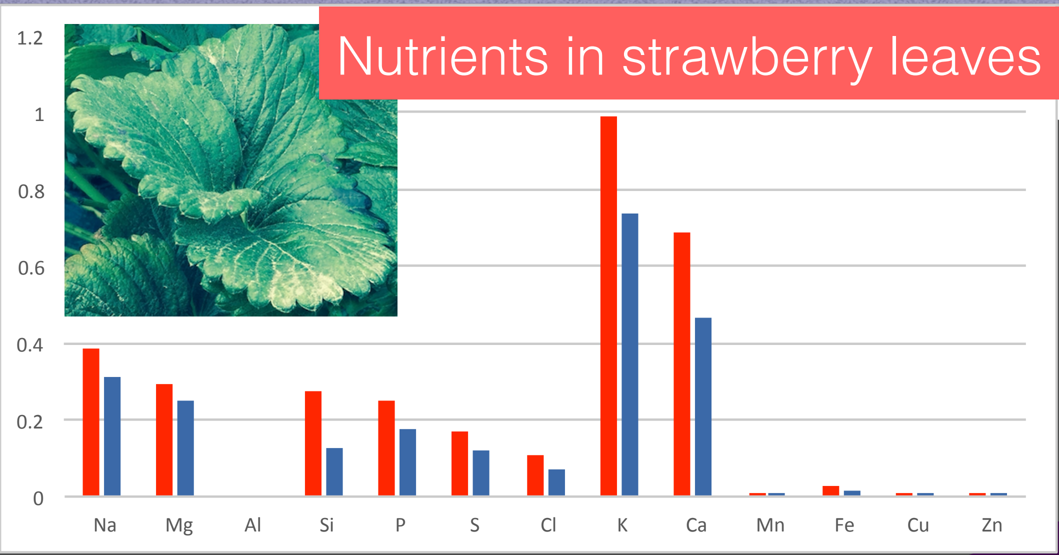
I-Cultiver, Inc.
Agriculture • Food • Health

VESTA benefit to strawberry plant nutrient uptake and to the environment

NUTRIENT DYNAMICS IN STRAWBERRY FIELDS

VESTA INFLUENCES NUTRIENT FLUXES BETWEEN SOIL AND PLANT



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Prepared by:
I-Cultiver, Inc.

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Acknowledgements:

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- **I-Cultiver, Inc.** is a technology transfer company, a consortium of interdisciplinary agricultural & food science experts in collaboration to translate fundamental science into applied science. This study was performed through Collaborative Research & Consultation Services:
  - Dr. Ted K. Raab, Director, Soil Fertility, I-Cultiver, Inc.
    - Senior Investigator, Department of Plant Biology, Carnegie Institution for Science, Stanford
  - Dr. Rajnish Khanna, Founder & CEO, I-Cultiver, Inc.

EXECUTIVE SUMMARY

VESTA, a soil amendment was tested for its affect on nutrient exchange between soil and commercially grown strawberry plants. Previously, we reported that bacterial communities in VESTA colonize and dramatically influence microbial community composition inside strawberry roots. Here we report that VESTA increased the uptake of nutrients in strawberry leaves and reduced soil nitrate levels, benefitting the plant and the environment.

Fields of commercial strawberries were treated with VESTA, a liquid product composed of a broad spectrum of microbes and soluble carbon (VESTA®, SOBEC Corporation, Fowler CA).

As a good source of nutrients, strawberries are a valued crop for their antioxidant and anti-inflammatory properties. Strawberries also provide healthy doses of Dietary Fiber, Vitamin C, Manganese, Folate and Potassium. Microbial activities in the soil and root endosphere are expected to mobilize nutrients, and make them available for uptake by the plant.

In this study, we investigated the effect of VESTA on nutrient exchange. Several nutrients were increased in strawberry leaves. There was increased root growth, increased % water in roots over time, and % Nitrogen and % Carbon (per dry weight) in leaves.

Our results indicate that VESTA influences nutrient flux between the soil and the plant possibly through microbial activity. It is likely that fungal activity is involved. Further analyses are needed to determine the critical mechanisms and activities of VESTA organisms associated with plant nutrient exchange.

PRIMARY RESEARCH QUESTIONS AND METHODS

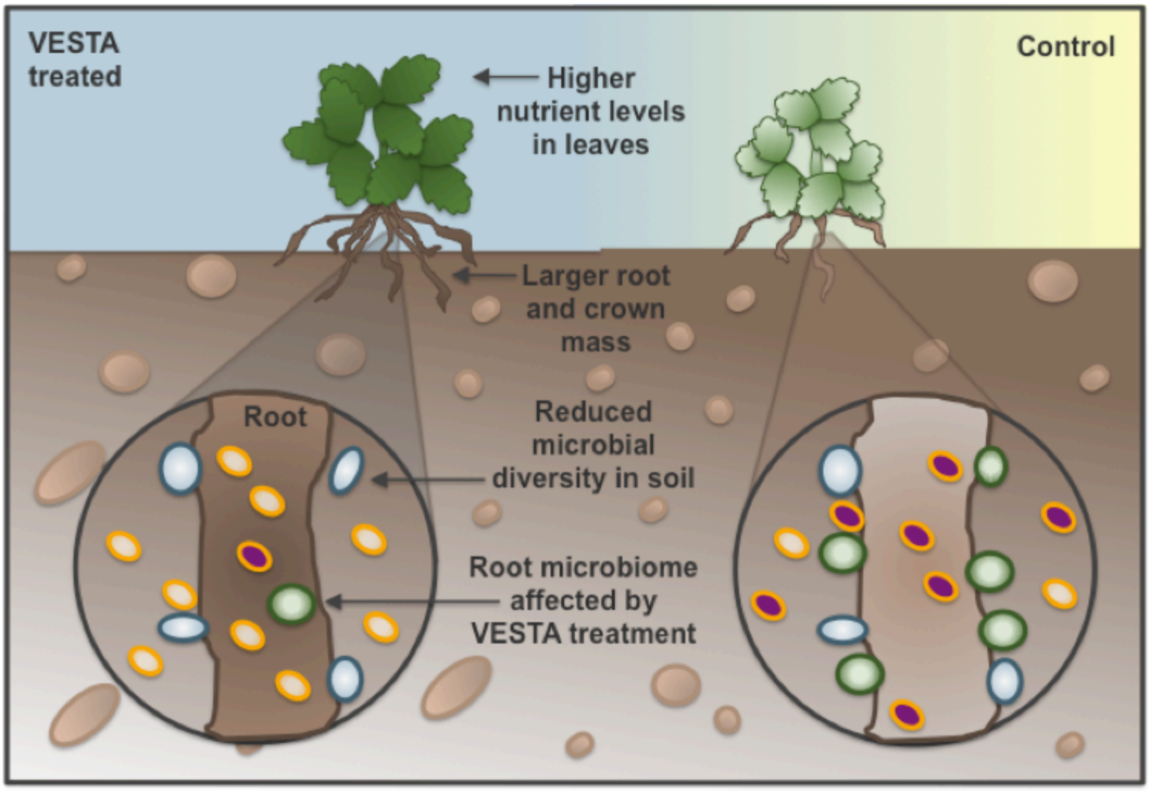
Does VESTA increase plant nutrient levels?

1. Does VESTA improve nitrogen uptake by the plant?
2. Is there an effect of VESTA on the uptake of macro-elements and micronutrients?
3. What is the impact of VESTA on the soil nutrient flux?
4. What are some of the nutrient elements that are influenced by VESTA?

Plant growth and phenology: Sampling commenced on March 18 2015 (**T_1** hereafter), April 8 2015 (**T_2**), May 13 2015 (**T_3**), and on August 24 2015, following strawberry harvest (**T_4**).

Methods used to asses nutrient levels were as described within.

KEY FINDINGS



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SUMMARY OF SIGNIFICANT CHANGES IN ELEMENTS ▲▼ Increased / Decreased

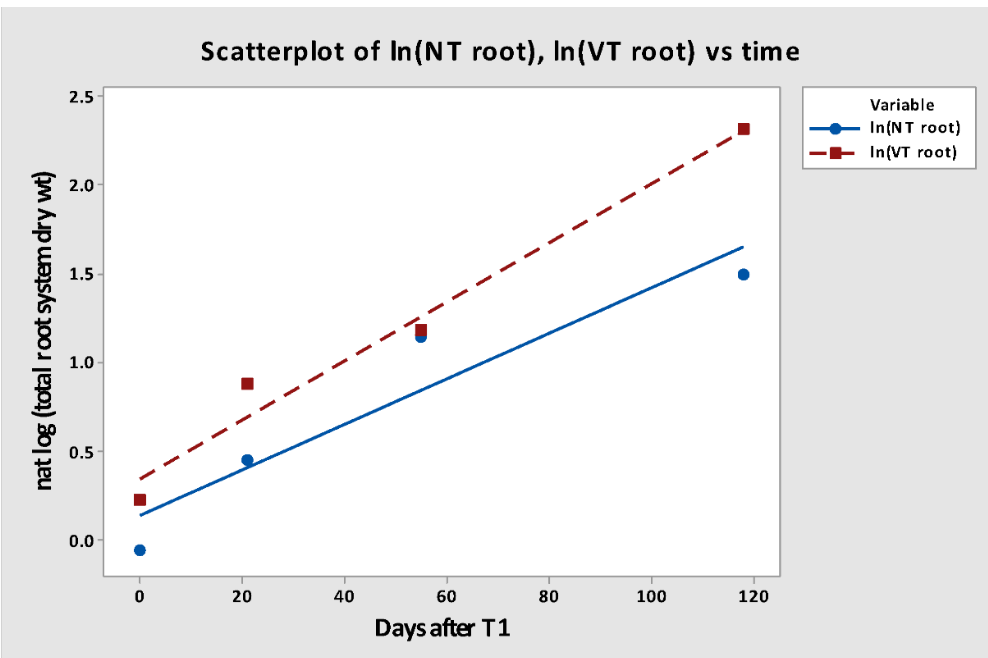
	In Soil	In Roots	In Leaves	Benefit
▲		Water		**Benefits to growth, nutrient uptake, flavor**
▲			**Nitrogen (N)**	**Increased nutrients**
▲			**Carbon (C)**	**Increased organic carbon**
▲		**Phosphorus (P)**	**Phosphorus (P)**	**Increased nutrients**
▲	**Potassium (K)**	**Potassium (K)**	**Potassium (K)**	**Increased nutrients**
▲	Calcium (Ca)		Calcium (Ca)	**Increased nutrients**
▲		Sodium (Na)	Sodium (Na)	**Possible impact on flavor (sugar transport)**
▲			Silicon (Si)	**Strengthen cellular defense against disease**
▲		Iron (Fe		**Increased nutrients**
▲	Sulfur (S)			**Soil exchangeable macro-element**
▼	**Nitrate (NO_3^-)**			**Reduced risk of water contamination**
▼	Phosphorus (P)			**Increased P uptake by the plant (see below)**
▼		Aluminium (Al^{+3})		**Healthier roots**

Figure 1. Increased Strawberry Root and Crown Size.

• VESTA-treated plants had increased root mass with larger leaves and crown size. The differences in size and plant growth were clearly visible between untreated and treated fields.

• Root growth appeared more vigorous in Vesta Treated (VT) plants, and this effect was likely from enhanced root-proliferation at the crown.

Figure 2. Vesta increased root Relative Growth Rate. RGR (grams gram^{-1} day^{-1}) from **0.013 to 0.017**.



Natural log-transformed (Ln) dataset for root harvests T_1-T_4. The utility of such transformation arises from comparison of the slopes of the lines – which directly report on the relative growth rate (dry matter accumulation) of the Control (NT root) and Vesta Treated (VT root) tissues. Each of the points is an average of 5-6 samples per treatment per time-point. VESTA-supplementation was given at roughly monthly intervals during T_1-T_4, paired with conventional fertigation.

We are considering the hypothesis that the microbial communities growing-up in Vesta treated soils may be creating plant hormone analogues that stimulate cell division in the root apical meristem.

Table 1. Root water % avg.

Time Point	Control	Vesta Treated
T1	**86.4%**	83.6%
T2	83.6%	**86.6%**
T3	83.2%	**87.2%**
T4	84.4%	**85.8%**

It may also be relevant that the water content of VT root tissues was uniformly higher after T_1 throughout most of the strawberry experiment (**Table 1**).

As nutrient- and sunshine-replete plants rely on expansion of their tissues for growth, higher water contents in tissues should correlate strongly with growth potential. Leaves were only collected at T_4, leaf tissues at the final harvest certainly had higher water content, and average area per leaf was higher in VT compared with NT leaves, and as we shall indicate in the next section, higher foliar N. In the next section, we address what we learned from all plant tissues with regards to nutrition.

Table 2. Leaf %N %C

Leaf	%N	%C
T4 Control	1.61	25.0
T4 Vesta Treated	**2.06%**	**27.6%**

Plant nutrient pools: The edible portions (strawberry drupes) rely on the concerted efforts of the root zone to mine available nutrients from the soil, and with the assistance of energy generated in leaves by photosynthesis, transport those nutrients eventually to the fruit.

We assessed nitrogen (N) and carbon (C) by Carlo Erba elemental analyzer (combustion/GC), ICP-OES (inductively coupled plasma-emission spectrometry) for Ca, Mg, K, Na, P, S and micronutrients following acid (HNO_3-$HClO_4$ digestion; **Miller 1998**), as well as energy-dispersive X-ray fluorescence for additional elements. Considering leaves first, we have only the T_4 leaves to judge, but soil-N was translocated from the root zone at a quicker rate (or fluxes through soil pools higher) under VT (**Table 2**).

Coupled with the higher overall biomass of the Vesta treated plants, we are certain that the standing stock of fixed-C and N are highest under VESTA-application.

This observation needs to be repeated in the field for high-biomass crops (e.g. sugar beets, broccoli, squash), as a Grower might (someday possibly in California) also receive “Carbon Credits”, in addition to net profits from sale of fresh vegetables. It also points to more efficient fertilization. Further chemical analyses of the desired product – strawberry drupes – need to be performed to “close” the nutrient budget precisely.

Depending on the fate of plant residues after strawberry harvest, the [C/N] ratios were uniformly lower in Vesta treated plants – an expression of their more rapid growth – and this would result in faster-decomposing litter in minimal-till systems.

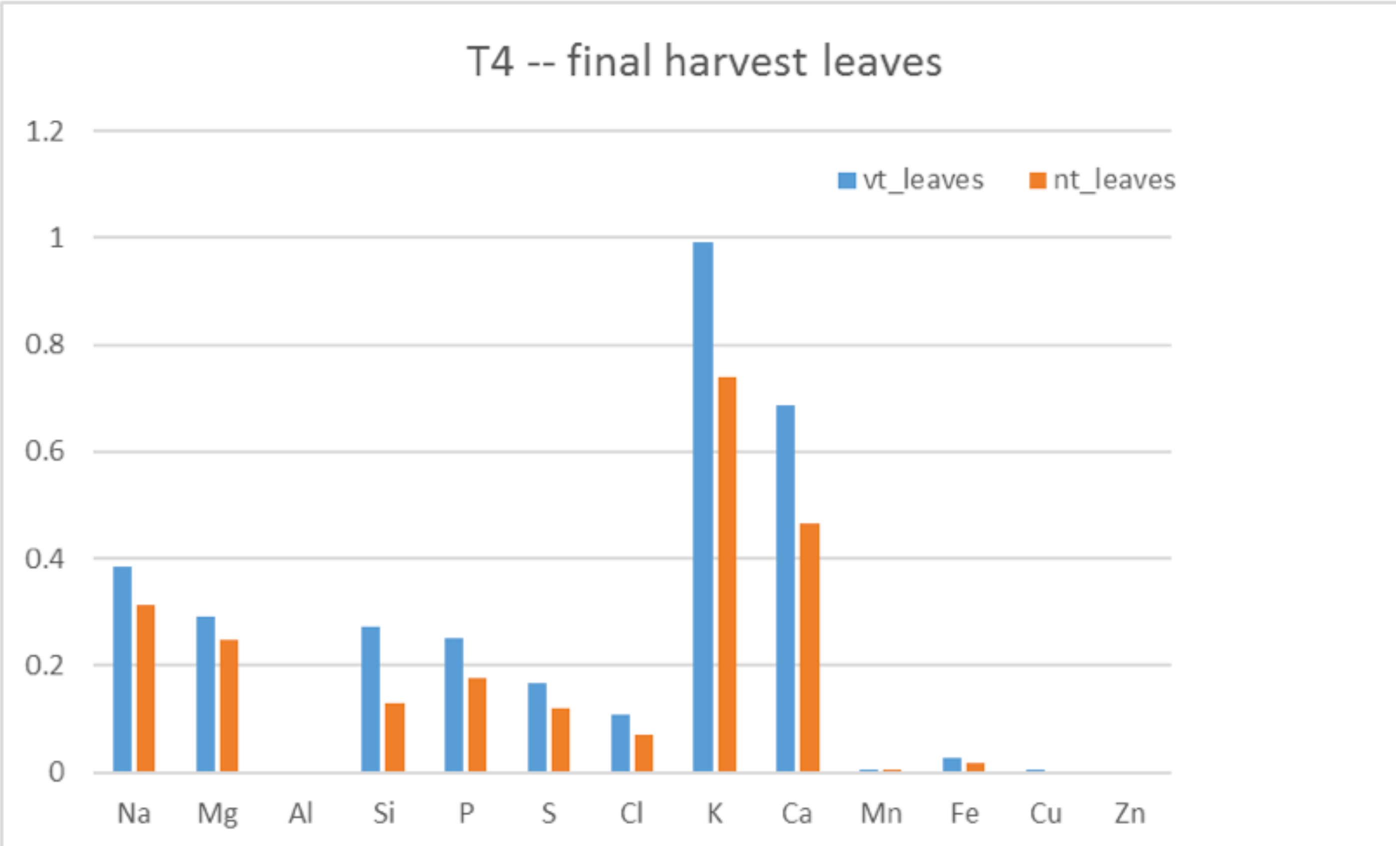


Figure 3. For the current Strawberry Field Test (2015), we utilized **XRF** to compare element pools for the pooled, ball-milled final leaf harvests for each treatment (T_4).

NOTE:: If this profile is at all related to the nutrients that reside finally in the strawberry drupes themselves, VESTA has contributed yet again.

Nitrogen and carbon are, of course, the most important components of plant growth, but i-Cultiver has the capacity to measure a very large suite of chemical elements (from Z=11 sodium to Z=92 uranium) in the Periodic Table, using a lab-based technique called **energy-dispersive X-ray fluorescence (XRF).** To be sure, it's a "broad sword" for compositional studies, in that it does not report on the chemical state (and bio-availability) of the elements measured. However, the method is non-destructive, involves straightforward sample preparation, provides quick insight on the plant-soil system, and can be used for more focused studies using appropriate chemical extractions.

In addition to the **macro-elements (P,K, S, Cl, Mg, Ca, Na)**, **micronutrients (Fe, Mn, Cu, Zn, Mo, Cr, Co, Ni, I)**, **XRF** also reports on **elements of potential concern for human health (As, Pb, Se, Hg, Th, U)**, and **elements of geological interest (Au, Ag, platinum-group elements, Rare-Earth elements).** It cannot provide data on Boron (B), but we have separate ICP-based methods for that element.

In the current Strawberry field test, we observed increased plant uptake of Silicon – useful as basal defense against disease – as well as an indicator of elevated transpiration rates, which in turn equated with faster plant growth.

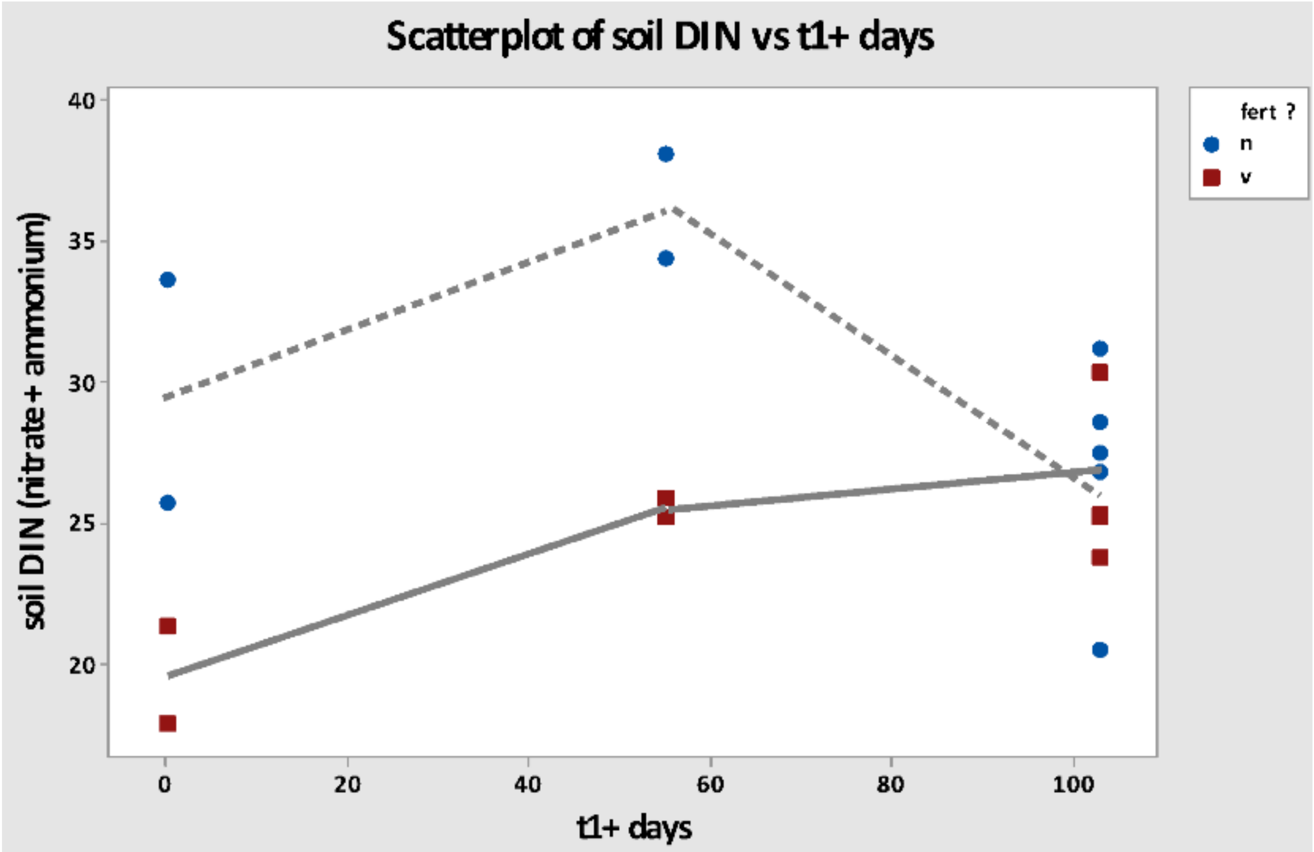


Figure 4. Extracting soil with 2M potassium chloride disrupts the exchange complex and loosely-associated nutrients. We analyzed for nitrate and ammonium (by two different chemical tests), the two most common nitrogen-sources for crop plants. Over the last 4 months of growth before strawberry harvest, we observe that the areas under the time-course for the two treatments are quite different. Looking at nitrate versus ammonium in the soil, we see that nitrate explained much of the distinction between Vesta treated (**v**) and Control (**n**) soils, since soil [NH_4^+] levels were flat over time, and did not vary between treatments for an average of 4.5 mg kg^{-1}. Only stable isotopes can really prove the case, but a reasonable interpretation is that soil organic matter mineralization (turning complex litter and microbial biomass into inorganic forms available to plants) continued at a constant rate, and was not influenced by the VESTA-treatment.

Given that nitrate levels are higher during the last four months of the study in the Control (n) soils, we conjecture that some nitrification (bacterial conversion of ammonium nitrate) must have been inhibited by some organism(s) associated with the VESTA consortium. **Reduced nitrate in soil has environmental benefits.**

Nitrification is an aerobic (oxygen-requiring) process, so if VESTA-treated soils were waterlogged, we'd have a physical explanation. But the soils in Guadalupe CA are fairly coarse-textured (and not the color of waterlogged soil), so we reject a physical mechanism. Also, a handful of chemical elements that would likewise be immobilized by anaerobic conditions, were also MORE available under Vesta treated. Finally, it is presumed that the application of the non-VESTA fertigation regimes was in comparable amounts of fertilizer on a Nitrogen-basis.

Are there biotic explanations? Since soil-bacteria, fungi and plants can all have different preferences for N-sources, we should point-out that an increase in abundance of **AM** (**Arbuscular mycorrhizal**) fungi in the soil could lead to an apparently lower levels of nitrification (**Sprent 1987**). **Soil fungal communities have not yet been quantified.**

In a previous study, we reported 16S sequencing of bacterial communities in soil, rhizosphere and root endosphere of these strawberries during the 2015 Field Test. Short of a full metagenome, we can not yet assign the bacteria responsible for distinct physiological roles (in the bar charts in Figure 3), but a few observations are pertinent:

Table 3. Soil NO_3^- (mg kg^{-1} dry soil) - Soil Nitrate

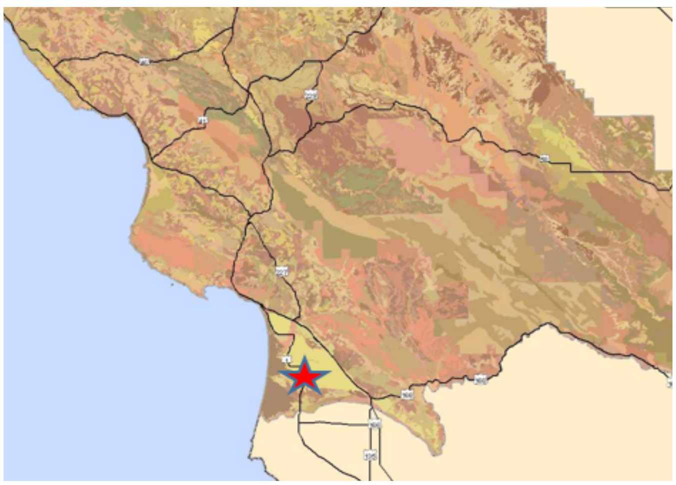
Treatment	N	Median	Ave. Rank	Z
Control	9	**22.36**	11.4	2.12
Vesta treated	8	18.51	6.3	-2.12
Overall	17		9.0	
H = 4.48	DF = 1		**P = 0.034 significant**	

Kruskal-Wallis Test

Kruskal-Wallis Test compares independent samples of equivalent or different sample size. This test is similar to the ANOVA (one-way analysis of variance).

These results indicate that the control soil had higher levels of nitrate (NO_3^-) compared to Vesta treated soil samples.

Figure 5. Natural Resource Conservation Service Soils



For the soils of the strawberry operation in San Luis Obispo County (near the junction of Highway 1 and Oso Flaco Road), we have a mix of sandstone-derived alluvium from the Coast Range, and wind-borne materials. As noted previously, the physical texture of the soil suggests a sandy loam:

Such soils would hardly prevent transport of nitrate away from an agricultural operation – this is an issue not just for water quality nearby, but is simply a loss-pathway for a resource.

The exact mechanism is not known, but some combination of factors must either: **(1) suppress microbial nitrification under VESTA treatment, or (2) stimulate uptake and utilization of soil nitrate.** Nitrate is a very useful nutrient to plants, as it contributes (along with sugars and amino acids) to the osmotic potential of the tissues in which it accumulates. Further studies are needed to confirm a model for VESTA action in capturing this valuable resource for plants and reducing its environmental impact on water bodies in the vicinity.

Was there any evidence for nutrient enhancement by microbial action? Looking at all available data, we can see enhancement of plant **P** and **Zn** status. In the follow-up soil microbiome study of i-Cultiver, a reasonable hypothesis from this data would be to look at the fungal composition of the Vesta soil communities versus Control; expectation is that **Arbuscular Mycorrhizal (AM) fungi** increased in relative abundance in the Vesta soils. This would also be consistent with the pattern of soil inorganic-N.

Foliar phosphorus showed enhancement by T_4, with [Vesta foliar-P] = 0.251% dry wt, and [Control foliar-P] = 0.177 %, an increase by one-third. This observation should be followed-up in future VESTA studies.

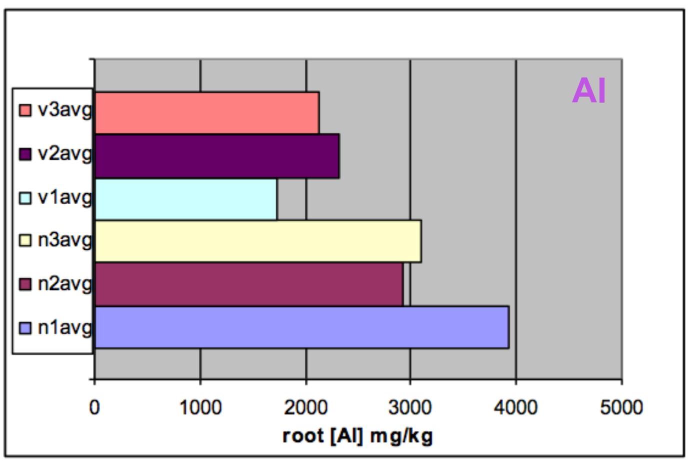
Nutritional targets for almost all major elements and micronutrients have been determined from a variety of field- and greenhouse-experiments performed at UC Extension (**Ulrich et al. 1992**).

Table 4. Recommended nutritional targets for strawberries in California.

Al (3961)	**B** (249.7)	**Ca** (317.9)	**Cu** (324.7)	**Fe** (259.9)	**K** (766.4)	**Mg** (285.2)	**Mn** (257.6)	**Mo** (202)	**Na** (5895)	**P** (2136)	**S** (1807)	**Si** (251.6)	**Zn** (213.8)
	25 ppm	3000 ppm	3 ppm	50 ppm	1000 ppm	2000 ppm	30 ppm	0.5 ppm		700-1000 ppm	1000 ppm		20 ppm

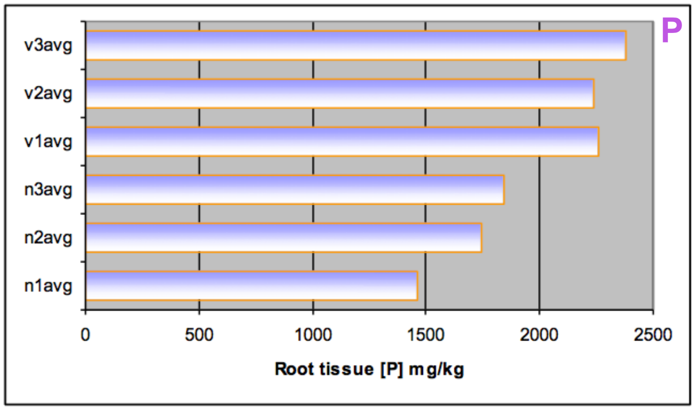
Above, you see **the recommended targets for strawberries in California (Table 4, top row (in units of tissue dry weight)),** with the list of elements determined for samples from the current VESTA trial (**Table 4, bottom row**). Next to the chemical name (top row), we have included the optimum detection wavelengths (in nanometers) for ICP analyses. Three elements were determined for which no guidelines exist: in the case of Aluminum, there is no known requirement; the same is technically true for sodium, but experienced growers are aware that controlling root-zone sodium can enhance flavor of the final harvest. Silica has been documented to protect plants from certain classes of pathogens.

Figure 6. Vesta treated strawberry roots had lower Aluminum (Al). Averages of time points T_1-T_3 are plotted for Vesta (v#avg) or Control (n#avg).



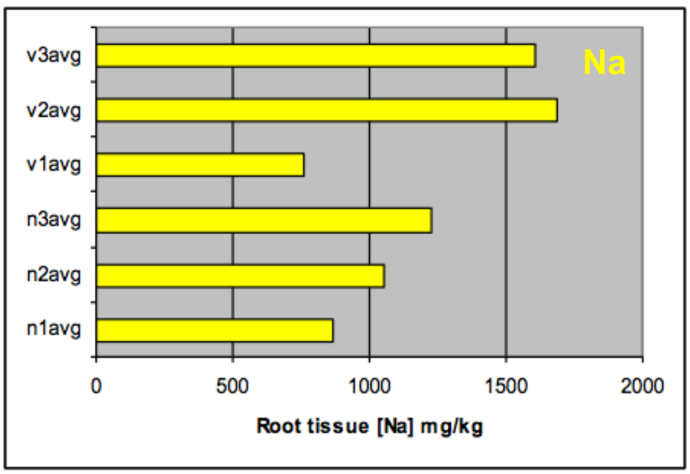
Following the **total extractable pools of strawberry root tissues** over the interval, we observe a few interesting things. Based on both strawberry foliar analyses and soil levels at the end of the T_4 harvest, there was little need for concern to fruit consumers, merely a partitioning of soluble [Al^{+3}] in to fulvic-acid or humic acids of Vesta-treated soils. **VT provided a measure of protection to the root system, for which Aluminum is antagonistic to Calcium-dependent structural/physiological roles of healthy roots.** Vesta FA may chelate Al and Fe, or help by adding organic matter.

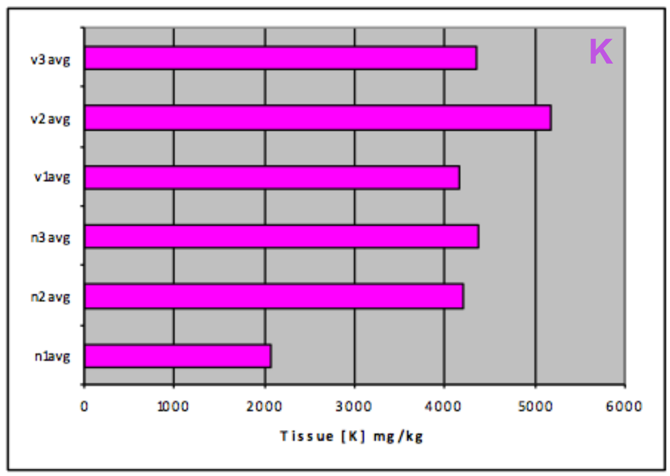
Figure 7. VESTA caused elevated accumulation of phosphorus (P) in tissues. Averages of time points T_1-T_3 are plotted for Vesta (v#avg) or Control (n#avg).



The range of **critical [P] levels is 700-1000 ppm** (mg per kg dry wt of tissue, see Table 4), so in neither case is deficiency indicated. **Phosphorus levels were higher in Vesta treated roots.** This could be of significance if phosphorus was limiting. As we discuss elsewhere in the report, there are a variety of mechanisms by which the VT microbial consortium might be impacting strawberry P-levels.

Figure 8. Transport within strawberry plants of sodium (Na) increased under VESTA, but with no inhibitory effect on potassium (K) utilization. Averages of time points T_1-T_3 are plotted for Vesta (v#avg) or Control (n#avg).Averages of time points T_1-T_3 are plotted for Vesta (v#avg) or Control (n#avg).





Based on the foliar values of these elements at T_4, and the **recommended "critical levels" of 1000 ppm for K**, we conjecture higher Na had no significant effect on potassium utilization. **Somewhat elevated levels of tissue [Na] might have induced local osmotic compensation, with an increase in sugar transport to the leaves and fruit.** Also, as we demonstrated in a previous section, water content was a bit higher in VT-treated tissues. Sugar content of the fruit or titratable acidity would be desirable in follow-up measurements of fruit from field-tests.

Table 5. Root P (ppm) - Root Phosphorus

Treatment	N	Median	Ave. Rank	Z
Control	8	1734	5.3	-2.73
Vesta treated	8	**2308**	11.8	2.73
Overall	16		8.5	
H = 7.46	DF = 1		**P = 0.006 v. significant**	

Kruskal-Wallis Test

One chief soil characteristic influencing biology, mobility of nutrients, and other processes is soil pH. Over the sampling from T1 to T4, there were no significant trends in **soil pH, with a median value for all treatments of 7.63**. VESTA-treated soil show more variability, and there are clearly small fragments of limestone in the soils, based on fizzing reaction to 1M hydrochloric acid. Further site details are needed to say whether these are rock-parent material derived, or pedogenic carbonates (from previous irrigation practices). As commercial strawberries are generally cultivated on raised beds over polyethylene sheeting, it's unlikely that caliche was forming under the root zone(s).

Table 6. Soil Exch. Phosphorus (ppm)

Treatment	N	Median	Ave. Rank	Z
Control	5	**28.28**	7.4	1.98
Vesta treated	5	25.75	3.6	-1.98
Overall	10		5.5	
H = 3.94	DF = 1		**P = 0.047 significant**	

Kruskal-Wallis Test

We also measured soil electrical conductivity (obtained EC_{10} values) of 5:1 dilutions of soils from either Control (NT) or Vesta (VT) zones, and observed no strong trend with time, although slightly higher mean conductivity values in VT-treated soils (0.096 dS/m) versus 0.062 dS/m for NT soils was noted. These values are not surprising, especially at a site so close to the Pacific Coast, and in that portion of Central California. Soil conductivities (by themselves, absent any other soil data) could impact water-uptake by crops in the region of ~2 dS/m. Also, a small amount of NaCl-salinity at harvest can improve flavor of many fruit crops, if managed well.

Table 7. Root Fe (ppm) - Root Iron

Treatment	N	Median	Ave. Rank	Z
Control	8	**2868**	11.3	2.31
Vesta treated	8	1875	5.8	-2.31
Overall	16		8.5	
H = 5.34	DF = 1	**P = 0.021 significant**		

Kruskal-Wallis Test

Soil exchangeable nutrients were estimated by agitating dry soils for 1.5-2 hrs in a solution of 1M ammonium acetate, filtering, and analyzing by ICP. Obviously this method cannot be used for ammonium or exchangeable acidity; in that case, one might prefer barium chloride.

Slightly alkaline soils are widespread in California – a combination of rock parent-materials, as well as a semi-arid climate. Especially in crops such as citrus, **elevated soil pH can inhibit Fe (Iron) availability to crops; however in the current field experiment, we saw little evidence of this based on Fe in leaves or roots.** Although Fe was apparently more available to Control strawberries, plant harvests did not support this. **VT tissues had elevated Fe compared with NT plants.**

Table 8. Soil Exchangeable Calcium (ppm)

Treatment	N	Median	Ave. Rank	Z
Control	5	1191	3.6	-1.98
Vesta treated	5	**1393**	7.4	1.98
Overall	10		5.5	
H = 3.94	DF = 1	**P = 0.047 significant**		

Kruskal-Wallis Test

Considering some of the exchangeable macronutrients on the soils, **we observed a slight but non-significant increase in exchange potassium [K^+] following VESTA-treatment; however Ca was still the major cation on the exchange complex**. In follow-up analyses of tissues, Vesta did in fact increase transport and accumulation of **potassium** in strawberry leaves and roots.

Table 9. Soil Exch. Sulfur (ppm)

Treatment	N	Median	Ave. Rank	Z
Control	5	519.3	3.0	-2.61
Vesta treated	5	**729.4**	8.0	2.61
Overall	10		5.5	
H = 6.82	DF = 1	**P = 0.009 v. significant**		

Kruskal-Wallis Test

Table 10. Soil Exch. Potassium (ppm)

Treatment	N	Median	Ave. Rank	Z
Control	5	136.0	3.8	-1.78
Vesta treated	5	**188.6**	7.2	1.78
Overall	10		5.5	
H = 3.15	DF = 1	**P = 0.076**		

Kruskal-Wallis Test

Total XRF analysis of the post-harvest soils from the Guadalupe Field-test was informative. We observed increased soil **[Na]**, **[Ca]** and **[Fe]** among major soil-forming elements. Due to the chemical nature of these elements, our interpretations can be somewhat nuanced. Soil sodium, for example, is predominantly soluble, and can help explain the soil EC_{10} trends. Iron, on the other hand, is either part of a soil mineral/clay, or in biologically-complexed form. Since the treatments were not expected to transform soil mineralogy or clay-fraction over the short 7-8 month cultivation period, we must conclude that **the Fe was associated with (1) microbial biomass of the VT-treated soil consortia, or (2) associated with the soluble fulvic-acid fraction of the soils.** Although a brief glance at the XRF table may uncover elements of unknown utility to the grower, the rules of chemistry likewise compel us to explain the parallel increase in soil pools of an Fe-analogue element, Gallium (Ga). **Though their basal levels are vastly different, the increase in soil Ga under VESTA was in direct proportion to soil [Fe]. Based on this observation, we might suspect the fulvic-acid enrichment scenario, as we might expect portions of the soil biota to be a bit more selective in uptake of such a critical biological element as iron.** Both bacteria and fungi have evolved several highly-specific uptake mechanisms for iron, generally insoluble in its Fe^{+3} form in temperate (unflooded) soils. **We have many straightforward ways (fluorescence spectroscopy of soil pore water, etc.) to monitor for seasonal Fe/Fulvic acid dynamics.**

Table 11. XRF of sieved (< 2mm) Strawberry soils (post harvest); each value is mean of (n = 4, 5 soil collections).

Color codes refer to element class. Values presented either in % dry weight (% dw), mg/kg, parts per million (ppm), or below detection limit (bdl) (see text).

Element (Macro)	Control Soil at Harvest	Vesta-Treated Soil at Harvest
Sodium (%)	**1.17**	**1.26**
Magnesium	1.19	1.27
Aluminum	6.34	6.42
Silicon	23.77	23.58
Phosphorus (%dw)	0.19	0.18
Sulfur (%dw)	0.08	0.07
Chlorine (% dw)	0.01	0.01
Potassium	2.01	2.02
Calcium	**1.25**	**1.32**
Titanium (%dw)	0.28	0.28
Iron (%dw)	**1.96**	**2.04**

Element (Micro, Toxic, of geological interest, and rare earth elements)	Control Soil at Harvest	Vesta-Treated Soil at Harvest
Vanadium (mg/kg, ppm)	48.10	42.00
Chromium (ppm)	303.02	305.95
Manganese (ppm)	44.64	46.13
Cobalt	bdl	bdl
Nickel	32.22	33.40
Copper	17.00	17.63
Zinc (ppm)	**55.88**	**58.28**
Gallium	13.64	14.28
Germanium	0.00	0.00
Arsenic	1.76	2.15
Selenium	bdl	bdl
Bromine	5.90	5.73
Rubidium	91.00	92.25
Strontium	231.20	230.28
Yttrium	19.72	19.08
Zirconium	431.10	377.38
Niobium	13.56	14.00
Molybdenum	4.66	4.25
Ruthenium	1.90	1.68
Rhodium	bdl	bdl
Palladium	0.84	0.93
Silver	6.62	7.00
Cadmium	5.16	5.00
Indium	6.18	5.93
Tin	0.00	0.00
Antimony	bdl	bdl

Element (Micro, Toxic, of geological interest, and rare earth elements)	Control Soil at Harvest	Vesta-Treated Soil at Harvest
Tellurium	0.00	0.00
Iodine	bdl	bdl
Cesium	0.00	0.00
Barium (ppm)	1955.00	1985.50
Lanthanum	bdl	bdl
Cerium	bdl	22.33
Praseodymium	bdl	bdl
Neodymium	bdl	bdl
Samarium	19.78	20.08
Hafnium	6.08	2.85
Tantalum	bdl	bdl
Tungsten	bdl	bdl
Gold	3.28	3.45
Mercury	bdl	bdl
Thallium	barely	bdl
Lead (ppm)	16.56	16.65
Bismuth	0.00	0.00
Thorium (ppm)	7.98	7.90
Uranium	bdl	bdl

CONCLUSION

Conclusion

- Vesta increased strawberry root and crown growth rate.
- Increased root initiation suggests Vesta organisms may create plant hormone analogues that increase cell division.
- Over time, Vesta treated roots had higher water content.
- Leaves collected at T_4 time point had higher nitrogen and carbon content. This observation should be tested with high-biomass crops like sugar beets, broccoli, squash. In the future, carbon-credits may provide a new source of income for growers using Vesta to capture higher carbon into biomass.
- Vesta treated plants showed lower [C/N] ratio. This would create faster-decomposing litter in minimal-till systems.
- Several nutritional elements tested were relatively higher in Vesta treated leaves.
- Increased silicon uptake is useful in providing defense against disease.
- Vesta enhanced phosphorus and zinc status of strawberry leaves.
- Soils treated with Vest had reduced nitrate levels that would lead to decreased contamination of water.
- Our results suggest there is likely involvement of fungal activity, which has not yet been determined.
- Vesta increased the transport and accumulation of potassium in strawberry roots and leaves.
- There was a significant increase in Calcium exchange on the soil following Vesta treatment.

See SUMMARY OF SIGNIFICANT CHANGES IN ELEMENTS (Page #4)

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I-Cultiver is continuously developing partnerships between academic institutions and industry to bridge the gaps between research and product development.

- Expertise in soil, agricultural, culinary & food nutritional sciences.
- Unique company model: Consortium of specialized, multidisciplinary experts affords an unprecedented ability.

Close ties with:

- Academic researchers
- Plant breeders
- Small / mid-size farmers
- Organic biological product manufacturers
- Food and environmental scientists

Strategic partnerships / collaborations:

- Dr. Devin Coleman-Derr, PGEC / USDA / U C Berkeley
- Dr. Ted Raab, Carnegie Institution For Science, Stanford University
- Dr. José Dinneny, Carnegie Institution For Science, Stanford University
- Dr. Fred Hempel, Baia Nicchia Farm
- Dr. Pamela Ronald, U C Davis
- Dr. Mohan Behl, Biotech. Park, Lucknow, India
- Dr. Todd De-Santis, Second Genome, Inc.
- TerreLocal (coming soon), a new way to find locally grown food.

Important Disclaimer

All data presented in this report were produced from primary research following guidelines on good research practice.

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