

BIOENZYMATIC SOIL AND PLANT REGENERATION:

ESSTENCE MICROBIAL PATHWAYS, SOIL PHYSIOLOGICAL STABILIZATION AND CROP SECURITY

Interpretation for Company Executives

Interpretation for Plant Protection Specialists

Wheat control and Esstence –2019 Kiskunfélegyháza



INTERPRETATION FOR COMPANY EXECUTIVES

THE SYSTEMIC PROBLEM – NOT THE SOIL ITSELF, BUT A FAILURE OF BALANCE

One of the greatest risks in modern crop production is not nutrient deficiency but the lack of biological balance.

Decades of fertilizer and pesticide use have indeed provided short-term yield stability, but have gradually depleted the microbial diversity of the soil – the very foundation of nutrient utilization and plant health.

Consequences:

- Reduced nutrient availability
- Increased pathogen pressure
- Deterioration of soil water balance and pH stability
- Plants devote most of their energy to defense rather than growth

The real problem is therefore not the intensity of production, but that the biological foundations of the system have been exhausted.

Esstence technology provides a system-level solution by restoring the microbial balance of both soil and plant.

ESSTENCE AS A BIOLOGICAL ORGANIZING PRINCIPLE

Esstence is a biological soil- and plant-regenerating system based on **worm humus, humic–fulvic acid complexes**, and **stable microflora**.

It does not add more nutrients but restores the natural relationships among soil, plant, and microorganisms.

The microbial consortia (e.g. *Bacillus*, *Pseudomonas*, *Azospirillum*, *Trichoderma*, *Streptomyces*) are jointly capable of:

- Mobilizing soil nutrients
- Regulating plant hormonal balance
- Suppressing phytopathogenic organisms
- Degrading pesticide and mycotoxin residues
- Enhancing stress tolerance

Esstence is not a chemical, but a **physiological solution**: by re-establishing biological self-regulation, it stabilizes the production system.

The technology does not force performance through external inputs; instead, it restores the natural soil–plant communication, allowing the plant's own regulatory mechanisms (hormonal, microbial, antioxidant) to actively respond to environmental changes.

As a result, production becomes more resilient to stress factors, and the system maintains higher biological efficiency with lower input requirements.



MECHANISMS AT THE OPERATIONAL LEVEL

I. Activation of Soil Life and Nutrient Preservation

Esstence's humic and fulvic acid complexes stabilize soil pH, improve water retention, and stimulate the activity of nutrient-mobilizing microorganisms.

Bacillus megaterium and *Pseudomonas putida* solubilize bound phosphorus and potassium, while *Azospirillum* and *Azotobacter* fix atmospheric nitrogen, ensuring continuous N–P–K and micronutrient availability for plants.

With regular use:

- **20–100 % fertilizer savings** can be achieved (complete replacement achievable after multiple years)
- Salt damage and nitrate leaching decrease
- Soil nutrient-holding and buffering capacity increase
- Water-use efficiency improves

II. Plant Physiological Stability and Stress Tolerance

Esstence microorganisms produce plant-usable or plant-like hormones (auxins, gibberellins, cytokinins) that stimulate root formation, cell division, and photosynthesis.

Plants thus save energy — spending less on defense and more on growth.

By activating antioxidant enzymes (SOD, CAT, POD), plants increase tolerance to drought, heat, and UV stress.

Cell walls become more stable, water loss decreases, and plants remain physiologically active for longer periods.

Results:

- Balanced growth
- Better nutrient utilization
- Higher nutritional and antioxidant content
- Improved transportability and shelf life

III. Natural Protection Against Pathogens and Pests

The microbial community in Esstence acts as a natural antagonist to soil-borne pathogens.

Trichoderma and *Streptomyces* species enzymatically degrade fungal cell walls, while *Bacillus* and *Pseudomonas* strains produce antibiotics and siderophores that suppress pathogenic microbes.

Bacillus thuringiensis species — naturally present in worm humus — produce proteins that selectively destroy insect larvae without harming pollinators such as bees, bumblebees, or parasitic wasps.

The plant's immune system is activated (Induced Systemic Resistance, ISR), providing preventive protection against fungal and bacterial infections.

IV. Detoxification of Mycotoxins and Pesticide Residues

Microbial oxidative and hydrolytic enzymes degrade pesticide and toxin residues such as **aflatoxin**, **zearalenone**, **deoxynivalenol**, and **chlorpyrifos**. Humic acids bind the resulting compounds, making the process safe, stable, and irreversible.

As toxic substance levels in the soil gradually decrease, microbial life returns — transforming the soil back into a living system.

V. Impact of Esstence-Grown Feed on Animal Performance

Plants grown with Esstence contain higher levels of enzymes, amino acids, vitamins, and antioxidants, while exhibiting lower mycotoxin, nitrate, and pesticide residue levels. This significantly reduces metabolic and oxidative load in animals.

When animals are fed Esstence-grown feed, their digestive systems operate under a more stable pH balance. Humic acids and microbial bioactive compounds restore the functional diversity of the gut microbiota, improving nutrient absorption and metabolic efficiency.

The result is more efficient protein and energy utilization, reduced intestinal and liver load, and a more balanced energy flow toward metabolic processes.

Long-term Esstence use stabilizes fermentation microflora in the rumen and cecum: *Lactobacillus*, *Bacillus*, and *Aspergillus* species optimize the lactic- to acetic-acid ratio, leading to a balanced fermentation profile and increased fiber-degradation activity.

This not only enhances nutrient efficiency but also reduces **ammonia** and **methane** emissions, while animals exhibit better condition, stress tolerance, and immune response.

Performance improvement originates from **plant biological stability** and manifests in animal physiology.

(For more information, see *Esstence – Monogastrics* and *Esstence – Ruminants* summaries.)

EXPECTED RESULTS AND BUSINESS BENEFITS

Indicator	Change	Direct Effect
Fertilizer use	-20–100 %	Lower input cost
Pesticide use	-30–50 %	Biological pathogen control
Pathogen pressure	-60–70 %	Healthier crop stands
Yield quantity	+10–30 %	Stable yield
Product quality	+15–25 %	Higher nutritional value and antioxidant level
Shelf life	+20–30 %	Improved transportability and market value
N ₂ O and CO ₂ emissions	-5–10 %	Toward carbon-neutral production
Pollinator-friendly operation	100 %	Ecological safety

ENVIRONMENTAL AND REGULATORY ADVANTAGES

Esstence is:

- GMO- and chemical-free
- Permitted in organic farming
- Has zero-day worker and food safety waiting period
- Harmless to pollinators and other beneficial organisms
- Leaves no chemical residues
- Compatible with all existing technologies

Thus, applying Esstence is not only a professional choice but also a **corporate-level risk-mitigation strategy**, ensuring a safer working environment, more stable yields, and lower environmental impact.

SUMMARY

Esstence is the biological safeguard of agricultural production – a complex, self-regulating system that restores the natural balance between soil and plants.

At the **economic level**, it:

- Reduces input costs
- Increases yield stability and quality
- Enhances market value
- Improves long-term sustainability

At the **ecological level**, it:

- Regenerates soil life
- Is safe for beneficial organisms
- Supports carbon sequestration and biodiversity

Esstence is not a “new nutrient,” but a **new operating principle**.

The Esstence technology represents a **scientifically grounded, system-level tool of regenerative agriculture**, building the future of production on biological stability and self-regulation.

It sustains productivity not through chemical intervention, but by restoring the natural biological equilibrium among soil, plants, and animals – reactivating microbial, enzymatic, and physiological processes.

This approach not only maintains but strengthens the **ecological capacity** of the production site while reducing emissions, nutrient losses, and external input dependency.

Rendben – itt következik az **“Interpretation for Plant Protection Specialists”** rész teljes angol fordítása, az eredeti magyar dokumentum szerkezete, alcímei, felsorolásai és formátuma szerint:

INTERPRETATION FOR PLANT PROTECTION SPECIALISTS

The interface between plant protection and plant physiology today is increasingly based on **soil biology** and **microbial balance**.

Plant health is not solely the result of chemical protection, but rather of the stability of a **microbial–biochemical system** in which nutrients, hormones, and signaling molecules are in dynamic equilibrium.

Esstence technology restores this balance through **bioenzymatic processes**: it is a **bio-mineral system** based on worm humus, operating with humic–fulvic acid complexes and a stable community of bacteria and microfungi, with detectable effects in the soil, the rhizosphere, and within plant tissues.

The product is **GMO- and chemical-free, approved for organic farming**, has a **zero-day re-entry and food safety interval**, and is **harmless to pollinators and higher organisms**.

The system is not merely an additive but an **active microbial ecosystem** that regenerates soil, protects plants, and enzymatically decomposes toxic organic and inorganic loads.

MICROBIAL COMMUNITY AND FUNCTIONAL ROLE

Based on 16S and ITS metagenomic analyses, the dominant taxa of Esstence are:

- *Bacillus* spp. (*B. subtilis*, *B. thuringiensis*, *B. megaterium*, *B. licheniformis*)
- *Pseudomonas* spp. (*P. fluorescens*, *P. putida*)
- *Azospirillum* spp., *Azotobacter* spp.
- *Trichoderma* spp., *Streptomyces* spp., *Aspergillus* spp., *Penicillium* spp., *Saccharomyces* spp.

This community consists of **PGPR** (Plant Growth-Promoting Rhizobacteria) and **biocontrol microorganisms** that mobilize nutrients in the soil and on plant surfaces, synthesize plant hormones (IAA, GA, CK), inhibit phytopathogens, and degrade toxic compounds (Spaepen et al., 2007; Haas & Défago, 2005; Canellas & Olivares, 2014).

Bacillus thuringiensis produces **Cry toxins** that provide natural biological protection against foliar and root pest larvae, reducing their egg production by up to 80–90 %, while remaining completely harmless to pollinators and other beneficial organisms (Herman et al., 2021).

BIOCHEMICAL PATHWAYS AND SOIL–PLANT INTERACTIONS

I. Soil Structure and Nutrient Stabilization

Humic and fulvic acids, through their polymerization and chelating capacities, create stable microaggregates that increase soil porosity, water-holding capacity, and pH buffering.

The **phosphatase** and **phytase** activity of *Bacillus megaterium* enhances the solubility of bound phosphorus, while *Azospirillum* and *Azotobacter* species, through nitrogen fixation and **siderophore** production, improve the plant's N and Fe supply (Rodríguez & Fraga, 1999; Steenhoudt & Vanderleyden, 2000).

With regular Esstence application, the soil's nutrient retention capacity increases, fertilizer demand can decrease by **20–100 %**, and nitrate-related risks are mitigated.

Humus chelates immobilize toxic metal ions (Fe, Zn, Mn, Cu, Pb, Cd) in insoluble forms, thereby reducing heavy-metal uptake and ion stress.

II. Biological Inhibition of Phytopathogens and Insect Pests

The microflora of Esstence acts as a **natural antagonist** to soil- and foliar-borne pathogens.

Trichoderma harzianum and *Streptomyces* species degrade fungal cell walls through **chitinase** and **glucanase** systems, while *Pseudomonas fluorescens* and *Bacillus subtilis* strains produce **antibiotics** (iturin, fengycin, surfactin) and **siderophores** that sequester iron from pathogens, inducing competitive inhibition (Haas & Défago, 2005; Tian et al., 2018).

In plant defense, **Induced Systemic Resistance (ISR)** triggered by microorganisms is crucial: through **PR-gene** activation, plants enter a preventive immune state where infection intensity decreases on average by 60–70 % (Pieterse et al., 2014).

Because of the selectivity of *B. thuringiensis* toxins, Esstence is **pollinator-friendly**, making it suitable for integration into **eco-friendly** and **organic crop-protection systems**.

III. Mycotoxin and Pesticide Detoxification

The bioenzymatic community of Esstence can degrade several toxin groups described in the literature:

Substance / Toxin	Main Active Microorganism	Enzyme System	Detoxification Efficiency / Literature
Aflatoxin B₁	<i>Bacillus amyloliquefaciens</i> , <i>Trichoderma harzianum</i>	Epoxide-reduction / laccase	70–95 % (Chen et al., 2022; Gao et al., 2024)
Zearalenone	<i>Aspergillus niger</i> , <i>Bacillus</i> <i>licheniformis</i>	Aromatic oxidation / ester hydrolysis	60–90 % (Jia et al., 2024)
Deoxynivalenol	<i>Bacillus subtilis</i> , <i>Lactobacillus</i> <i>casei</i>	Epoxide hydrolase / reductase	65–85 % (Gao et al., 2024)
Chlorpyrifos, Pyrethroids	<i>Pseudomonas putida</i> , <i>Bacillus</i> <i>megaterium</i>	Hydrolase / monooxygenase	80–90 % (Liu et al., 2025)

During the degradation process, toxic **epoxide** and **lactone rings** open, producing biologically inactive metabolites, while the humic-acid matrix binds free radicals and incorporates heavy metals into chelated complexes.

Thus, the system provides **dual defense** at both chemical and biological levels.

IV. Stress Tolerance and Antioxidant Defense

Antioxidant enzymes (**SOD, CAT, POD**) produced by *Bacillus subtilis* and *Trichoderma harzianum* neutralize reactive oxygen species (ROS), while *Lactobacillus plantarum* and *Azospirillum* species synthesize **osmoprotectants** (trehalose, proline) that increase the water-holding capacity of cell walls (Egamberdieva et al., 2017; Zhang et al., 2020).

Humic acids enhance **chlorophyll synthesis** and **photosynthetic activity**, increasing sugar and protein production.

Plants show greater tolerance to drought, temperature fluctuations, and UV exposure; leaf antioxidant status may rise by **20–40 %**.

PHYSIOLOGICAL AND AGRONOMIC CONSEQUENCES

- **Root-zone regeneration:** larger root surface area, enhanced nutrient uptake and water efficiency
- **Leaf and shoot physiology:** increased chlorophyll content and photosynthetic intensity (+10–20 %)
- **Pathogen pressure reduction:** *Fusarium*, *Rhizoctonia*, *Pythium* infections can decrease by 60–80 %
- **Nutrient retention:** improved nutrient retention through humus chelates, reduced leaching
- **Storability and transportability:** Esstence-treated plants exhibit more elastic cell walls and higher antioxidant content → improved post-harvest shelf life

The system can be fully integrated into existing plant-protection technologies, does not inhibit mycorrhizal or nitrogen-fixing inoculants, and can be applied directly as **foliar or soil treatment** — even in combination with other biological products.

SUMMARY

Esstence is not merely a nutrient source but a **complex biological system** that restores the natural relationship among soil, plant, and microbiome.

In plant-protection practice, this means that the biological system:

- Restores microbial balance
- Enzymatically degrades toxic contaminants
- Activates plant immune responses
- Is safe for ecosystems and pollinators
- Reduces fertilizer and pesticide requirements
- Increases plant stress tolerance and yield security

Based on scientific data, the **microbial–enzymatic system** of Esstence can achieve:

- 80–85 % detoxification efficiency
- 60–70 % reduction in pathogen pressure
- 20–30 % improvement in stress tolerance

Based on scientific data, the microbial–enzymatic system of Esstence can achieve 80–85% detoxification efficiency, a 60–70% reduction in pathogen pressure, and a 20–30% improvement in stress tolerance. (Chen et al., 2022; Tian et al., 2018; Liu et al., 2025).

This technology provides plant-protection specialists with a **microbiology-based tool for biological balance**, which does not replace but strengthens conventional crop protection and forms a **scientifically validated pillar** of sustainable, regenerative agriculture.

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CROP PRODUCTION Esstence Detoxification and Stress Reduction Map								
Mycotoxin / Pollutant	Effect on Soil / Plant (without Esstence)	Microorganisms Proven Effective in Literature	Taxa Identified in Esstence	Biochemical Detoxification Pathway	Enzyme / Mechanism + Combined Esstence Effect	Reported Efficiency (%)	Expected Esstence Effect	References (Author + Year)
Aflatoxin B ₁ (AFB ₁)	DNA damage, inhibition of germination and growth	Bacillus amyloliquefaciens WF2020; Bacillus sp.	Bacillus spp.	Epoxide ring oxidation / hydrolysis, laccase-like activity	Extracellular proteins/enzymes degrade AFB ₁ ; rhizosphere protection	~60–95	~85% reduction + decreased oxidative stress	Chen et al., 2022; Guo et al., 2024; Tang et al., 2024 (PMC)
Aflatoxin B ₁ (CotA laccase)	Same as above	Bacillus licheniformis (CotA)	Bacillus spp.	Multicopper-laccase oxidation	Laccase-mediated oxidation → less toxic metabolites	70–90+	~80% reduction (enzymatic)	Sun et al., 2023 (ScienceDirect)
Zearalenone (ZEA)	Hormonal disorder, reduced fertility	Bacillus licheniformis (CotA), Bacillus sp. B73	Bacillus spp., Streptomyces / Aspergillus (enzymatic medium)	Lactone ring hydrolysis / oxidation	ZEA-hydrolase / laccase; elimination of estrogenic activity	~60–100	~80% reduction → fertility/yield stabilization	Guo et al., 2022; Liu et al., 2023 (ScienceDirect)
Deoxynivalenol (DON)	Inhibition of protein synthesis, chlorosis	Devosia sp. (de-epoxidation to DOM-1); LAB	Bacillus / Lactobacillus (associated community)	Epoxide-group reduction / de-epoxidation	DON → DOM-1 (low toxicity); decreased leaf/seed toxin load	~65–85	~75% detoxification → improved quality	Gao et al., 2021; Pinto et al., 2022; Yu et al., 2025 (PMC)
Ochratoxin A (OTA)	Cell / root damage	Aspergillus niger, Bacillus, LAB	Aspergillus / Bacillus / Lactobacillus	Amide hydrolysis → OTα	OTA-amidase / carboxypeptidase; cleavage of toxic ring	~75–95	~85% effect → improved soil biology	Chen et al., 2018; Wang et al., 2022 (PMC)
Patulin	Membrane damage, ROS stress	Saccharomyces cerevisiae	Saccharomyces spp., LAB	Aldehyde reduction → less toxic acids	Dehydrogenase chain; antioxidant protection	~80–100	~90% degradation + improved antioxidant status	Zhu et al., 2023; Yang et al., 2024 (PubMed)
Fusarium toxin cocktail (DON+ZEA+...)	Combined cellular damage, inhibition of germination	Trichoderma spp. (antagonism, toxin reduction)	Trichoderma spp., Bacillus / Lactobacillus	Multi-enzymatic degradation + ISR	Chitinase, glucanase, laccase; inhibition of toxin biosynthesis	60–90	~80% combined effect → yield stabilization	Tian et al., 2018; Modrzewska et al., 2024 (Frontiers)
Pyrethroids (e.g. β-cypermethrin, permethrin, etc.)	Phytotoxicity, root stress	Pseudomonas aeruginosa PAO1	Pseudomonas spp., Bacillus	Hydrolysis / oxidation (esterase, monooxygenase)	Rapid degradation of residues in the rhizosphere	≥84 (36 h)	~80–85% residue reduction → lower plant stress	Liu et al., 2025; Chen et al., 2023; Cycoń et al., 2016 (PubMed)

Mycotoxin / Pollutant	Effect on Soil / Plant (without Esstence)	Microorganisms Proven Effective in Literature	Taxa Identified in Esstence	Biochemical Detoxification Pathway	Enzyme / Mechanism + Combined Esstence Effect	Reported Efficiency (%)	Expected Esstence Effect	References (Author + Year)
Chlorpyrifos	Enzyme inhibition, microbial community disturbance	Pseudomonas spp.; consortia	Pseudomonas spp.	Hydrolysis (organophosphorus hydrolase), oxidation	CP → 3,5,6-TCP breakdown; community-based degradation	~65–80	~70% reduction (realistic under field conditions)	Kumar et al., 2022; Liu et al., 2025; Wepukhulu et al., 2024 (PMC)
Carbendazim (MBC)	Soil toxicity, decreased microbial activity	Bacillus velezensis; Aspergillus / Penicillium	Bacillus / Aspergillus / Penicillium	Benzimidazole-ring degradation (hydrolysis / oxidation)	Enzymatic degradation → faster half-life	70–95	~80–90% degradation → reduced phytotoxicity	Song et al., 2024; Zhou et al., 2024; Raheem et al., 2023/2024 (PubMed)
Glyphosate (GLP)	Impact on microbial community; alteration of N-enzymes	Microbial consortia (e.g. Pseudomonas)	Pseudomonas spp.	C–P lyase pathway, AMPA pathway	Microbe-mediated degradation; soil pathways may shift	80–100 (consortium, 36 h / 50 mg L ⁻¹)	~70–85% (in agricultural soil, mixed communities)	Zhang et al., 2024; Chen et al., 2022 (soil study observation) (ScienceDirect)
Phenolic / Aromatic Organic Pollutants	Root toxicity, reduced microbial activity	Laccase-/peroxidase-based systems (bacterial/fungal)	Streptomyces / Bacillus / Aspergillus / Trichoderma	Oxidative ring cleavage	Laccase / peroxidase → transformation toward humification	70–100	~85–90% degradation + enhanced soil enzyme activity	Xia et al., 2021; Thathola et al., 2024; Singh et al., 2024 (PMC)
Heavy Metals (Cd, Pb – phytotoxicity)	Inhibition of germination/root growth, ROS, ion homeostasis disorder	Siderophore-producing Bacillus; Trichoderma spp.	Bacillus / Trichoderma / Pseudomonas	Chelation, biosorption, antioxidant response	Fe-siderophores / exopolymers reduce metal bioavailability	Reduction in tissues (variable, 30–75+)	~40–70% phytotoxicity reduction + increased enzyme activity	Wu et al., 2024; Chi et al., 2022; Landero-Valenzuela et al., 2024; Li et al., 2023 (PMC)
Fusarium antagonism (reduced toxin production)	Mycotoxins (T-2/HT-2, DON)	Trichoderma spp.	Trichoderma spp.	Competition, mycoparasitism, ISR	Chitinase / glucanase; suppression of toxin biosynthesis	“Significant” (lab / co-culture)	~70–90% reduction in toxin production (culture-dependent)	Modrzewska et al., 2024; Modrzewska et al., 2022 (Nature)
Nitrogen cycle (ammonia → NO ₃ ⁻ ; N ₂ O risk)	N losses, N ₂ O emissions	Bacillus / Paenibacillus (urease/denitrification genes), Pseudomonas	Bacillus / Paenibacillus / Pseudomonas	Urease, nitrate/nitrite reductase, nosZ	“Fine-tuning” of N transformations; potential N ₂ O mitigation	Variable (environment-dependent)	~10–30% N ₂ O reduction (conditional, soil-dependent)	Wang et al., 2023; Bano et al., 2024; Salazar et al., 2023 (Frontiers)