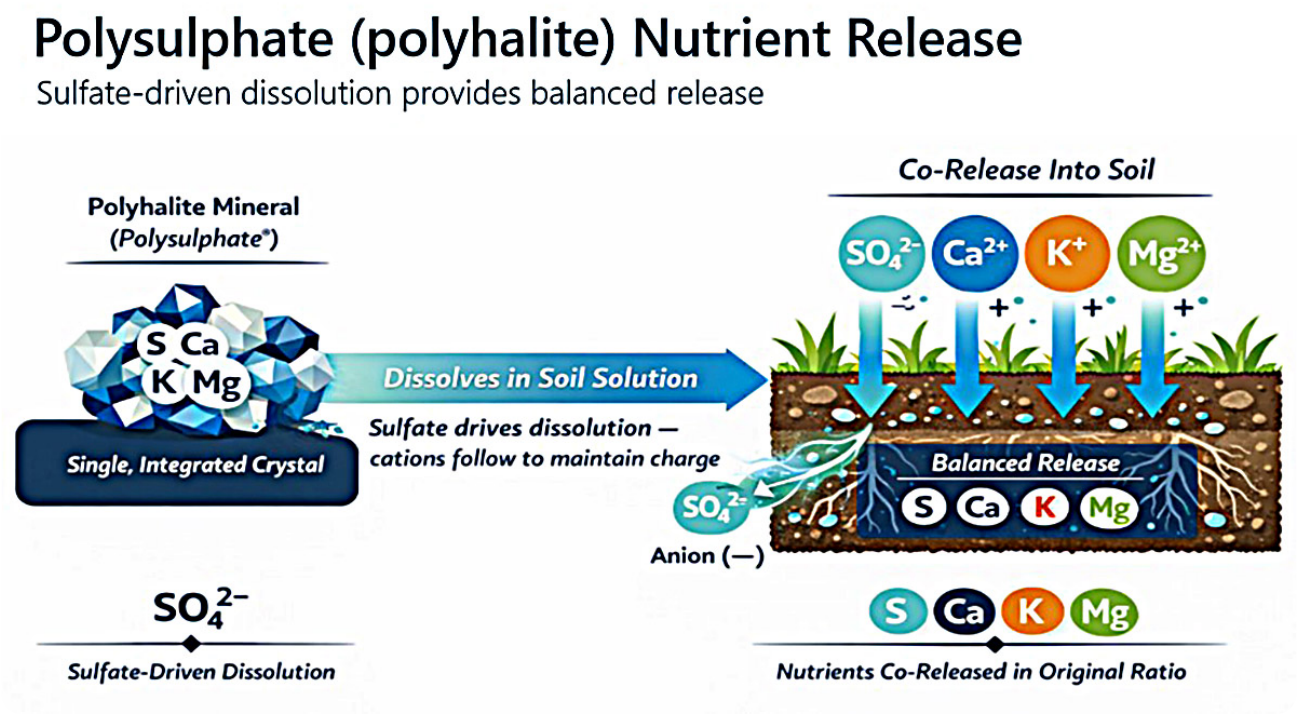
- Sandy and coarse-textured soils prone to nutrient leaching.
- Soils across a wide pH range.
- High-Mg soil systems where calcium supplementation supports structural balance.

By delivering four essential nutrients in a single granule, polyhalite aligns nutrient supply with crop uptake while reducing the need for multiple fertilizer passes.

Sulfate chemistry: Sulfur leads, cations follow

Sulfur deficiency has become increasingly common due to reduced atmospheric deposition and greater crop removal. Polyhalite supplies sulfur exclusively in sulfate (SO_4^{2-}) form, which is immediately plant available.

A key principle in polyhalite management is that **sulfur drives application strategy**. Because all the nutrients in polyhalite share the common sulfate ion, its dissolution governs the release $MgSO_4$ > KSO_4 >$CaSO_4$.



Application rates should be determined by sulfur requirement

Across numerous Polysulphate trials studying various blends and application rates based on each nutrient (S, K, Mg, and Ca), a consistent pattern emerged: programs that prioritize sulfur requirements deliver the most favorable agronomic and economic outcomes. Research findings, supported by observations from commercial field use, show that applying polyhalite according to sulfur requirement is the most effective approach for optimizing nutrient efficiency and overall performance.

Recommended rates

Based on research and field experience, across diverse crops and soil systems, **100–200 lb/ac** of polyhalite has proven effective in addressing sulfur demand while supplying complementary K, Ca, and Mg. Final rates should be refined according to soil test levels, yield goals, and crop sensitivity.

This sulfate-led dissolution provides a buffered release pattern compared with highly soluble sulfate sources, supporting sustained nutrient availability while minimizing early-season leaching risk.

Nutrient use efficiency: Beyond single-element thinking

Nutrient stewardship increasingly emphasizes nutrient use efficiency (NUE) across systems rather than isolated yield responses. As a natural multi-nutrient mineral, polyhalite consolidates nutrients, reducing **risk of uneven application** and contributing to improved efficiency through synergistic nutrient interactions.

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Nitrogen efficiency

Balanced sulfur nutrition is essential for efficient nitrogen assimilation as S is required for amino acid and protein synthesis. Trials evaluating polyhalite alongside nitrogen programs have demonstrated:

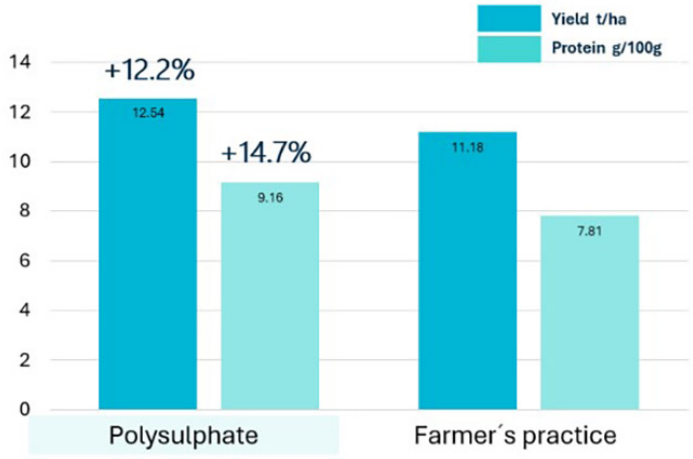
- Increased yield response at equivalent nitrogen rates.
- Improved nitrogen recovery under certain soil conditions.

By supplying sulfate-based S, Ca, K, and Mg in synchrony with nitrogen uptake, polyhalite can enhance protein formation and reduce inefficiencies associated with unbalanced N fertilization.

Increase Nitrogen Use Efficiency in Corn

Polyhalite (Polysulphate trial) improved protein and yield compared to GSP

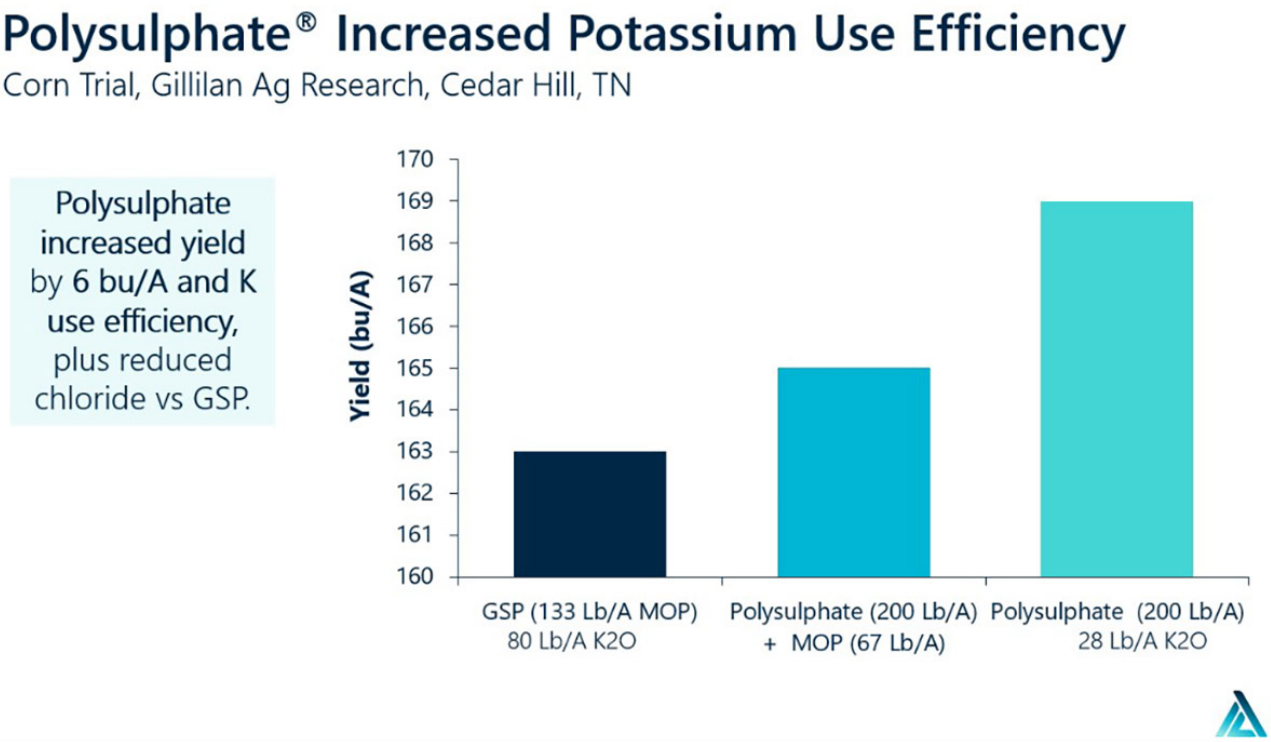
	Treatments	
	T-1 Polysulphate	T-2 Grower's practice
Yield (t/ha)	12.54	11.18
Protein content (g/100 g grain)	9.16	7.81
Lipid Content (g/100 g grain)	1.01	1.07
Carbohydrates (g/100 g grain)	75.80	76.55



Potassium efficiency

Comparative work evaluating potassium sources has shown that polyhalite can deliver equivalent yields at substantially reduced K□O rates relative to muriate of potash (MOP) in specific systems. In some reported trials, similar yield was achieved with up to **65% less applied K□O**, suggesting improved potassium efficiency when delivered alongside sulfate, calcium, and magnesium.

The absence of chloride may also be beneficial in chloride-sensitive crops or high-salt environments.



Operational efficiency

Polyhalite's multi-nutrient profile allows **one application to supply S, K, Ca, and Mg.** This offers the potential to reduce the number of passes required for nutrient application, saving labor and operational inputs while maintaining consistent nutrient delivery.

- Blend: Bulk density 93.6 lb/ft^3, uniform particle size.
- Compatible: pH neutral; stable in blends.
- Storage and handling: Low hygroscopic fertilizer.
- Spatial: Multi-nutrient profile improves uniform nutrient coverage, reduces field passes, and requires less storage space and handling.

The particle size distribution of polyhalite granules is shown in Table 1.

Early-season vigor and stand establishment

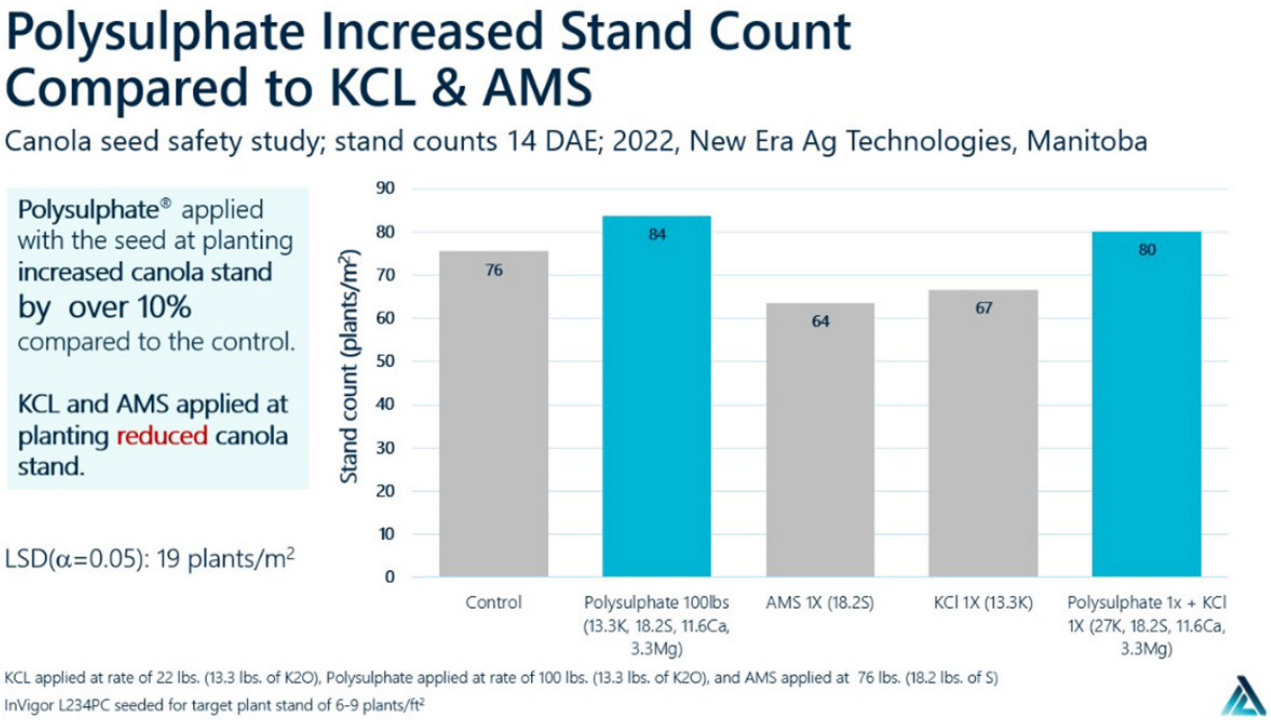
Polyhalite has been associated with improvements in early emergence and plant stand in certain cropping systems. While responses are environment dependent, contributing mechanisms may include:

- Balanced early sulfur supply supporting protein synthesis.
- Calcium contributions to cell wall development.
- Reduced localized salt effects relative to some highly soluble fertilizers.

Table1. Particle size distribution of polyhalite granules.

Mesh size			
mm	Tyler	U.S.	Typical retained range (%)
4.75	4	4	0–2
4.00	5	5	5–15
2.80	7	7	50–80
2.36	8	8	75–95
2.00	9	10	88–99
1.18	14	16	99

Improved early vigor can translate to stronger canopy development and enhanced yield potential, particularly in stress-prone environments.



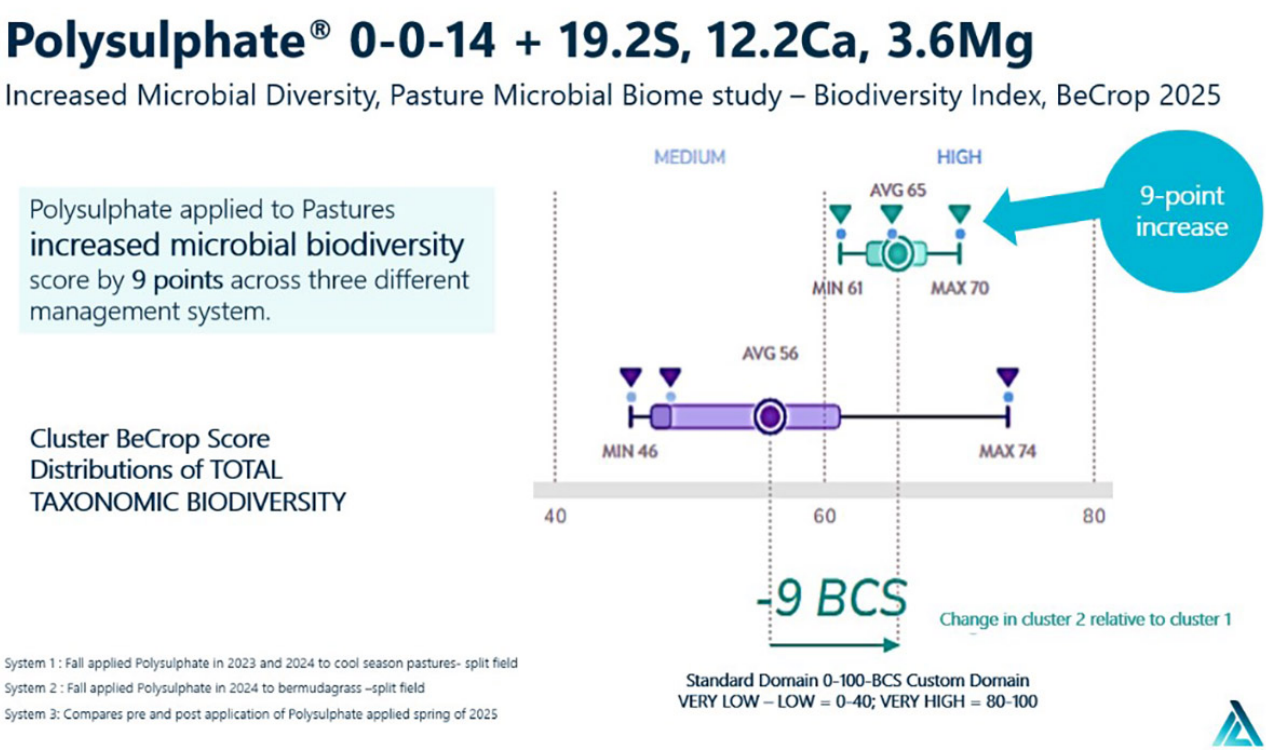
Restoring soil function with soluble calcium

Soil function depends not only on nutrient supply but also on structural integrity and biological activity.

Polyhalite provides water-soluble calcium, which contributes to:

- Improved soil aggregation in dispersive or structurally weak soils.
- Enhanced pore continuity and infiltration.
- Support of rhizosphere microbial activity.

Emerging data suggest that balanced Ca, Mg, and S inputs can positively influence microbial biodiversity, potentially improving nutrient cycling and soil resilience over time.



Environmental footprint

Among commonly available fertilizers, polyhalite is reported to have one of the lowest carbon footprints per unit of nutrient delivered. The carbon footprint was calculated by ICL using the Scope 1 carbon footprint following the GHG Protocol and ISO 14064 standards for carbon footprints.

In an era of increasing scrutiny on agricultural emissions, multi-nutrient fertilizers with low embedded carbon offer strategic advantages for both producers and supply chains.

The low carbon footprint is due to both minimal processing requirements and mining best practices. Polyhalite is mined and physically processed without chemical synthesis, and life-cycle assessments indicate substantially reduced greenhouse gas emissions compared with many conventional fertilizers. Polyhalite, sourced from Boulby Mine, has a significantly low carbon footprint also a result of energy improvements, including fully renewable electricity in 2023 and removal of the combined heat and power plants and ISO 50001 accreditation.

In an era of increasing scrutiny on agricultural emissions, multi-nutrient fertilizers with low embedded carbon offer strategic advantages for both producers and supply chains. Commercially available polyhalite, Polysulphate Granular, is also approved by the Organic Materials Review Institute.

Application: Standalone or in blends

Polyhalite can be applied alone or incorporated into bulk blends and compound fertilizers.

Blending compatibility

- Compatible with phosphorus (P) and potassium fertilizers.
  - Polyhalite is also available as a single granulated superphosphate-polyhalite based prill—PKpluS 0-24-6 + 15.4Ca-1.8Mg-9.1S ideal for seed row, sideband, and surface applications.
- Available in multiple grades: granular for conventional.
- Blends effectively with urea; caution sit time; once blended ideally apply within a few hours.
  - In hot, humid environments, blends approximating **80% urea : 20% polyhalite** have shown favorable agronomic and handling performance.

- Depending on soil test results and crop needs, polyhalite can be blended with MOP
    - For general recommendations on cotton, corn, and soy, for example:
        - **If soil test K > 100 ppm:** Apply **100–150 lb/ac of Polysulphate**.
        - **If soil test K < 100 ppm:** Apply **100 lb/ac of Polysulphate + 50–75% of the recommended MOP rate**.

Its high bulk density promotes uniform spreading patterns, often comparable to common granular fertilizers. Additionally, polyhalite's physical characteristics make it suitable for impregnation with:

- Pre-emergent herbicides.
- Biological products.

This compatibility enables operational efficiency by combining nutrient and crop protection passes.

Application timing and placement

Primary timing windows:

- Pre-plant.
- At planting.
- Early-season broadcast.

Because moisture drives dissolution, polyhalite performs well across diverse soil types and climatic regions. Irrigated systems offer additional flexibility as controlled moisture enhances predictable nutrient release.

Fall application fit

In regions with moderate winter precipitation and low leaching risk, fall application can be appropriate, particularly for crops with early spring sulfur demand. However, soil texture and drainage should guide fall management decisions to minimize sulfate movement.

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Best management practices summary

1. **Base rates on sulfur need** (commonly 100–200 lb/ac).
2. **Use soil tests** to refine K, Ca, and Mg contributions.
3. **Target early-season availability** through pre-plant or at-planting application.
4. **Leverage blending flexibility** to simplify logistics and improve nutrient balance.
5. **Consider system goals**—including NUE, soil structure, and carbon footprint—not just single-nutrient replacement.

Conclusion

Polyhalite represents a low-salt, multi-nutrient strategy aligned with contemporary agronomic priorities: efficiency, soil health, and environmental stewardship. By delivering sulfate-S alongside sulfate-based K, Ca, and Mg in a gradual, moisture-mediated release pattern, it offers an integrated approach to nutrient management

across a wide range of crops and soil systems.

It is recommended that polyhalite rates—depending on soil and crop—are based on sulfur requirements for optimal results.

As sulfur deficiencies become more prevalent and system-level efficiency gains greater importance, polyhalite provides a practical tool to optimize both crop performance and long-term soil function.

Dig deeper

Interested in this topic? Check out the webinar, "Beyond N x S: How Ca & K Drive Nitrate Assimilation and Protein Production," featuring Drs. Foster and Haegele, ICL Growing Solutions.

Self-study CEU quiz

Earn 0.5 CEUs in Nutrient Management by taking the quiz for the article. For your convenience, the quiz is printed below. The CEU can be purchased individually, or you can access as part of your Online Classroom Subscription.

1. What is the primary factor that governs nutrient release from polyhalite?

a. Soil moisture.

b. Soil pH.

c. Air temperature.

d. Microbial activity.

2. Which nutrient form does polyhalite supply sulfur in?

a. Elemental sulfur (S^0).

b. Sulfide (S^{2-}).

c. Sulfate (SO_4^{2-}).

d. Sulfur dioxide (SO_2).

3. According to best management practices, polyhalite application rates should primarily be based on

a. potassium requirements.

b. magnesium requirements.

c. calcium requirements.

d. sulfur requirements.

4. Which soil type is most likely to receive the greatest benefit from polyhalite application?

a. Heavy clay soils with poor drainage.

b. Sandy soils prone to leaching.

c. Peat soils with high organic matter.

d. Saline soils only.

5. What benefit does balanced sulfur nutrition provide in nitrogen management?

a. Reduces soil pH.

b. Increases nitrogen volatilization.

c. Improves nitrogen assimilation and protein synthesis.

d. Eliminates the need for nitrogen fertilizer.

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