AQUAHOLDER Executive Summary Report

Strategic conclusion

AQUAHOLDER should be positioned as a seed-zone moisture-management and abiotic-stress-mitigation technology, rather than as a universal yield stimulant. Across Good Experimental Practice (GEP) trials in maize (corn), sunflower, winter oilseed rape (OSR), and sugar beet, the consolidated evidence shows a consistent root-first biological response: stronger early root development, improved vegetative growth, faster and more uniform crop establishment, and excellent crop safety.

The clearest commercial value occurs when seed-zone moisture is limiting and soil physical resistance is high, particularly under drought on medium-to-heavy loam and clay soils. Under timely rainfall or irrigation, treated crops can retain early-vigor benefits, but untreated controls may catch up, narrowing or eliminating final-yield differences. AQUAHOLDER should therefore be marketed as establishment and drought-risk insurance, with crop- and site-specific positioning.

General agronomic benefits

AQUAHOLDER creates a localized moisture reserve around the seed. This supports germination, early root penetration, and early root exploration, particularly where drying soil, crusting, cracking, compaction, or interrupted rainfall restrict establishment.

- Early root development: Root dry-matter gains were consistently recorded across the four crops: +24.4% in corn, +18.2% in OSR, +12.9% in sunflower, and +24.3% in sugar beet.
- Early shoot and canopy development: Improved root function translated into higher shoot, leaf, stem, or above-ground dry matter. Average shoot dry-matter improvements reached +16.1% in corn, +17.8% in OSR, +11.5% in sunflower, and +20.0% in sugar beet.
- Faster and more uniform establishment: The treatment commonly improved emergence speed, early stand density, and crop uniformity. Corn and sugar beet emergence was advanced by approximately one to two days in selected Slovak trials. Average early plant-density improvements reached +19.9% in corn, +21.5% in sunflower, +7.0% in OSR, and +11.9% in sugar beet.

- Drought buffering: The product stores and gradually releases moisture in the immediate seed zone, helping seedlings establish during dry seedbed conditions and gain earlier access to water in a larger soil volume.
- Yield protection, not guaranteed yield uplift: The strongest yield response occurs when untreated controls experience meaningful moisture limitation. Under non-limiting moisture, final yield separation is often neutral because controls establish and recover well; this is the water-masking effect.
- Crop safety and selectivity: Across the reviewed multi-crop data set, no treatment-attributable phytotoxicity, chlorosis, necrosis, stunting, malformation, crop thinning, or phenological delay was reported. The consolidated phytotoxicity rating was 0%.

Crop-specific performance

Crop	Main biological response	Key quantified outcomes	Principal commercial value
Corn (maize)	Rapid fibrous-root and early-vigor response, especially in dry, compacted clay soil	Root dry matter +24.4%; shoot dry matter +16.1%; early stand density +19.9%; average drought yield response +6.41%; heavy/clay × drought yield response +8.79%	Improved establishment and drought protection, with potential harvest-management benefits from lower grain moisture and improved grain quality
Sunflower	Better taproot penetration and establishment in drying, crusting, shrinking, or mechanically resistant soils	Root biomass +12.9%; shoot/stem biomass +11.5%; early plant density +21.5%; average drought yield response +6.43%; 16 of 18 yield-assessed trials positive; flower-head diameter +11.0%	Most consistent conversion of early vigor to harvest performance; strong flower-head response and high potential on dry clay

Crop	Main biological response	Key quantified outcomes	Principal commercial value
Winter OSR	Enhanced autumn rosette, root reserve, and shoot development before winter	Root dry biomass +18.2%; shoot dry biomass +17.8%; emergence +7.0%; average drought yield response +3.01%; leaf number +4.7%; medium/loam × drought yield response +4.29%	Establishment stability and rosette development before winter, especially under post-sowing drought on loam soils
Sugar beet	Strong early taproot and canopy response, with potential industrial-quality benefits	Root dry mass +24.3%; shoot dry mass +20.0%; emergence +11.9%; significant root or sugar-corrected yield gains in 5 of 10 harvested trials, averaging +7.2%	Root yield and processing quality, including polarization increases and lower molasses-forming impurities; requires strict sowing-condition screening

Corn

Corn responds rapidly to improved seed-zone moisture because early fibrous-root development is highly sensitive to dry, compacted, mechanically resistant soils. The strongest value was observed under drought in heavy or clay soils, where AQUAHOLDER simultaneously mitigates seed-zone water limitation and supports root penetration.

- Root dry matter averaged +24.4% across 14 trials, while shoot dry matter averaged +16.1% across 15 trials.
- Average early stand density increased by +19.9%, and emergence was approximately one day earlier in selected Slovak trials.
- Average drought-associated yield improvement was +6.41%, increasing to +8.79% under heavy/clay × drought conditions.

- Harvest grain moisture was reduced by 1.2% to 5.4% in selected trials, including −5.4% in Türkiye and −3.9% in Czechia. This may reduce grain-drying demand.
- Thousand-grain weight improved by up to +5.0%, hectolitre weight improved by up to +2.6%, and NDVI increased by up to +26.7% under drought.

Sunflower

Sunflower benefits from improved taproot penetration through drying, crusting, or shrinking soils. The treatment supports both early establishment and later generative development, with flower-head diameter serving as a particularly sensitive indicator of product activity.

- Root biomass averaged +12.9%, shoot/stem biomass averaged +11.5%, and early plant density averaged +21.5%.
- Average drought yield improvement was +6.43%; under heavy/clay × drought conditions, the average gain was +6.73%, with individual results up to +29.4%.
- Sixteen of eighteen yield-assessed trials showed a positive final-yield trend relative to untreated controls.
- Flower-head diameter increased significantly in 15 trials, averaging +11.0%.

Winter oilseed rape

For OSR, the principal value is autumn establishment. Faster root and rosette development helps the crop accumulate biomass and reserves before winter dormancy, particularly where post-sowing drought or large day–night temperature variation constrains early growth.

- Root dry biomass averaged +18.2% and shoot dry biomass averaged +17.8%.
- Average emergence improvement was +7.0%.
- Leaf number increased in 11 trials, averaging +4.7% and reaching a maximum of +14.5%.
- Average drought yield improvement was +3.01%. The most balanced response occurred on drought-prone loams, where the average yield gain was +4.29%, with root and shoot dry-matter improvements of +22.3% and +24.2%, respectively.

Sugar beet

Sugar beet shows strong potential for both establishment improvement and industrial-value enhancement, but it is also the crop most sensitive to cold, dry sowing conditions. Proper site and sowing-window selection are therefore essential.

- Root dry mass averaged +24.3%, with individual responses reaching +55.8%; shoot dry mass averaged +20.0%.
- Emergence improved by an average of +11.9% and was advanced by approximately one to two days in selected Slovak trials.
- In harvested trials, significant final root or sugar-corrected yield gains occurred in 5 of 10 cases, averaging +7.2%.
- Polarization increased by +2.7% in Romania and +3.4% in Czechia in selected trials, with reduced potassium and alpha-amino nitrogen indicating lower molasses-forming impurity potential.
- In a warm, exceptionally wet Romanian environment, sugar-corrected yield increased by +5.4%, polarization by +2.7%, and root dry mass by approximately +22%, showing that positive performance remains possible even under high rainfall where soil and crop conditions are favorable.

Soil and weather interaction

AQUAHOLDER performance depends on the interaction between soil texture, soil physical condition, sowing moisture, temperature, and subsequent rainfall or irrigation.

Soil × weather scenario	Expected value	Practical interpretation
Heavy/clay + drought	High	Priority application zone for corn and sunflower. The product can maintain a more pliable seed-zone microenvironment, reduce mechanical resistance, and support earlier root access to capillary water. Average yield gains: corn +8.79%; sunflower +6.73%; sugar beet +1.92%.
Medium/loam + drought	High to moderate	Particularly favorable for OSR and sugar beet. Loams balance water retention, drainage, and aeration. Average yield gains: OSR +4.29%; sugar beet +6.80%.
Heavy/clay + normal or wet moisture	Moderate biological value; lower yield certainty	Use where establishment uniformity, early vigor, root development, crop quality, or harvest-management benefits justify treatment.
Medium/loam + normal or wet moisture	Often neutral at harvest	Early benefits may be measurable, but final yield uplift should not be assumed because untreated crops can catch up.
Sandy + irrigation or dependable rainfall	Conditional opportunity	Use only where adequate moisture is available at drilling and is likely to continue during early development. Positive examples include sunflower +16.10% yield in Greece and OSR +5.00% average yield, including +18.9% in one Hungarian result.

Soil × weather scenario	Expected value	Practical interpretation
Coarse, low-organic-matter sand + drought at sowing	Avoid or validate locally first	Highest risk of inadequate polymer hydration, temporary competition for scarce water, reduced emergence, later water depletion, and yield loss.
Cold, dry clay + early sugar-beet sowing	Caution	Delay or avoid use until soil moisture and temperature are adequate for normal germination and polymer hydration.

Highest-value conditions

Heavy and clay soils under drought represent the broadest high-value application zone. When dry, these soils can crack, crust, and become mechanically resistant despite retaining water deeper in the profile. AQUAHOLDER can help maintain local seed-zone hydration and pliability, reducing the energy required for radicle penetration.

Medium and loam soils under drought also provide a favorable operating environment, particularly for OSR and sugar beet. They offer a more balanced combination of water storage, drainage, and aeration without the severe hydraulic limitations of coarse sand.

Water-masking effect

In normal, wet, or irrigated conditions, AQUAHOLDER can remain biologically active: roots, biomass, emergence, leaf number, flower-head diameter, or crop quality may improve. However, final yield differences can become small or statistically neutral because untreated plants do not face enough moisture stress for the treatment advantage to translate into harvest yield. This does not indicate product failure; it defines the technology as a risk-management tool rather than a luxury-input yield stimulant.

Operational risk boundaries

Bone-dry, coarse sandy soils with low organic matter are the primary risk scenario. When insufficient water is available at drilling, the polymer may not hydrate properly and can temporarily compete with

germinating seed for scarce moisture. In severe German examples, sugar beet showed −12.3% emergence and −25.0% yield, while OSR showed −5.9% yield. The resulting early canopy can also create higher later-season water demand after the local moisture reserve is depleted.

Cold, dry heavy clay is a second important risk scenario, particularly for early sugar-beet sowing. In a Czech trial at approximately 4.7°C soil temperature, the emergence response was −11.3%, consistent with delayed seed metabolism and limited polymer hydration.

Positioning and recommendations

AQUAHOLDER should be positioned as targeted establishment and drought-risk insurance at sowing. Its value proposition is improved crop reliability where early seed-zone moisture limitation and soil physical constraints threaten establishment, rather than a promise of a universal yield increase in every field and season.

- **Prioritize corn and sunflower on drought-prone heavy or clay soils.** This is the strongest multi-crop fit because the treatment addresses both localized moisture limitation and mechanical resistance in drying soil.
- **Prioritize OSR for autumn drilling on drought-prone loam soils.** The main benefit is reliable root-and-rosette establishment before winter, with a meaningful yield-protection pattern where autumn moisture stress occurs.
- **Use sugar beet selectively on medium-to-heavy soils with adequate sowing moisture and temperature.** Potential value includes establishment, root yield, sugar-corrected yield, polarization, and reduced impurities, but cold dry clay and bone-dry coarse sand should be excluded.
- **Treat sandy soils as conditional opportunities, not default targets.** Consider treatment only where moisture is present at drilling and reliable rainfall or irrigation is available through early growth. Local validation is recommended before broad commercial deployment.
- **Set realistic expectations in favorable seasons.** Communicate that safe early-vigor effects may occur under normal or wet conditions, while final yield differences may remain small because untreated plants can catch up.

- **Screen fields before use.** Assess soil texture, organic matter, seedbed moisture, soil temperature, compaction/crusting risk, forecast rainfall, irrigation availability, crop species, and growth-stage sensitivity.

Final statement

AQUAHOLDER has a clear, commercially defensible role as a seed-zone moisture-management technology for more reliable establishment and drought-stress buffering. The highest return is expected in drought-prone medium-to-heavy soils with sufficient initial moisture for product hydration—especially corn and sunflower on clay soils, OSR on loam soils, and carefully selected sugar-beet sites. Proper environmental targeting, rather than blanket application, is the key to consistent agronomic performance and grower return on investment.