



Canola

CHALLENGES IN CHARACTERIZING PRODUCT PERFORMANCE IN MULTIFACTOR ENVIRONMENTS

—
Daniel McDonald

Co-Founder and President

Phenotype Screening Corporation

AGENDA

- The Challenge
- The System
- The Measurements
- The Analysis
- The Impact

Cotton Field, Starkville, MS



Coffee Plantation, Kona, Hawaii





INTRODUCTION

Our clients have important questions about their products under development and in the market.

Phenotype Screening Corporation works with commercial companies to evaluate product performance using a laboratory-based system to grow and treat subject plants followed by phenotypic analysis.

Our focus is on whole-plant interactions.

Our clients come to us from the agriculture, horticulture and forestry industries.

CHALLENGES IN CHARACTERIZING PRODUCT
PERFORMANCE IN MULTIFACTOR ENVIRONMENTS



THE CHALLENGE

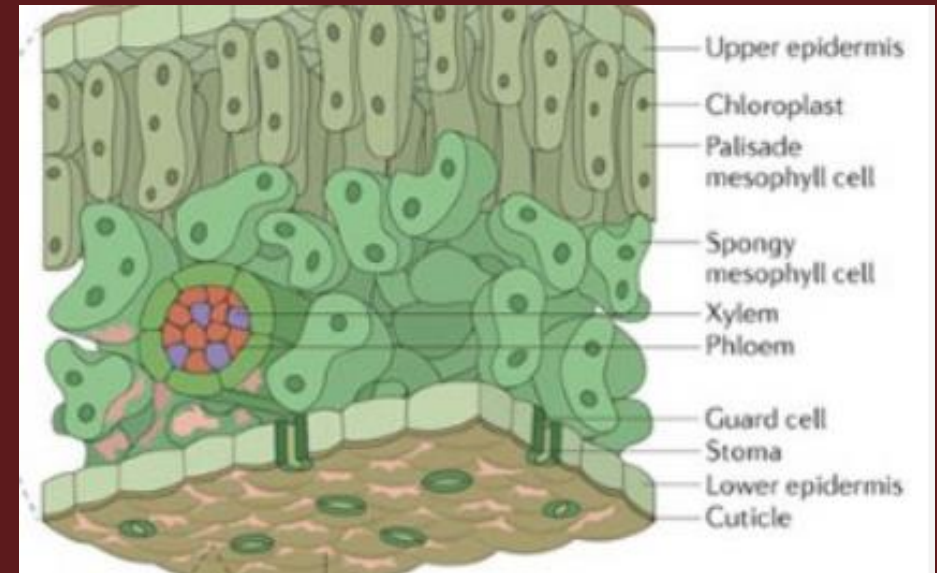
The characterization of the whole-plant impact of modern agricultural treatments requires understanding of both the phyllosphere and the rhizosphere. These spheres are living ecosystems. In each case, these spheres interact with abiotic and biotic factors in a complex, dynamic and interactive manner.

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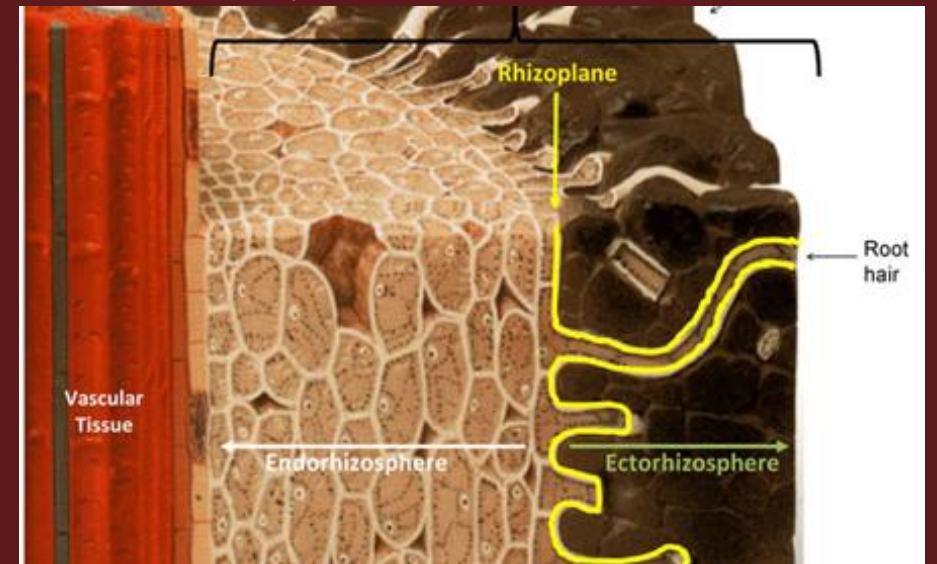
A LITTLE CLARIFICATION

- The spheres include plant tissue and its biochemistry, the interface between the plant and the external world and volumetric effects a short distance from the interface due to the external world and the plant's biochemical response to it.
- Microorganisms and their interactions are included in the spheres.

Phyllosphere (Vorholt 2012)



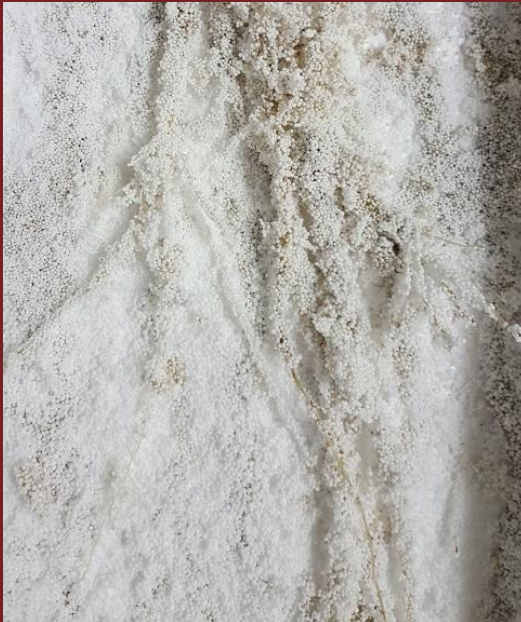
Rhizosphere (McNear 2013)





THE SYSTEM

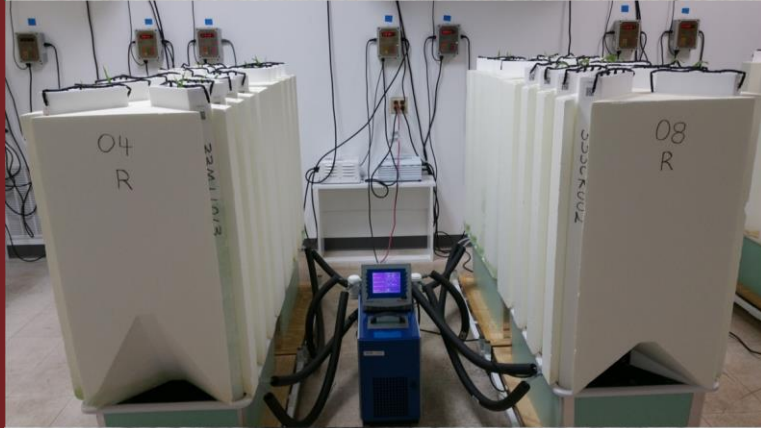
To respond to our clients' queries, we've developed a unique, comprehensive laboratory-based "induced-expression" phenotyping system that allows for study of both the phyllosphere and the rhizosphere.



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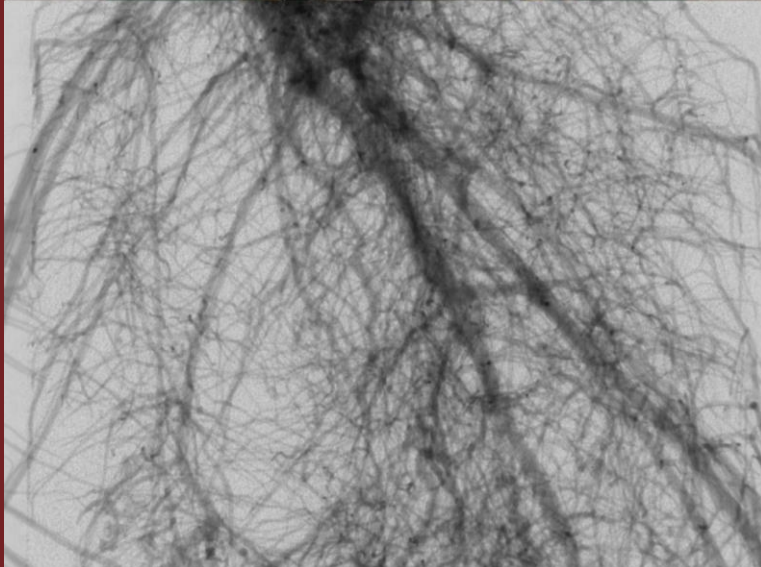


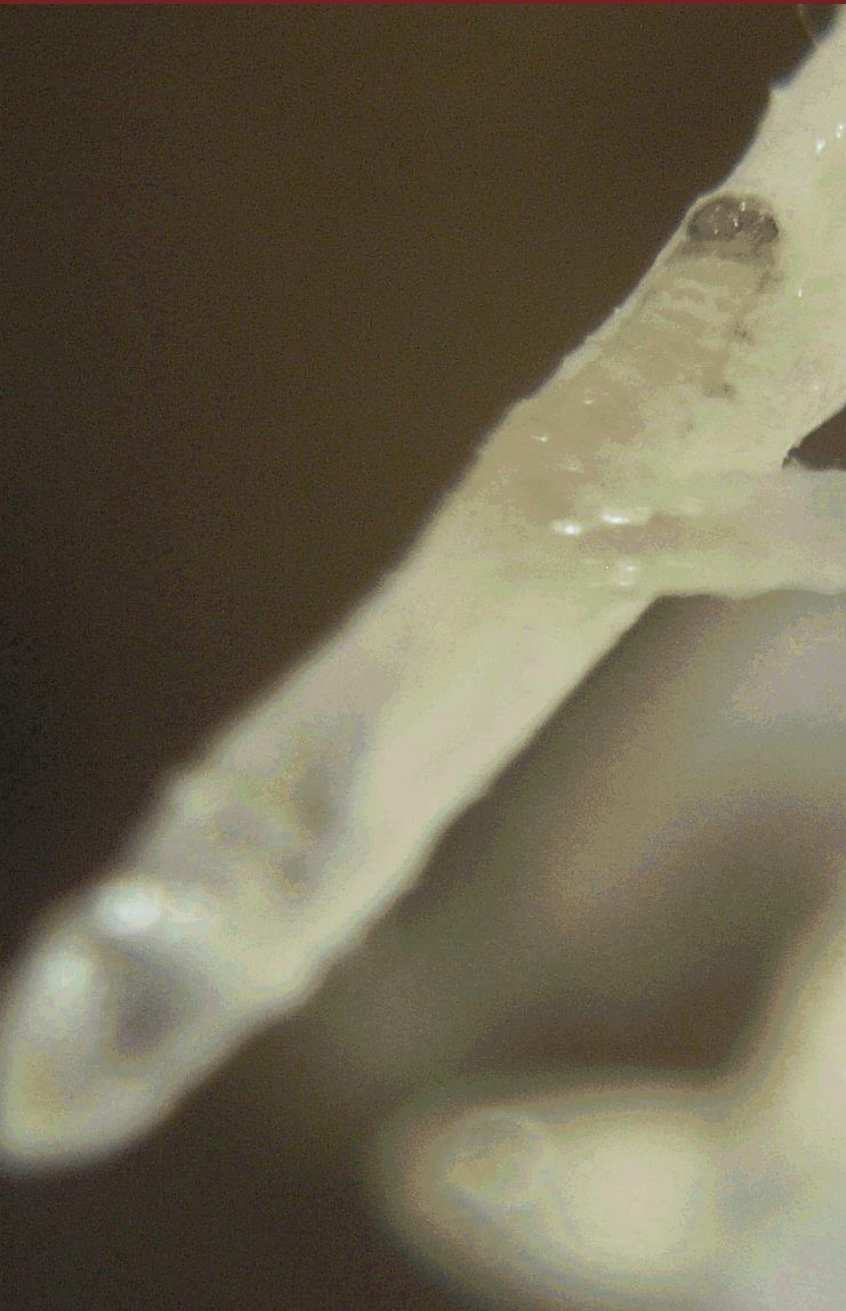
SPECIAL INERT MEDIA



Our plants are grown in a special media, expanded polystyrene (EPS). This media is inert, transparent to X-rays, offers physical support for the plant and root system, and has low water retention, comparable to coarse sand.

This media allows us to precisely adjust the watering rate, nutrient formulation, inoculum level and the product concentration to the plant.

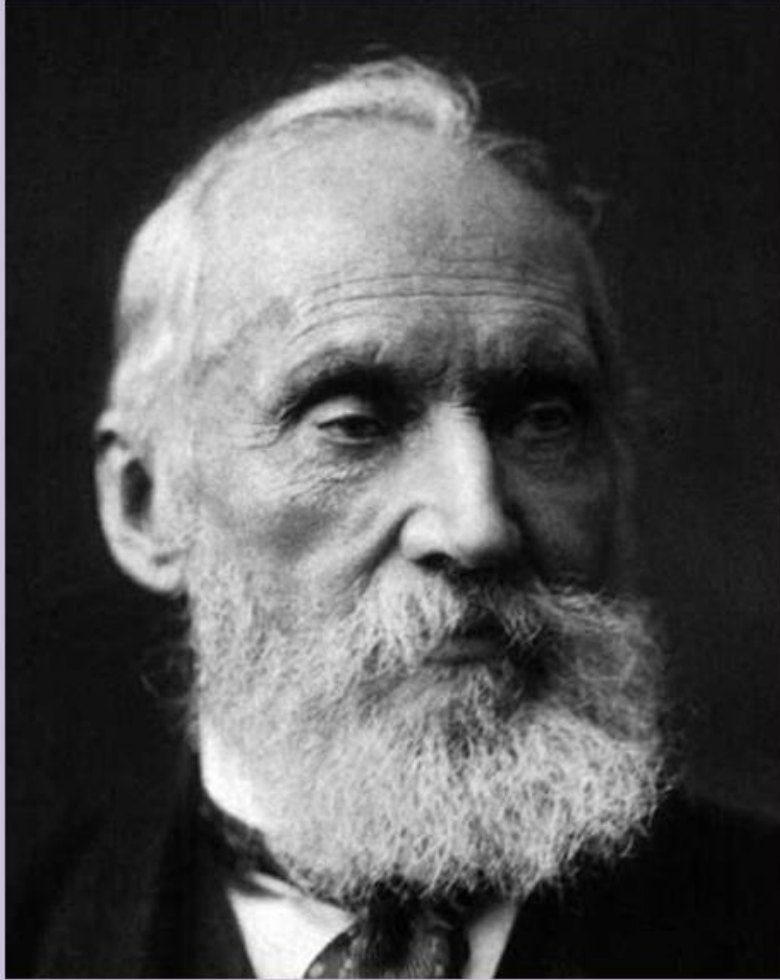




CORN ROOT WORM FEEDING

Generally, the plants are grown in our media for the duration of the experiment, however, at any time we can open a container, shake away the media and physically examine and sample clean root tissue. Our system has been used to investigate insect, nematode, fungi, and bacteria interactions with our plants under test.

UNDERSTANDING REQUIRES MEASUREMENT



"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be."

Lord Kelvin, 1883

MEASUREMENTS

We perform a suite of measurements on the roots and shoots of our plants throughout their developmental stages.



Non-destructive X-ray Imaging of Root System



Multiwavelength Leaf Reflectance



Wet and Dry Weight of Roots and Shoots



Joliot Spectrometer for Photosynthetic Efficiency

CHALLENGES IN CHARACTERIZING PRODUCT PERFORMANCE IN MULTIFACTOR ENVIRONMENTS

PRACTICAL & SCIENTIFIC LEAF INVESTIGATIONS

Foliar and in-furrow product formulations interact with the plant physically and chemically. The dynamics of these interactions are captured via plant height, leaf area, leaf mass, chlorophyll content, light absorption spectra, and photosynthetic efficiency measurements.



Surface Tension Measurement
for Characterizing Product Spread



Leaf Area Determination



Leaf Interaction with Light

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PRACTICAL & SCIENTIFIC ROOT INVESTIGATIONS

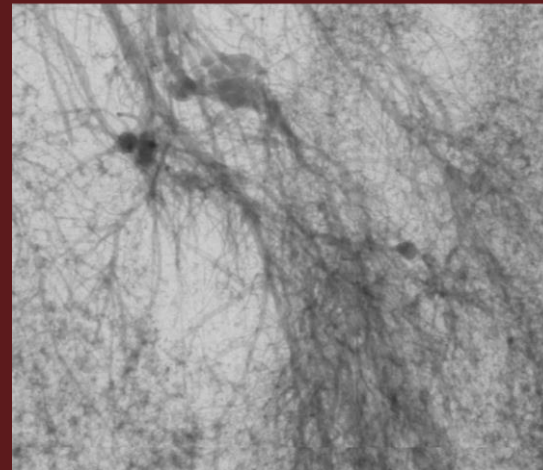
Foliar and in-furrow product formulations also impact the root system, affecting the root system architecture and the chemical composition of the rhizosphere. Our software extracts important metrics of the root system (area, length, size distribution, and density by depth.) Our measurements also include the extraction of root exudates and metabolite analysis.



Maize Root



Root Mucilage



Root Knot Nematode
Galls in Sunflower Root



Microorganism Consortia
Delivery Package

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(min)	compound	BSMMS category	formula
1.147	Glycine	bile acids & bile salts 4	C2H5NO2
1.174	Alanine/Sarcosine	Amino acids; amino acid precursors and derivatives 40	C3H7NO2
1.145	Serine	Amino acids; amino acid precursors and derivatives 48	C3H7NO3
1.841	Uracil	other 29	C4H4N2O2
1.999	2-Oxoisovalerate	amino acid metabolism 8	C5H8O3
1.414	Valine/betaine	Amino acids; amino acid precursors and derivatives 39	C5H11NO
1.196	Homoserine/Threonine	Amino acids; amino acid precursors and derivatives 18	C4H9NO3
1.182	Taurine	bile acids & bile salts 5	C2H7NO3
3.289	Thymine	Nucleosides nucleotides and analogues 70	C5H6N2O
2.04	Leucine/Isoleucine	Amino acids; amino acid precursors and derivatives 46	C6H13NO
2.25	Leucine/Isoleucine	Amino acids; amino acid precursors and derivatives 46	C6H13NO
1.144	Asparagine	Amino acids; amino acid precursors and derivatives 41	C4H8N2O
4.49	Aspartate	Amino acids; amino acid precursors and derivatives 28	C4H7NO4
3.464	Anthranilate	amino acid metabolism 2	C7H7NO2
1.677	phosphorylethanolamine	other 1	C2H8NO4
0.906	alpha-Ketoglutarate	TCA cycle 2	C5H6O5
1.167	Glutamine	Amino acids; amino acid precursors and derivatives 12	C5H10N2
0.921	Lysine	Amino acids; amino acid precursors and derivatives 32	C6H14N2
4.372	Glutamate	Amino acids; amino acid precursors and derivatives 11	C5H9NO4
2.773	2-Oxo-4-methylthiobutanoate	Lipids and lipid-like molecules 13	C5H8O3S
1.748	Methionine	Amino acids; amino acid precursors and derivatives 21	C5H11NO
1.242	xylitol	carbohydrates and carbohydrate conjugates 13	C5H10O5
2.815	Guanine	Nucleosides nucleotides and analogues 65	C5H5N5O
2.89	Xanthine	Nucleosides nucleotides and analogues 71	C5H4N4O
4.75	Hydroxyphenylacetate	amino acid metabolism 26	C8H8O3
1.809	Vanillin	other 8	C8H8O3
1.21	Xylitol	carbohydrates and carbohydrate conjugates 12	C5H12O5
5.438	2_3-Dihydroxybenzoate	other 3	C7H6O4
0.955	Histidine	Amino acids; amino acid precursors and derivatives 16	C6H9N3O
7.905	Orotate	Nucleosides nucleotides and analogues 67	C5H4N2O
5.553	Dihydroorotate	Amino acids; amino acid precursors and derivatives 45	C5H6N2O
1.288	Allantoin	other 26	C4H6N4O
1.205	Methionine sulfoxide	Amino acids; amino acid precursors and derivatives 33	C5H11NO
4.327	Phenylalanine	Amino acids; amino acid precursors and derivatives 36	C9H11NO
5.402	Uric acid	other 28	C5H4N4O
7.089	sn-Glycerol 3-phosphate	Glycolysis & Gluconeogenesis 1	C3H9O6P
1.251	N-Acetylornithine	Amino acids; amino acid precursors and derivatives 24	C7H14N2
0.963	Arginine	Amino acids; amino acid precursors and derivatives 7	C6H14N4
1.192	Citrulline	Amino acids; amino acid precursors and derivatives 42	C6H13N3
6.27	Ascorbate	Vitamins 5	C6H8O6
2.682	tricarballic acid	other 19	C6H8O6
1.447	N-Carbamoyl-L-aspartate	amino acid metabolism 16	C5H8N2O
4.911	Allantoate	Amino acids; amino acid precursors and derivatives 5	C4H8N4O
5.852	Gluconolactone	Pentose phosphate 10	C6H10O6
1.206	Glucosamine	carbohydrates and carbohydrate conjugates 3	C6H13NO
5.164	myo-Inositol	carbohydrates and carbohydrate conjugates 5	C6H12O6
2.683	Tyrosine	Amino acids; amino acid precursors and derivatives 38	C9H11NO
9.885	Homovanillic acid (HVA)	other 6	C9H10O4
3.693	4-Pyridoxate	Vitamins 4	C8H9NO4
1.54	Acetyllysine	Amino acids; amino acid precursors and derivatives 4	C8H16N2
4.995	2-Dehydro-D-gluconate	Pentose phosphate 1	C6H10O7
4.876	D-Gluconate	Pentose phosphate 7	C6H12O7
7.443	Tryptophan	Amino acids; amino acid precursors and derivatives 55	C11H12N
3.737	Kynurenine	amino acid metabolism 18	C10H12N
5.723	Jasmonate	Lipids and lipid-like molecules 23	C12H18O
0.132	Pantothenate	Vitamins 3	C9H17NO
1.249	N-Acetylglucosamine	carbohydrates and carbohydrate conjugates 6	C8H15NO
1.144	Cystathionine	amino acid metabolism 15	C7H14N2

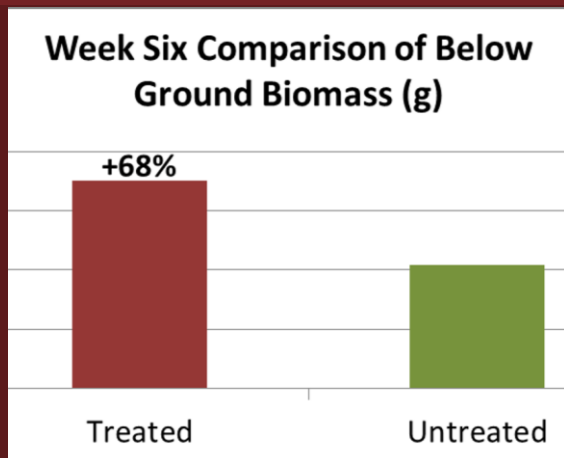
THE ANALYSIS

Each of our experiments generate multiple gigabytes of data in the forms of images and tables. We perform basic statistical analysis and data visualization to orient our clients to our data sets and results. All raw data is provided to our clients for their in-house use.

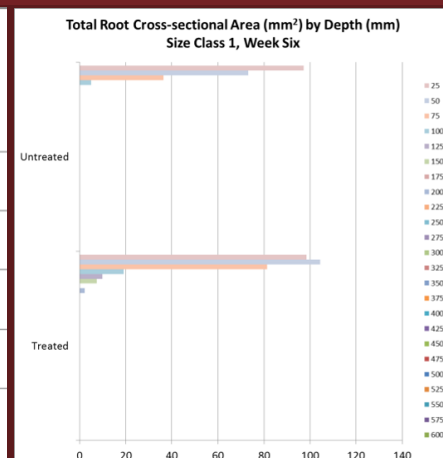
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END POINT RESULTS

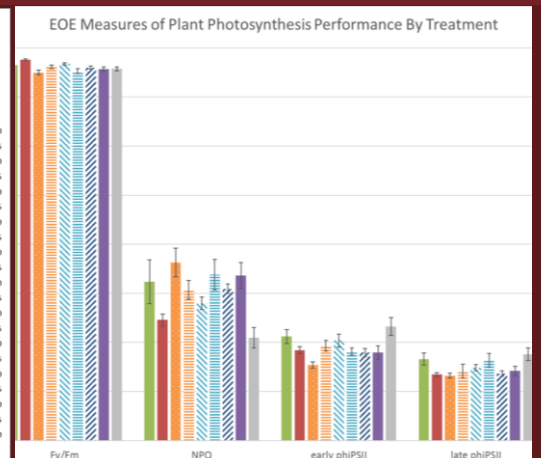
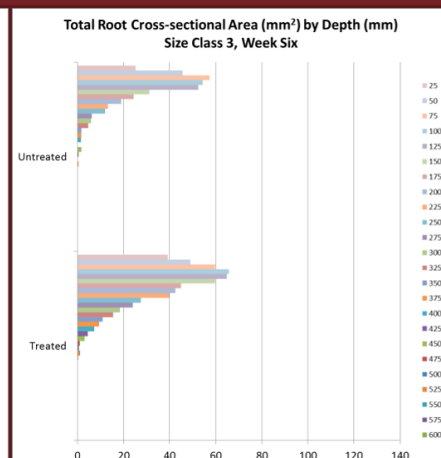
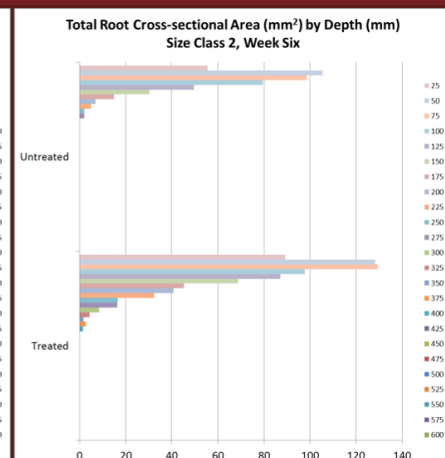
Summarizing the end of experiment results gives an overview of product impact on critical plant attributes.



Dry Weight



Root Density by Depth for Different Root Diameters

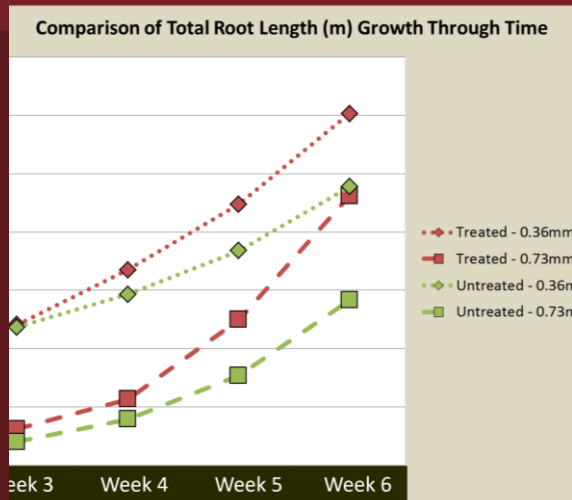


Photosynthetic Efficiency

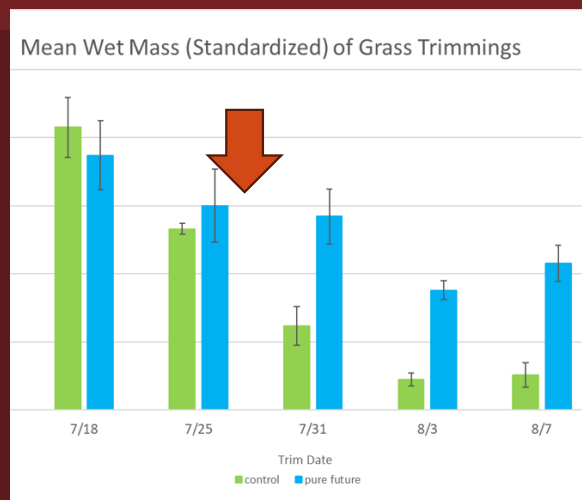
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THE TIME DIMENSION

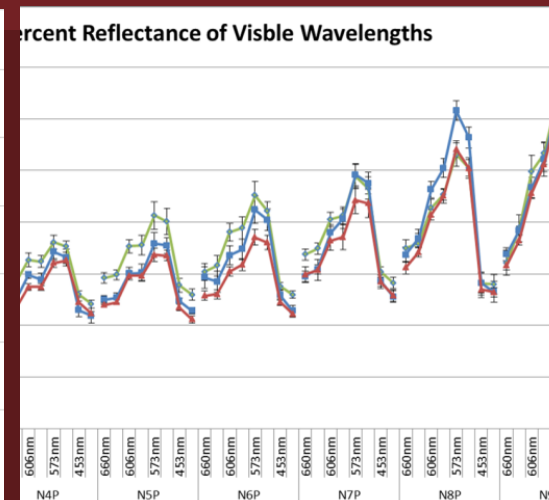
Our clients are often also interested in time related impacts: how long to results, how long between recommended applications, is plant development rate accelerated?



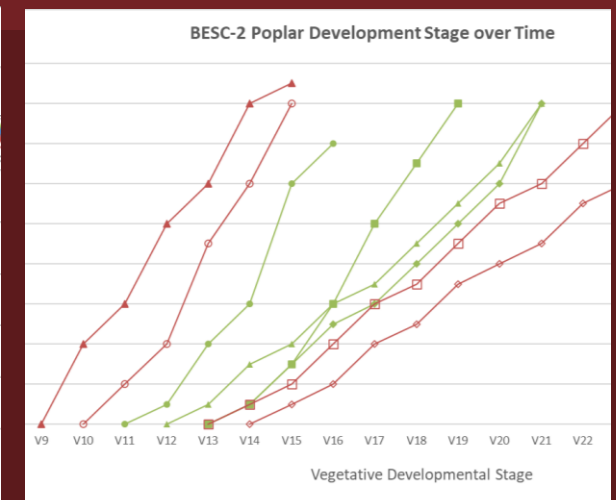
Root Length Impact For Different Root Diameters



Response Time to Concentration Change



Duration of Treatment Impact



Successful and Unsuccessful Microorganism Colonization

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THE IMPACT

There is power in providing a coherent picture of how the entire plant responds to formulation applications.

Our clients benefit from new insights into their challenges with abiotic stress tolerance, pathogen control, resistance breeding, formulation optimization, microbial ecology, and nutrient utilization.

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SUMMARY

Our team partners with clients to design and execute studies that provide insight and knowledge useful for formulation development, microorganism inoculum, application guidance, mode of action interpretation, validation data, and marketing guidance.



Romaine Lettuce



Broccoli



Poplar Trees



Orange Trees

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THANK YOU,
LET'S TALK ABOUT
YOUR CHALLENGES!



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Celebrating Our 20th Year of Induced-Expression Phenotyping.

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