The Key To Your Soil Health

For organic crops' high productivity

Flor·ès·Sens System & 59 Degrees

"…yields outperforming control scenarios by an average of 72%."

An alternative approach

Foundation for **optimal** plant nutrient cycling, plant health and plant productivity: a complete and healthy Soil microbiological community.

A consistent tool

A Soil Regeneration trial using Soil microbiological web reconstruction: bringing missing microbiology back in our soils to reach organic crops **high productivity.**

SOIL MICROBIOLOGY REMEDIATION

Transitioning toward total organic, high yield Human Food Production systems.

Appraising Human food systems holistically, starting at soil microbiological level.

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FOREWORDS:

We set up this case with the purpose to open & deepen the conversation about how we manage our soil fertility. Scientist, biologist, botanists, garden market producers, agriculturists, environmentalists, politicians, and any other environmentally and food concerned persons are very welcome to join this conversation and contribute to this emerging truth.

More precisely, we bring to the forefront a holistic approach where we discuss the following: soil fertility, hence subsequent crop productivity, is a function of a healthy & diverse soil microbiological web, first.

The more diverse abundant beneficial soil microbiology is, the more productive our crops are. Note that in this report, we do not enter soil microbiological species identification, but general morphological identification where we speak about trophic levels: a soil food web.

Microbial life is indeed responsible for optimal nutrient cycling to plants, thus optimal plant, crops, and vegetable growth.

59 Degrees, based in Sweden, is a company providing microbiological solutions for tree systems, wanted to put their professional know-how under a scientific experiment and apply it to a vegetable production unit. Over this first goal, 59 Degrees was willing to provide more consistency and visibility to its surrounding market environment.
In this regard, Flor.ès.Sens Systems, company being specialised in Soil microbiological diagnostic, soil & land restoration, and holistic project management, accepted to set up a scientific experiment and run a trial case to address 59 Degrees' need.

This trial provides direction and a solid offer to the biologic and organic agriculture needs for scalable, yet cheap, solutions for regenerative agricultural systems. A total organic agriculture is indeed reachable, and the door-opening key is at soil microbiological level.

Flor.ès.Sens Systems, author of this report, put a strong emphasis on "documenting scientifically" that case study.
In this context, "Scientifically" has to be understood as: "observing what is" using the best technology available in context, and as pragmatically as possible.

PREFACE:

This trial has its roots in PhD Work done by R.E. Ingham, J.A. Trofymow, E.R. Ingham and D.C Coleman. Soil microbiology literature says that plant growth is increased by interaction of microfloral grazers, i.e protozoa, nematodes & microarthropods eating bacteria in aerobic environment. From that literature, the 4 authors above show that microbivorous protozoa and nematodes (referred below as 2nd & 3rd trophic level) grazing on surrounding bacteria (1st trophic level) had a positive effect on N plant uptakes, nutrient cycling, plant growth, C, N & P mineralisation and increased substrate utilisation.[1]

The present trial report is an extension of this previous PhD work, where both **Flor.ès.Sens Systems** and **59 Degrees** have been the 2 main stakeholders. Both companies, with their complementary set of skills, decided to apply the previous PhD work fundamentals to an organic vegetable garden production.

While designing and running the below trial, Flor.ès.Sens Systems assessed the relationship between Soil Organic Matter, Soil microbiological web activity and crop productivity.

Flor.ès.Sens Systems, among its holistic & multiple Land restoration's skills, has been studying closely and applying Dr. E.R. Ingham (author in the above PhD work) land restorations' methods, cases and technics[2].
The company is specialized in soil direct microscopy diagnostics for any agricultural and tree systems, & provides Soil microbiological remediation solutions. The company designed, led, managed, and executed the below project; also provided with solutions for increasing microbivorous protozoan number.

59 Degrees, based on the same Dr. E.R. Ingham professional skills, has applied the foundations of her work to tree systems care. The company is now extending its offer to agricultural systems. Holistic tree care, aerobic compost making, and compost extract production (liquid form of compost) for foliage and root inoculation are the company's main offers. From its know-how on producing Compost Extract for bioremediation purposes, 59 Degrees provided compost extract for the purpose of this trial.

Karshamra Mat Och Trädgård is an Organic vegetable market producers operating on approximately 1Ha, based in Grödinge, Botkyrka, 30 km south south west Stockholm, Sweden. The company was suffering low productivity and crop diseases. They were keen to embark in this non-conventional biological trial in order to boost their organic vegetable production, both in quality & quantity.

All 3 stakeholders are looking at providing consistent & efficient solutions for total biological & regenerative agriculture.

Geo localisation: 59°08'09.05"N

TECHNICAL JARGON – TERMINOLOGY:

Microfloral/Microbivorous grazers:
Microbiological life such as protozoa & nematodes eating bacteria.

Mineralization:
In soil science it is the decomposition or oxidation of compounds in organic matter releasing the nutrients contained in those compounds into forms that may be plant-available.

Soil Organic matter:
It is the organic matter component of soil, consisting of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by soil organisms.

Aerobic conditions:
Soil conditions that mostly enable oxidation, i.e oxygen to flow through and around. Relates to mineralization.

Anaerobic conditions:
Soil condition with absence of oxygen; enable "reduction" of surrounding organic compounds and development of anaerobic type of life, which is most of the time detrimental to humans.

Compost extract:
Liquid in which microorganisms have been extracted from compost. Can be aerobic or anaerobic.

Microbiological inoculation:
Process by which compost extract is applied to soil medium.

Regenerative agriculture:
Agricultural methods using holistic ecosystemic approaches that take care of building ecosystem services at many levels: soil, soil water holding capacities, organic crops, rational rotational grazing, etc. It is opposed to "conventional agriculture" which is mostly "degenerative": soil loss, erosion, livestock in feedlots, crop loss of productivity, chemical use, aquifers pollution, etc.

Microbiology biomass:
Methodology using weight calculation for microbial life (bacteria, fungi, protozoa, etc.)

Penetrometer:
Instrument measuring soil compaction in pound per square inch (psi) and soil related depth in cm.

Prophylactic:
Method or product guarding from disease spread or occurrence.

Soil Food web:
Related to the all microorganism composing soil life; i.e. microbiological life.

Humics:
Come from humic acid, coming from humus. Beneficial to plants, therefore humans.

Fulvics:
Similar to humic acid. Present in humus. Beneficial to plants therefore humans.

Highlights:

Filling the need to address terminology in this section, readers will keep in mind the following: "Microbiological inoculation" stands for Compost extracts which is a liquid form coming from compost produced in aerobic conditions, where the compost's microorganisms has been extracted. Following step is field inoculation for the purpose of this trial.

- In trial scenarios receiving microbiological inoculation and commercial compost amendment together, total Edible biomass production skyrocketed compared to "control" scenario with no input.

- Weed pressure, where soil was microbiologically inoculated, was reduced compared to other non-microbiologically inoculated ones.

- Edible biomass of scenarios receiving "commercial compost" amendment only, with no microbiological inoculation, underperformed "control" scenarios.

- Measured soil compaction (psi) remained low and homogenous among all the scenarios at a same decent depth.

- Microbiological biomass analysis (before & after trial) shows that scenarios receiving simultaneous microbiological inoculation + commercial compost amendment, produced higher edible biomass, enjoyed a higher fungal biomass, a lower bacterial biomass, a higher Fungi:Bacteria ratio (F:B ratio), and a higher 2nd & 3rd trophic level number.

All weights below are displayed in "Edible biomass" in relevance with the crop itself.

Table 1: Highlights – Yield Results

Highlights - Yield results

Days at field	CROPS (g/m2)	Scenario 1 Control	Scenario 2 Compost	Scenario 3 Microbiological inoculation + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
64	Rutabaga	1532	1353	2658	73%	-12%
78	Onions	1835	1784	2059	12%	-3%
64	Salad	3083	2236	5773	87%	-27%
70	Swiss Chard	1211	1619	1968	63%	34%
73	Celeriac	1434	1378	3570	149%	-4%
73	Fennel	3421	2791	5416	58%	-18%
92	potatoes	1049	596	1492	42%	-43%
81	Purple Kale	742	326	1680	126%	-56%
	Total	**1925**	**1582**	**3188**	**72%**	-16%

(Source: Flor.ès.Sens Systems, 2017)

Date of monitoring: 17/07/2017 onward.

Abstract:

All numbers, quantities and numerical comparisons in this section are given on average coming from all trial' statistical series displayed in section 4 & 5.

An emerging organic biological market garden producer, based in southwest Stockholm countryside, could benefit greatly from non-conventional methods, i.e. a tailored Soil microbiological inoculation coming from a high quality aerobic compost, mitigating pests, diseases, and increasing market garden productivity & quality.

Among the 8 crops tried, on edible biomass production, we found that: scenarios microbiologically inoculated & amended with commercial compost, **outperformed** "control" scenarios by an average of 72%. On the same 8 crop trials, scenarios receiving nothing else but commercial compost amendment **underperformed** the "Control" by 16% on average.

In relationship with the previous outperforming edible biomass production scenarios: soil microbiology biomass accounts show *Fungal biomass* 4,4 times higher, *bacterial biomass level* 0,43 times lower, and that *Fungi:Bacteria ratio* 9,52 times higher compared to "Control" scenarios. Simultaneously with the previous, bacterial predators, i.e the 2nd & 3rd trophic level responsible for nutrient cycling start up (amoebae & nematodes), is 2,13 times higher than "Control" scenarios. This confirms R.E. Ingham, J.A. Trofymow, E.R. Ingham and D.C Coleman work mentioned in preface section[3].

Also, in Comparison with "Control" scenarios, the scenarios receiving nothing else but "commercial compost amendment", with measured lower edible biomass production, displayed 1,83 times more fungal biomass, the same amount of bacterial biomass, a fungi:bacteria ratio 2,1 times higher, but a low or absent of 2nd & 3rd trophic level.

At microscopic biomass count level, looking at the fungal density/ distribution, i.e the total fungal distribution in our soil samples, we found that scenarios receiving simultaneous microbiological inoculant & commercial compost amendment, displayed a 83% greater fungal distribution (fungi occurrence per each field of view) compared to the "control".

Under the weed pressure trials, the scenario receiving microbiological inoculation, with no commercial compost amended, displayed 38% fewer weeds compared to "Control" scenario with no inoculation.
Then, comparing scenario receiving "only commercial compost" to the same one but with a tailored microbiological inoculation showed 33% less weeds on the latter.
This could be attributed to the fact that both microbiologically inoculated scenarios show 2nd & 3rd trophic level (mostly the protozoan group) respectively 1,78 times and 3 times higher than their control.

A direct correlation between biology and weed pressure can be drawn.

We checked compaction level for each crops in each scenario tried with John Dickey penetrometer tool. All soil physical conditions remained roughly equal among all trial. Compaction at over 100 psi was realized at approximately the same depth: between 22 cm & 24 cm. **(see table section 4)**

Table 2: overall 8 crops averages - trial

OVERALL AVERAGES - TRIAL

INDICATORS		Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD	g/m2	N/A	1788	1510	3077	72%	-16%
1st Trophic Level	FUNGI	24	132	372	707	4,38	1,83
	BACTERIA	12829	9784	9011	5534	0,43	0,08
	FUNGI:BACTERIA	0,0019	0,0134	0,0412	0,1277	9,52	2,07
2nd & 3rd Trophic level Protozoan	FLAGELATES	0	0,01	0,05	0,04	3,57	5,14
	AMOEBAE	0	0,54	0,54	1,49	1,74	-
	CILIATES	0	0,13	0,07	0,04	-3,00	0,45
Fungal density At 100X Total Mag	Total Strands Occurrences	N/A	55	88	101	+83%	+59%
	Av. Strand per field of view	N/A	0,72	1,14	1,32		
SOIL PHYSICAL PROPERTIES	DEPTH CM REACHED under 100 PSI	N/A	21,61	23,22	23,56	9%	7%

(Source: Flor.ès.Sens Systems, 2017)

Table 3: Weed pressure trial highlight

WEED PRESSURE - TRIAL

WEED BED TRIAL	Scenario 1 CONTROL + Microbiological Inoculation	Scenario 2 CONTROL	Scenario 3 COMMERCIAL COMPOST ONLY	Scenario 4 Microbiological Inoculation + Compost
	Comparison pair		Comparison pair	
Kg/m2	0,93	1,51	2,17	1,46
Difference	-38%	Reference	Reference	-33%

(Source: Flor.ès.Sens Systems, 2017)

1. INTRODUCTION – TRIAL'S SCIENTIFIC BACKGROUND:

The "Green revolution" also called "conventional agriculture" produces high yields by means of large resource inputs (NPK and other non organic salts), prophylactics, and plant protection treatments (Gutiérrez et al., 2005; Pimentel et al., 2005). This mode of production introduces into our agricultural ecosystems large and numerous synthetic substances with a broad spectrum of activity, high toxicity and long persistence in the environment. All the previous giving rise to serious concerns about public health and environmental pollution (Schuman, 1993; Pimentell, 2005; Pimentel et al., 2005).
These substances can also have negative effects on agricultural production and practices. When most farmers', whose knowledge on soil microbiology basics is close to null, amend soil unconsciously with non selective herbicides, synthetic fertilizers, hormones, etc., they disrupt and kill microbiological microorganisms diversity. It results in a decrease and/or stopping of nutrient cycling that plants depend on, same nutrient cycling that was previously performed by a broader and diverse microbiological web of life.
As a consequence, the vicious circle of "conventional agriculture" starts here where it induces to the farmer, well directed by agricultural majors, to use more non-natural fertilizers to boost their crops growth, then to select for pesticide resistant crops, contributing more and more to the previous soil microbiological diversity carnage; contributing to a more and more chemically dependent agriculture; contributing to soil physical condition changes, and a very high cost model for our agricultural practices; and potentially contributing to a decline in interest of staying or becoming a farmer.

Well, the good news is that an increasing public demand for quality food products, health and environment protection has triggered worldwide initiatives and even government regulations to foster more sustainable agricultural practices: reduced tillage, integrated pest management, and soil carbon capture.
So called organic production integrates appropriate cultural techniques (i.e. crop rotation, planting dates, cover crop strategies, natural C/N ratio management with plant physiology), also biological pest controls, naturally occurring chemicals, soil microbiological ecosystems management in order to help deal with pests while maintaining reasonable yield with a significantly reduced environmental impact (Rechcigl and Rechcigl, 2000; Horowitz and Ishaaya, 2004; Russel E.Ingham et Al 1985).

In monoculture organic systems, where single or very few plant varieties are grown, a holistic approach through soil microbiological management can mitigate the pre cited ecological disequilibrium. Soil microbiological management practices promoting evenness & diversity at soil life level enhance plant growth and productivity (Russel E.Ingham et Al 1985). Hence, successful crop production under organic agriculture spirit requires a strong core of knowledge about the Soil microbiological ecosystem complexity. The previous can help develop

strategies to preserve a healthy and diverse soil ecosystem that is capable of controlling pests and pathogens while stimulating plant growth and health.

1.1 Basics of soil microbiological nutrient cycling for plants:

A step further entering Soil microbiological diversity, i.e what we call the soil food web, drives us to set the basics of our trial: how and why a healthy & organic crop production functions, and what do we have to do to look after at soil food web level to keep our crop productivity high and of quality.

Theorical discussions about nutrient cycling have long represented the mineralisation process as a flow from litter or soil organic matter component to a component representing plant available nutrients (Gosz 1981, Van Cleve and Alexander 1981). Micro faunal grazers were not yet included in the nutrient cycling process.

More and more evidence has been accumulating in the past decades showing that faunal grazers (i.e. protozoa and nematodes) are responsible for a significant portion of the mineralization previously attributed to microflora only (algae, fungi, bacteria). On terrestrial ecosystems, since mineralization is a key process in delivering nitrogen, carbon and other nutrients available to plants needs (Alexander 1977, Marion et al 1981), it is important to understand the roles of all organisms involved in this process, the interactions that may occur between them, and where these interactions occur (Russel E.Ingham et Al 1985).

Then, on the top of understanding the previous, it is of the highest importance to design and apply agriculture strategies capable to conserve them, feed them, or to bring them back when these microbivorous grazers community disappeared due to "conventional agriculture" uninformed practices: ploughing, and chemical amendment of any kind killing them.

1.2 Effects of microbial grazers on nutrient cycling and plant growth:

As quoted by Russel E. Ingham in their ecological monograph (Russel E.Ingham et Al 1985) [4] : In carbon rich environments (C from organic matter), mineralized nutrients are released at an accelerated rate when microbial population (bacteria) are grazed by protozoa and bacterial feeding nematodes. In these carbon rich environments, net mineralization of P, S, N into aerobic forms (beneficial for optimal plant growth) is higher than in environments with less oxygen (anaerobic), less C organic content and without microbial grazers.

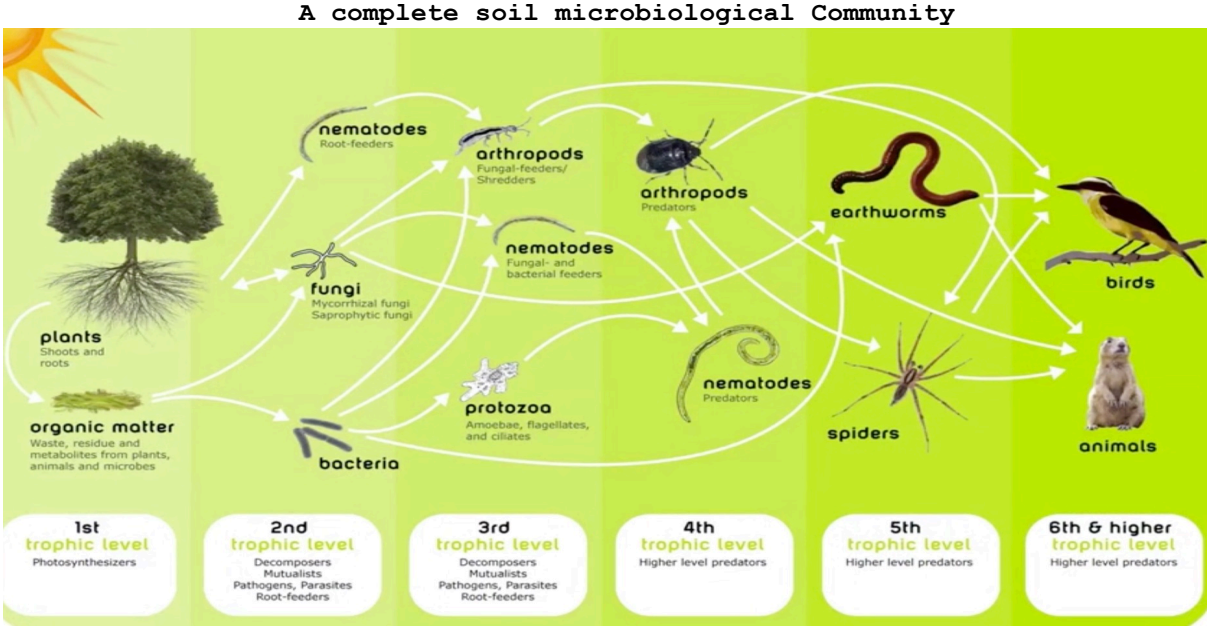
Microbial grazers (Protozoa & bacterial feeding nematodes) having a high bacterial consumption, release a considerable amount of nutrients for

plants. As a consequence, the mineral nutrients rate turnover may serve plant growth. Elliot et al. (1979a) showed that the response of plant growth to nutrient dynamics is significantly higher when bacteria are being grazed by amoebae and bacterial feeding nematodes (2nd & 3rd trophic level faunal grazers).

Russel E.Ingham et Al 1985 also pointed out that presence of fungi and fungal feeding nematodes, without bacterial feeder & protozoa, have a limited effect on plant growth.

Table 4: a complete soil microbiological community

A complete soil microbiological Community



(photo credits: soil symbiotics – Source Soil Symbiotics)

1.3 Soil structure, aerobic vs anaerobic environments and plant health:

Taking this trial background a step further, we want to insist on what kind of soil conditions are necessary to see this healthy relationship between soil microbiological activity, organic compounds present and the resulting plant health.

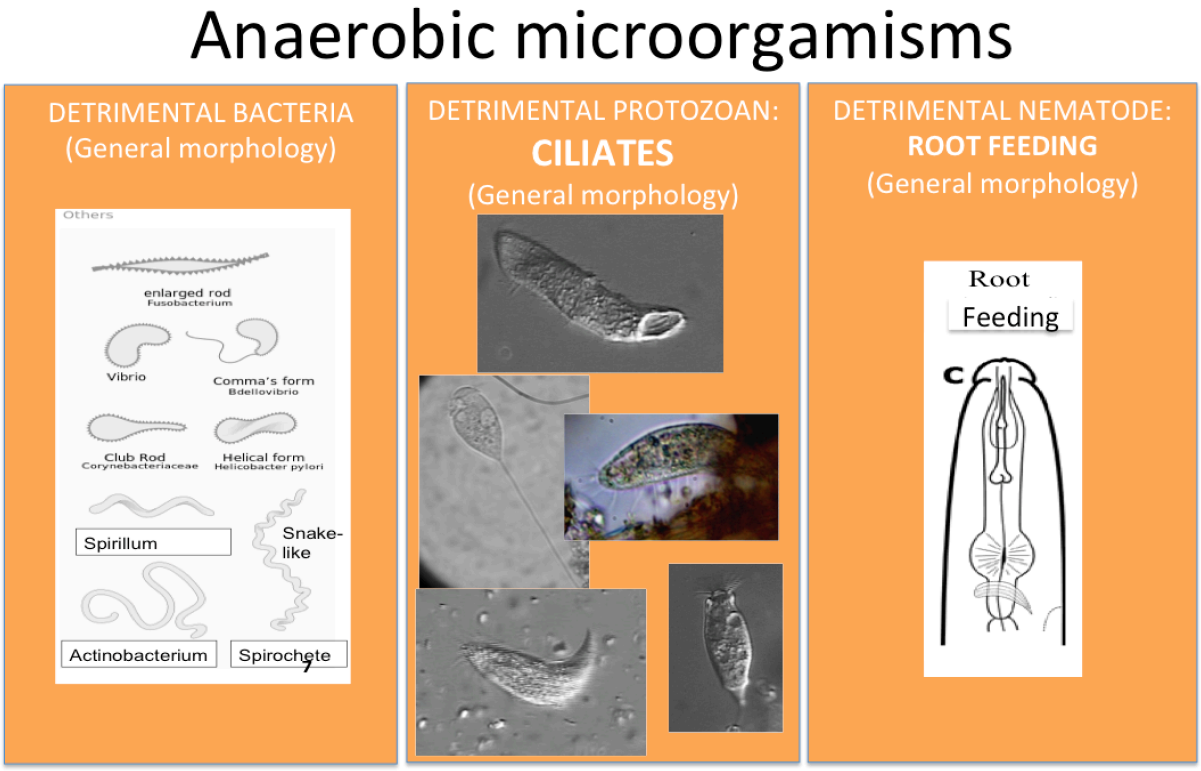
The first and most important factor for this relationship to happen is to get aerobic conditions at soil, and thus microbiological level (DR E.R. Ingham, Environmental celebration institute, 2014).[5]

Soil microbiology literature shows that anaerobic conditions, i.e. reduced oxygen conditions, benefit the development of organisms and substances detrimental to plant growth. In our human agricultural models, anaerobic conditions are often reached because of human disturbances.
The chronological sequence of disturbances happens as follow: tillage (intensity, depth, repetition, timing), monoculture, bad organic matter management (timing, type, replacement), compaction (heavy machinery,

repetition), fertilizers, pesticides, and herbicides etc. From these disturbances, both soil microbiological population, soil physical conditions, and nutrient mineralization change.
Consequently, these undesired anaerobic conditions benefit the appearance of a certain kind of microbivorous organisms. They are responsible for anaerobic mineralization, detrimental to plant growth. As soil conditions go anaerobic, we can identify at microscopic level these detrimental organisms as follows: anaerobic bacteria, ciliates protozoa that release ammonia from the bacterial grazing (NH3 as gaseous form of N), and root feeding nematodes that feed on plant roots *(see table 5 below)*. All are anaerobic markers that we can screen when we analyse our soils with direct microscopy.

Above and below ground signs of anaerobic conditions are: low crop productivity, crops' pest and disease, greater "weed" pressure, water run off, nutrient losses, and consequent higher level ecosystem issues.

Table 5: Anaerobic microorganisms morphology

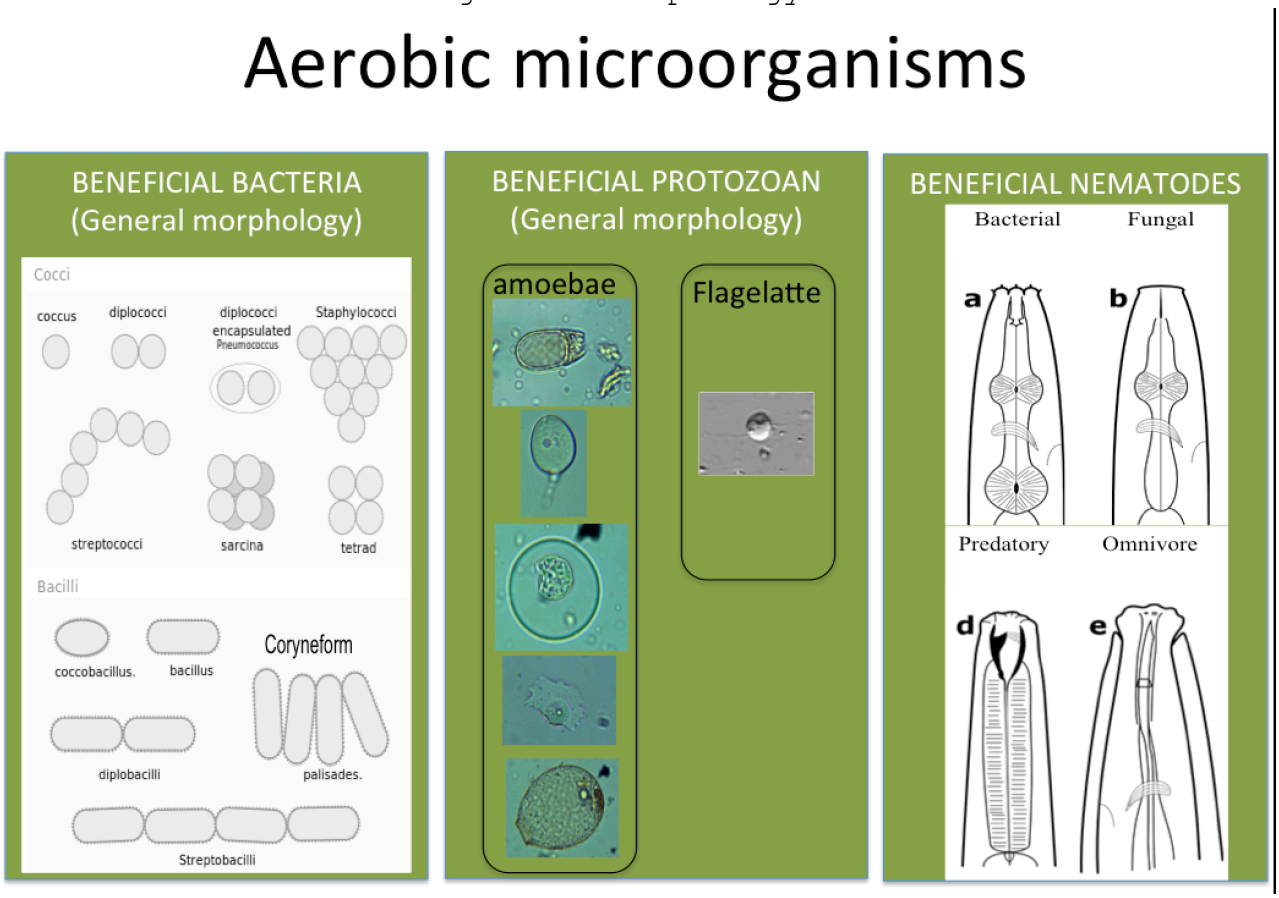


(Source: Soil Food web inc, 2014)

The other way around, optimal aerobic conditions are: presence of decomposing organic matter on the top soil (fungal smell), high content of mineralized residues at rhizosphere level (soil being chocolate brown coloured), soil structure being aerated, and appearance of another set of microbiological organisms. Microorganisms present are: flagellates and amoebae protozoan (releasing plant available ammonium NH_4), bacterial feeding nematodes, fungi, fungal feeding nematodes, and higher trophic level microorganisms such as predatory nematodes, mites, microarthropods, till earthworms.

As a matter of fact, aerobic soil systems shelter way more microbial life diversity, provide a much bigger resilience to small disturbances (low till for instance), reduce use of water by greater soil water holding capacities, tolerate pests and diseases, enable inorganic fertilizers and pesticide free systems, set ecosystem conditions for plants and crops health and productivity.
In such conditions, decomposing organic matter is fuelling mineralization below ground, nutrients are held plant available at rhizosphere level, water is kept longer and in higher volume in the soil, diseases are suppressed by microbial competition inhibition consumption, toxins are decomposed, soil structure is built, enabling plant root structure to grow healthier and deeper.

Table 6: Aerobic microorganisms morphology



(Source: Soil Food web inc, 2014 & Flor.ès.Sens Systems, 2017)

About soil structure, the R. Fosters' book dealing with the ultrastructure of the rhizosphere [6] mentions the following: as aerobic soils enable more plant beneficial microbiological life to thrive, the same microorganisms will contribute to strengthen soil structure, increasing soil aerobic conditions.
Bacterial bodies hold a glue compound, fungal threads act both as structural material and spread glomalin all over the soil, mites, microarthropods earthworms and higher trophic level microorganism dig

soil tunnels, contributing altogether to building soil aerobic structure.
All this complex microbiological life under our feet, that we call Soil Food Web, is responsible for keeping our soils aerobic, benefiting plant health and productivity.

In other words, under aerobic/oxygenated conditions soil microbiological microorganisms are: the architects, the carpenters, the network designers, the water filtering and drainage services, the organic fertilizing facility, and much more.
Microbiological life working for higher-level life, reaching sooner or later human communities basic need for food.

1.4 Soil microbiological diversity & biological succession[7]:

After we reviewed the basics of soil microbiology for plant nutrient cycling, effects of microbial grazers on nutrient cycling, effects of aerobic environment on plant growth, we are now discussing the relationship between soil microbiological diversity and the above ground biological response.

Soil microbiology literature shows that microbiological biomass & diversity is changing as we travel from a soil bare parent medium towards an old growth forest soil. At each broad stage of the microbiological succession corresponds a set of above ground plants *(see table 7 below)*. Early successional stage holds only bacteria & weeds, while an old growth forest soil is a fungal kingdom with trees.

Between one extreme and the other one of table 7 below are human food soil systems. These crops are in symbiosis with a certain set of microbiological diversity and biomass: from bacteria & fungi, including microbivorous protozoa & nematodes, to microarthropods and earthworms if we practice a conservative enough agriculture.

First organism establishing life on planet earth bare soil were cyanobacteria, slowly igniting a change in the surrounding soil's conditions; influencing the evolutionary patterns of other very early successional plants.
While these bacteria are at the very root of current planet earth ecosystems, they also opened the door to life evolutionary patterns; they opened the door to more complex species along the tree of life, above and below ground. Among these branches, appeared human food and the corresponding microbiology.

When we look at an old growth forest system, we can understand it as the work of time and/or microbiological evolution with no human or natural disturbances (volcano, earthquakes, tidal wave, flood, etc). *(see table 7)*.

When we look at an agricultural system above ground plant response, we can intuitively project what kind of soil microbiology we have below ground.
If we want to enable crops to respond to their optimum potential, we want to make sure we have the right microbiological soil communities below ground.

In the below graph we see the relationship between 1st trophic level soil microbiological life biomass (fungi & bacteria) and the human agriculture crops we grow. Note that the µg weights below are indicative ranges. The important factor to manage is the ratio between fungi and bacteria: the Fungi:bacteria ratio.
It shows how soil fungal biomass increases as we go towards forests' soil and at the same time bacterial biomass decreases.

Table 7: Microbiological biomass distribution & Above ground biological succession

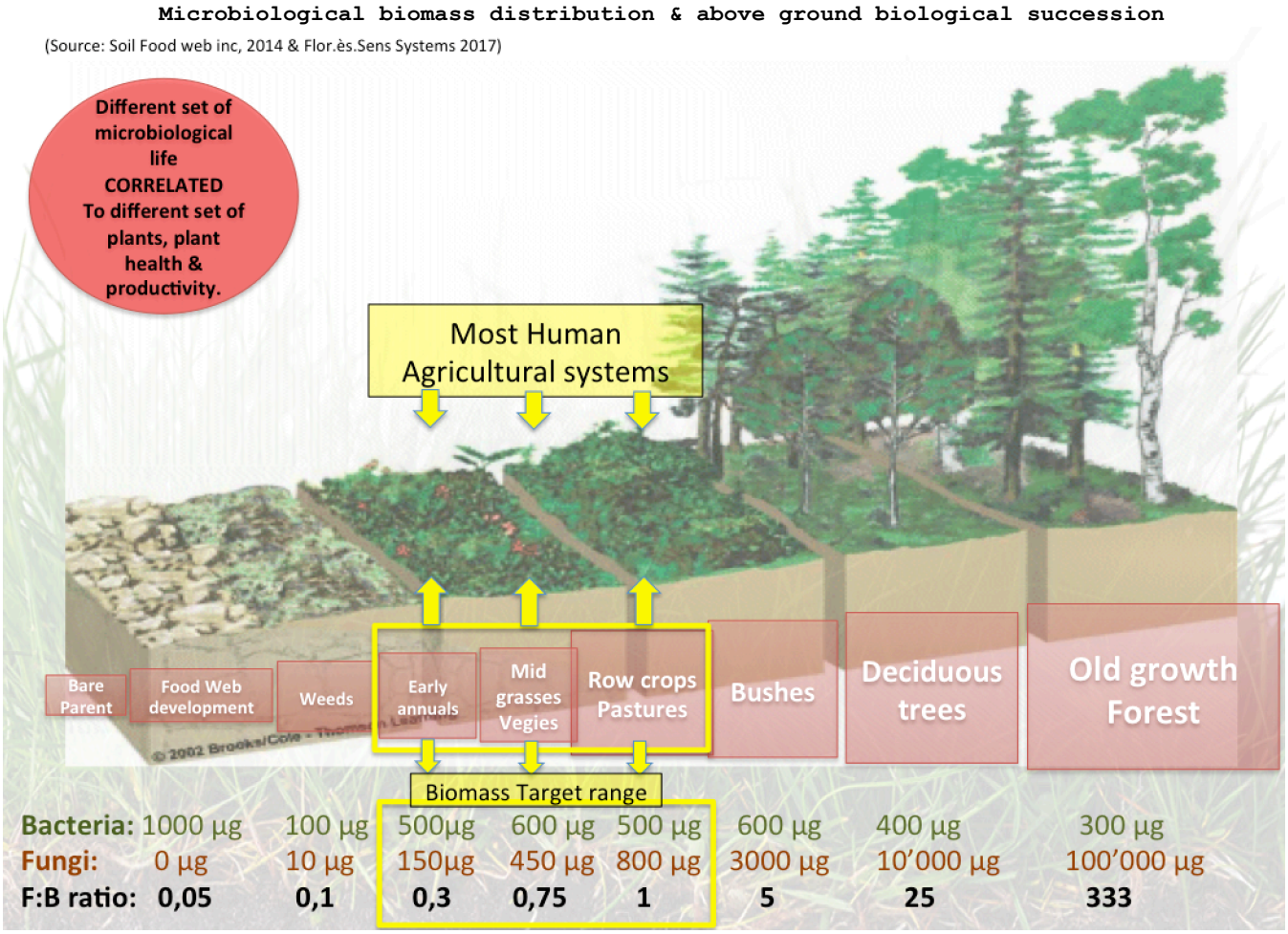


Table 8 targets human food systems, and provides more details about the relationship between Fungi to bacteria ratio, fungi and bacterial biomass, the related vegetation growing, the soil physical conditions, nutrients, 2nd & 3rd trophic level needs.

This table will guide us through the remediation decision making in this trial; i.e what condition we have to provide to enable optimum plant growth and health.

Table 8: Microbiological Guideline "from early successional to productive pastures"

MICROBIOLOGICAL GUIDELINE:
From early succesionnal to productive pastures & row crops

Biology & SUCCESSION	EARLY SUCCESSIONAL	VEGETABLES & EARLY SUCESSIONAL GRASSES	MID SUCCESSIONAL	PRODUCTIVE PASTURE ROW CROPS
AEROBIC vs ANAEROB	AEROBIC DEV	AEROBIC	AEROBIC	AEROBIC
FUNGI:BACTERIA ratio	F:B = 0.3	F:B = 0.5	F:B = 0.75	F:B = 1.0
VEGETATION	Wetlands, Brassicas, e.g. Cole, Kale, Mustards. Limited root depth. Strong tap rooted plants provide foods & break compaction.	Bromus, Bermuda grasses, Root-crops, lettuce, greens, etc.	Turf such as ryegrass, vegetables, annual crops and flowers.	Lawns with no weed, Corn, wheat, barley, etc. Requiring no fertilizers.
SOIL STRUCTURE	Soil Structure begins.	Compaction not well tolerated	No compaction. Walking on a mattress	No compaction. Walking on a mattress
NUTRIENT STATUS	Nitrate high but measurable ammonium present at times. Nutrient cycling starts normally	Need both nitrate and ammonium.	Use predominately nitrate but need ammonium	Need equal balance of nitrate and ammonium.
1st trophic biomass: bacteria & Fungi	Bacteria 500-2000 µg/g Fungi 70-200 µg/g	Bacteria 300-1000 µg/g Fungi 150-500 µg/g	Bacteria 500-3000 µg/g soil Fungi 150-2000 µg/g	Bacteria 300-3000 µg/g Fungi 300-3000 µg/g
1st trophic details	Bacterial diversity increase Soil Actinobacteria very important to protect roots from fungal colonization. Fungi may be mostly disease ones.	Greater bacterial diversity For most species, mycorrhizal colonization is required (VAM)	Greater bacterial diversity Mycorrhizal colonization required (VAM)	Greater bacterial diversity Mycorrhizal colonization required (VAM) The higher the balanced biomass of both F and B, higher the yields, deeper roots grow, higher retention of nutrients, higher organic matter sequestered
2nd & 3rd trophic level: PROTOZOA	Flagellates and amoebae = 10,000/g	Constant #'s of flagellates and amoebae 10,000 – 50,000 /g in growing season.l	Constant #'s of flagellates and amoebae > 50,000/g in growing season.	Constant #'s of flagellates and amoebae > 50,000/g in growing season.
2nd & 3rd trophic level: NEMATODES	Bacterial-feeders present.	Bacterial, fungal and predatory nematodes usefu	Nematodes: Bacterial, fungal and predatory nematodes useful	Bacterial, fungal and predatory nematodes needed

(Source: Soil Food web inc, 2014)

NOTA BENE:

For the below microbiological analysis appearing in section 4, 2nd & 3rd trophic level biomass appearing here, are converted in microorganism numbers per microscope field of view. *(see table 12)*

Table 8' below provides soil ecosystemic indicators for the successional stage appearing before our human agricultural systems. It will help us to assess & monitor our soil ecosystems; it shows us what soil ecosystem conditions we don't want our human food ecosystems to go. *(see table 8).*

Table 8': Microbiological Guideline "from dirt to weeds"

MICROBIOLOGICAL GUIDELINE:
From Dirt to Weeds

Biology & SUCCESSION	DIRT	BARE SOIL	WEEDS
AEROBIC vs ANAEROB	ANAEROBIC	ANAEROBIC	ANAEROBIC
FUNGI:BACTERIA ratio	F:B 0,01	F:B = 0.05	F:B = 0.1
VEGETATION	No vegetation.	No vegetation.	"Weeds" selected. Little effort put into building soil. Limited root depth. Towards end of this stage, tap root plants.
SOIL STRUCTURE	No structure, Compacts easily	Poor soil structure. Compacts easily.	Compaction is common.
NUTRIENT STATUS	None. no nutrient cycling. Inorganic fertilizer required for lack of soluble nutrients. Any excess leaches rapidly.	Loss of nutrients through anaerobic conditions. Plants suffer lack of available nutrients. Strictly nitrate, pulses.	Uses strictly nitrate. Low Functioning food web. Soluble nutrients pulse high, low, high, low.
1st trophic biomass: bacteria & Fungi	Low to no bacteria Low to no fungi both under 10µg	Bacteria > 1000 µg/g soil Fungi 1-10 µg/g,	Bacteria > 1000 µg/g Fungi 5-50 µg/g,
1st trophic details	none	Low bacterial diversity. Typically mostly disease fungi.	Low bacterial diversity. Typically mostly disease fungi
2nd & 3rd trophic level: PROTOZOA	none	Protozoa: Ciliates indicate loss of soluble nutrients.	Protozoa: Ciliates often present. Pulses typical.
2nd & 3rd trophic level: NEMATODES	none	Rare	Rare to find bacterial-feeders.

(Source: Soil Food web inc, 2014)

Table 8'' shows the stages following our human crop systems. We will use it for shrub, bushes and tree systems providing food for humans.

Table 8'': Microbiological Guideline "from shrubs to conifers & evergreen"

MICROBIOLOGICAL GUIDELINE:
From Shrubs to Conifers & Evergreen

Biology & SUCCESSION	SHRUBS BUSHES VINES	DECIDUOUS TREES	CONIFER EVERGREEN To OLD GROWTH FOREST
AEROBIC vs ANAEROB	**AEROBIC**	**AEROBIC**	**AEROBIC**
FUNGI:BACTERIA ratio	F:B = 2.0-5.0	F:B = 5-10	F:B = 10-100
VEGETATION	Therefore fungal activity must be greater than bacterial activity.	Deciduous trees	Conifer, evergreen, old growth forest
SOIL STRUCTURE	No compaction. Walking on a mattress	No compaction. Walking on a mattress	No compaction. Walking on a mattress
NUTRIENT STATUS	Require more ammonium than nitrate.	Require mostly ammonium. Nitrate can be harmful and encourage disease fungi.	Require strictly ammonium. Nitrate will harm the trees
1st trophic biomass: bacteria & Fungi	Bacteria 300-3000 µg/g Fungi 600-6000 µg/g	Bacteria 300 – 2000 µg/g Fungi 1500 – 20,000 µg/g	Bacteria 300-1,000 µg/g Fungi 3,000-100,000 µg/g
1st trophic details	Lower Bacterial biomass Mycorrhizal colonization required (VAM/ Ecto/Ericoid)	Lower Bacterial biomass Mycorrhizal colonization required (VAM).	Mycorrhizal colonization required (Ecto) Fungal biomass seasonally consumed by predators to provide the nutrients plants require. Fungal re-growth occurs in the dormant season.
2nd & 3rd trophic level: PROTOZOA	Constant #'s of flagellates and amoebae > 50,000/g in growing season.	Constant #'s of flagellates and amoebae > 10,000/g in growing season.	Not as important in a fungal dominated system n# > 10,000/g in growing season.
2nd & 3rd trophic level: NEMATODES	Fungal & predatory nematodes along with microarthropods should start to rival bacterial feeder numbers.	Fungal & predatory nematodes should equal bacterial feeder numbers, unless their function is replaced by microarthropods.	Fungal & predatory nematodes should exceed bacterial feeder numbers unless their function is replaced by microarthropods

(Source: Soil Food web inc, 2014)

1.5 Aerobic compost, Organic matter decomposition, nutrient cycling, plant productivity & health:

Quality compost can be seen as a replication of the humus building process enabling mineralisation. This happens under aerobic conditions. It is in essence what our plants need, carrying the beneficial microbiology with it.[8]
Aerobic means, that we are setting the right oxygen conditions to enable beneficial organisms to grow and feed in the pile. While being aerobic, the same microorganisms will decompose organic materials making it plant available.

Decomposition: that implies that you have to have the bacteria and the fungi doing the job. Nothing else on the planet has the enzymes to perform that decomposition. Optimum decomposition implies having a diversity of organic materials, all these different temperatures, different moistures, all of these different chemical concentrations and different nutrient availability. All of these factors determine which species of bacteria, which species of fungi are present and functioning, doing their job of decomposition[9] making it plant available.

Quality compost then (aerobic decomposition), is all about the microbiological life, the bacteria and the fungi and consequent protozoa and nematodes; these are the beneficial species *(see table 9)*. In order to ensure these microorganisms strive: we make sure our compost remains aerobic, we make sure there is a diversity of foods (diverse organic materials) so they are active, living and growing. Consequently they will outcompete and wipe out the diseases, the pests, and the problem organisms.
If we get a good set of organisms growing in our compost, they're going to build the structure to allow oxygen to move into your pile so there's plenty of air movement through the pile.

Going back to decomposition, and in the perspective of addressing soil conditions lacking part of the soil food web, we have to ask ourselves if we need a bacterial dominated or a fungal dominated pile. This issue is addressed by building up an adequate compost recipe: different types of organic material feeding different type of microorganisms *(cellulose, browns and nitrogen based)*.

Then, the chemistry in your compost pile and in your soils becomes a consequence of what the biology is doing. Microbiology is going to be making nutrients available: the soluble nutrient pool plant can uptake. Biology is critically important so the chemistry is going to be what our plants require.
Once these organisms get back out into your soil, it's the organisms that determine how rapidly the nutrients in you sands, your silts, your clays, your rocks, your pebbles, in the organic matter that you're adding back in that compost, are cycled. It's the biology that determines the speed at which those nutrients are made available to the

plants. Quality in this compost is determined by the biology you have. Chemistry is a consequence.

Table 9: Aerobic vs Anaerobic mineralization

Aerobic vs Anaerobic mineralization:

predominant mineral form in soil for N, S, P

AEROBIC MINERALIZATION (Oxidized)	ANAEROBIC MINERALIZATION (Reduced)
NO3 (nitrate) NO2 (nitrite) NH4 (ammonium)	NH3 (amonia) **Colorless Gas**
SO4 (sulfate) SO3 (sulfite) SO2 (sulfur dioxide) S2 (Elemental S)	H2S (Hydrogen sulfide) **Colorless Gas smelling rotten eggs**
Rock P PO4 (phosphate)	Phosphine Gas **Colorless flamable toxic gas**

(Source: Soil Food web inc, 2014)

We see from the table that most of anaerobic mineralization of N, S, P end up as gaseous form, not taken up by our plants, potentially dangerous for humans.

Table 10: Other materials produced under anaerobic conditions

Other materials produced under Anaerobic conditions

ANAEROBIC ORGANIC ACIDS
Acetic acid (strong vinegar smell) Butyric acid (vomit like smell) Valeric Acid (Rancid smell) Putrescine (putrefaction smell)

TOXIC MATERIALS PRODUCED UNDER ANAEROBIC CONDITIONS	
Alcohol	• 1 ppm alcohol solubilizes any plant cell wall • anaerobic soil/compost produces 25 ppm alcohol
Formaldehyde	colorless, strong-smelling gas – Toxic for human health
Phenols	Toxic to humans

(Source: Soil Food web inc, 2014)

Remember, the only way to get the nutrients out of the bacteria and fungi and into a form that is plant available, requires that we have the protozoa and nematodes[10]. At the very least we have to have those two organism groups. It would be nice to have microarthropods and it would be wonderful to have earthworms as well.

Table 11: Benefits of thermal composting.

BENIFITS OF THERMAL COMPOSTING:
Kill weed seeds
Kill human pathogens
Kill plant pathogens
Kill root-feeding nematodes
Get Ciliates protozoa in Dormant mode, inactive
Wipe out detrimental bacteria
Kill insect pests
Concentrate nutrients

(Source: Soil Food web inc, 2014)

We acknowledge plant productivity is a consequence of the overall soil microbiological community health, organic matter content quality & diversity.

In that regard, we have to develop a set of relevant and consistent monitoring indicators helping our food systems management decision-making.

This report aims to propose and study a set of indicators enabling an informed holistic decision making for a total organic & regenerative food system:

- ***Fungi to bacteria ratio (1st trophic level)***
- ***Protozoa & Nematodes population (2nd & 3rd trophic level)***
- ***Organic matter content (C/N ratio)***
- ***Soil physical condition: compaction measured in psi.***

NOTA BENE:
The reader will keep in mind that all the previous apply to "all human food systems": from vegetables, vines, fruit trees to mushroom growing, etc.

2. THE CONCEPTUAL TRIAL & EXPERIMENT DESIGN:

Organic & Biological Soil Fertility solutions are real, available, cheap and provide good yields. In this trial we explore soil microbiological solutions to restart plant nutrient cycling, health and productivity.

From topics discussed in section 1: Human food systems' fertility & productivity is a function of, i.e is systematically linked to, corresponding aerobic soil microbiology biomass levels and aerobic soil organic matter content &/or compost related materials (carbon and nitrogen content).

2.1 Experimental design:

Following Russel E.Ingham et Al 1985 findings, we designed experimental scenarios *(see trial layout at section 2.3)* exploring the improving of market garden crop yield, health, and weed pressure from tailored microbiological inoculation that we produced.

We put a special attention in our remediation work to the "1st, 2nd & 3rd trophic level" population, the fungi:bacteria ratio; i.e. soil microbiological organisms diversity in relationship to the plant we want to see growing; a certain volume of bacteria, fungi, amoebae and nematodes biomass *(see table 8)*. Anaerobic markers were checked as well.

We followed broad targeted Biomass range for 1st 2nd & 3rd trophic levels for aerobic microbial life suggested by DR E.R. Ingham network (see table 8).

Simultaneously with the previous, soil carbon & nitrogen content being of crucial importance in our agricultural systems, we got hold of commercial compost reputed to be of good quality, analysed its soil microbiological quality (see table 19), and amended fields with approximate same weight/m2 *(see section 3.6)*.
We also got the soil's carbon and nitrogen content analysed by an independent laboratory *(see table 15)*.

2.2 Predictions:

By managing both aerobic soil Microbiological life activity at 1st 2nd 3rd trophic level, and Soil organic matter we will achieve: optimum nutrient cycling plants need to grow, and, as a result better yields, less disease, and less "weeds".

2.3 General trial layout:

Following section 1 & 2, we designed two experiments exploring yield, and weed pressure changes.

Both experiments holds in itself scenarios designed to witness changes due to our tailored microbiological inoculation & compost amendments simultaneously, separately, and compared to the control scenario.

2.3.1 Yield experiment scenarios:

1. Scenario 1: Control.
   Control beds are kept with no amendment at all.

2. Scenario 2: Commercial compost amendment only. This scenario receives commercial compost only.
   It is designed to explore the results in yield coming from compost amendments only; disregarding its possible lack in microbiological life. Comparison will be done with scenario 1 and scenario 3.

3. Scenario 3: Microbiological inoculation + commercial compost amendment.
   This scenario receives commercial compost amendment with 59 Degrees' compost extract, topped up with Flor.ès.Sens Systems protozoan infusion. Supporting points made in section 1 & 2, this scenario is designed to explore if there is a difference in yield due to the tailored microbiological inoculation, compared to scenario 2 and scenario 1.

2.3.2 Weed pressure experiment scenarios:

This experiment is made to assess whether or not tailored microbiological inoculation decreases the weed pressure.
Scenario 1 & 2 are compared the one to the other.
Similarly, Scenario 3 & 4 are compared the one to the other.

1. Scenario 1: Microbiological inoculation only. No other amendment.
   In similar field conditions than scenario 1, does a microbiological inoculation make a difference with weed pressure?

2. Scenario 2: Control.
   Trial bed is kept with no amendment at all. How much weeds do we have?

3. Scenario 3: Microbiological inoculation + commercial compost amendment.
   This scenario receives commercial compost amendment with 59 Degrees' compost extract, topped up with Flor.ès.Sens Systems protozoan infusion. In similar field conditions than scenario 4, does a microbiological inoculation make a difference with weed pressure?

4. Scenario 4: Commercial compost only.
   Only commercial compost is added to the trial bed. Weed pressure is checked.

3. MATERIAL & METHODOLOGY:

3.1 Shadowing microscopy & Soil microbiological assays:

3.1.1 Shadowing microscopy:

In the context, we used an OMAX MD8211E30 microscope, with iris diaphragm, shadowing features, built in digital camera enabling pictures and videos and related microscope software for identification purposes.
Magnification used were 100x where we can see details at 2mm, and 400X magnification where we are able to see 0,45 mm (450 microns).

Shadowing techniques are critical in that context. The microscope has use DIC, which is a shadowing technique. It allows you to clearly see things that have the same refractive index as water.

3.1.2 Soil microbiological assays

Biomass assay methodology has been developed by Dr Elaine Ingham, and has been in use for more than 30 years now.
Flor.ès.Sens System & 59 Degrees Sweden are active in Dr Elaine Ingham network.
All assays are performed with slide & coverslip, reproducing aerobic conditions. *(Note that plate-count method reproduces anaerobic methods)*.

In relationship to the on-going market garden operations, we analysed the below indicators, keeping target on beneficial aerobic microbiology status & soil aerobic microbiological trophic levels for:

- Soil samples at pre growing season.
- Soil samples for each trial scenario at harvest.
- Commercial compost used for field amendment.
- Commercial compost used for seedling production.
- Pond water samples for watering during growing season.
- Compost extract samples before field inoculations.

To guide the « remediation inoculation solutions » in this very trial, Flor.ès.Sens systems used a microbiological database about productive biological ecosystems referred as Native Environments (see table 12 below). As shown in table 8 & 12, each Native Environment relates to a biological succession level in which we have "Fungi:Bacteria ratio" biomass target, 2nd & 3rd trophic level. It corresponds to average expected microbiological biomass ranges for optimum crop production health results.

Table below shows targeted Fungi:Bacteria ratio, the corresponding 2nd and 3rd trophic level, and the corresponding above ground plants.

Table 12: Soil microbiology biomass targets

Soil Microbiology Biomass Targets: 1st, 2nd & 3rd trophic level

	F:B Ratio Target	Plant present
		Bare Parent material
1st trophic level	0,01	early successional
	0,1	weeds
	0,3	early annuals (Bromus - Bermuda)
	0,75	mid grasses & Vegetables
	1	late successional grasses - row crops
	2 -- 5	Shrub, vines, bushes
	5 -- 100	Decidous trees
	100 - 1000	Conifer, old growth forest

	Protozoa n# / field of view in slide analysed	Flagellate	Amobae
2nd trophic level	Conventionnal ag.	0	0
	weeds	< 0,7	< 0,7
	annuals & Vegetables (IN SPRING)	1 -- 1,5	1 -- 1,5
	Productive pasture (IN GROWING SEASON)	1,5 -- 5	1,5 -- 5
	Shrubs to Decidous Forest	3+	3+
	Conifer to Old growth	1 -- 2	1 -- 2

	Total nematodes n# in slide analysed	Root F.	Bacterial F.	Fungal F.	Preda.
3rd trophic level	Conventionnal ag.	1	0	0	0
	weeds	1	0	0	0
	annuals & Vegetables (IN SPRING)	0	1+	1	0
	Productive pasture (IN GROWING SEASON)	0	1 -- 2	1 +	0
	Shrubs to Decidous Forest	0	1 -- 5	1 -- 3	1
	Conifer to Old growth	0	1 -- 5	1 -- 3	1

(Source: Soil Food web inc, 2014)

Our posture is more ecosystem relationship based, than of a syndrome based and mechanical one.
We look at microbiological morphology over identity.
We look for "beneficial organisms" corresponding to aerobic environment ecosystems, as opposed to "detrimental" which corresponds to anaerobic environment.

When in doubt on our microbiological morphological identifications, we can refer to Dr. Elaine Ingham's network of professionals, specialised in Soil shadowing microscopy analysis and Soil microbiological remediation.

We assess the following organism biomass:

- Bacteria biomass & diversity.
- Fungal strands: hyphae & ascomycetes, oomycetes.
- Actinobacteria & Bacterial biomass & diversity.
- Protozoan number & diversity
- Nematodes general type

Flor.ès.Sens uses a built in excel file inspired from Dr Elaine Ingham one, with macro helping the biomass account.

3.1.3 Soil microbiological analysis workflow:

- 1g of the soil sample gathered from each scenario, soil, water.
- 1g of the sample diluted with water according to need; starting at 1/5. Enables clearer fields of view as we go up in dilution.
- 1 drop of the previous dilution is set on slide and covered with coverslip.
- 20 fields of view analysed per slide.
- 1 slide per soil sample (or more if needed).

3.2 Soil Compaction:

We use John Dickey tool, which is a soil compaction tester.

By pushing the tester into the ground at different locations, this tool will help us to measure psi and related depth of our soil.
Pennsylvania State University Soil department showed that above 150 psi root growth is quite completely inhibited and yields reduced.

In order to make sure this trial soil compaction were the same all over the experiments, we checked all scenarios, at a rate of 10 points measured per crop per scenario at the end of the trial. *(see results in section 4.5)*.

3.3 Commercial compost:

Most of small growers and farmers have usually not enough time, sufficient skills to give to aerobic compost making and microbiological quality management.

In this trial's context, Karshamra producers decided to buy commercial compost from a neighbouring compost producing company reputed of good quality.
When delivered, this commercial compost was still warm and actively decomposing. However, we could not get information about organic material diversity used in the compost, composting methods (aerobic or not), time to work it etc. 15 % of biochar was inside, and we didn't have information about the its quality.

One fact helping identify compost microbiological quality is to observe a pile sitting for some time and finding out what is growing on the top of it. If we see "weeds" *(early successional grasses)* coming up, it is a sign that our pile is highly bacterial. This could help decision making whether or not amending your field depending what your field may require. *(see table 8 & 12)*

This topic is discussed in the "Discussion" section below.

3.4 Microbiological inoculant & Protozoan infusion:

59 Degrees is producing aerobic compost under section 1.3 & 1.4 statements. The company uses that compost for producing commercial compost extracts. End purpose is to service & remediate microbiologically tree and agricultural organic systems.

Flor.ès.Sens Systems share the same skills but with a mobile/nomad commercial offer; i.e offering aerobic compost, compost extracts operation set up, and related soil microbiological remediation services. On top of these skills, Flor.ès.Sens manages recipes for 2nd & 3rd trophic level biomass increase, i.e increase of protozoan numbers mostly.

Results appear in section 4.2.2.

3.5 Soil Organic matter:

Crop yields & health level are correlated to Soil Organic Matter levels and microbiology to cycle up to plants. Both Nitrogen and Carbon constitute the two main building blocks of life.
While approaching this topic, we acknowledge that carbon content, thus Soil organic matter, has to be cared for at soil level too. Low carbon content in soil equal to low crop productivity, low water holding capacity, low microbiological diversity, low ecosystem resilience.

Soil Organic Matter analysis is provided by an independent laboratory[11].
Analysis performed using "Dumas method" for molecular weight determination. *(see results in section 4.1.1 & 4.1.2)*

3.6 Monitored points' context:

This section provides context about the analysis we performed for this trial.

Soil organic matter & Carbon content: pre-production.

- Fields Pre production:
  What is the carbon and Nitrogen content baseline to start with?

- Commercial Compost used for amendment:
  How much carbon & Nitrogen we may be adding.

Microbiological Biomass assays: pre & post-production.

- Pond water used for fields watering:
  Making sure water was microbiologically "beneficial" for the crops.

- Compost used for seedlings:
  Evaluating microbiological level & quality starting the crops production process.

- Commercial Compost used for amendment:
  Assessing how microbiologically beneficial it was at 1st, 2nd & 3rd trophic level.

- Trial fields before production:
  Establishing a microbiological baseline for later comparison at harvest in same scenarios.

- Applied Microbiological inoculations:
  Making sure we kept our microbiological remediation actions in the right direction with our biomass targets.

- Trial scenarios post-production:
  Assessing microbiological evolution at harvest enabling to correlate soil microbiology trends with yield and weed pressure.

Commercial Compost amended: pre-production.

The below amended amount was decided upon the total volume of compost the producers bought in relationship with the total surface of production.

That compost was bought trusting the company selling it as being "good". An independent laboratory checked level of C & N, and we checked the current microbiology status.

- Roughly 1ha in production. 8Kg/m2 of commercial compost amended.

We recognize, we may have been spreading sometimes above or under this weight/m2.

Microbiological inoculant applied:

After checking the Kasharma Garden soil microbiological status, current commercial compost levels of microbiological life, i.e overall lacking in terms of 1st, 2nd and 3rd trophic level, we decided to inoculant at:

- 1L/m2

10'000 litres of compost extract were inoculant, coming from an average of 400 kg of beneficial aerobic thermal compost produced by 59 Degrees.

We produce the inoculant using a commercial brewing facility: a tank filled with water in which air is blown by a pump at relevant rate enabling aerobic conditions.

We recognize we may have inoculant sometimes more, sometimes less than this volume.

Crops' yields: post-production.

A set of vegetables has been selected for their "monitoring" features: size, weight, and physiological structure *(details in section 3.8)*.
Each crop used in this trial was allocated 1m2 per scenario.

We compared different scenarios results crop by crop:

- Kg/m2 of edible biomass produced.

Weed pressure: one month after seeding without weeding done.

We will look at weed density in respect to each of the scenarios designed.

- Kg/m2 of green weight produced.

3.7 Trial work flow:

Action were taken as follow:

1. Microbiological biomass assays baseline analysis for: Pre production Fields, bought commercial compost for field trial application, seedling commercial compost, water for future watering operations. Setting the trial context for remediation decision-making.

2. Soil Organic Matter baseline analysis for pre-production fields & commercial compost: adding up to the context.

3. Delivery of commercial compost; Microbiological assay and spread on field at levels defined above. Remediation start.

4. From our biomass microbiological assay performed on the trial fields (point 1, 2 & 3 here), we put together microbiological inoculant having the identified missing microbiology. We inoculant the soil on which we are performing this trial. Consequently microbiological remediation is performed.

5. Between one and two weeks after inoculation we monitored microbiological biomass in our trial fields, ascertaining whether to inoculant more or not. We made sure we were keeping our microbiological targets on the right track; no second inoculation was performed. Remediation monitoring.

6. Monitoring yields at harvest on trial fields. Results check.

7. Monitoring weed pressure on trial fields. Results check.

3.8 Crops selection:

Experiment 1: Vegetable yield
Fennel
Onions
Salad
Swiss Chard
Cabbage
Potatoes
Carrots
Celeriac
Swede

We allocated 1m2 for each crop in each scenario.

Experiment 2: Weed pressure
Pumpkin
Zucchini - Courgette
Leeks
Sage
Broad beans
Purple beans
Beetroot
Parsnip

Note that the purpose of experiment 2 is measuring the difference in terms of weed pressure with and without microbiological inoculant; Crop yield results has not been performed.

4. RESULTS:

All results below are displayed in "edible Biomass" in relevance to the crop.

All microbiological assays in the below section come from section 3.1.3 workflow.

Table 13: Highlights – Yield Results

Highlights - Yield results

Total days at field	CROPS PROD (g/m2)	Scenario 1 Control	Scenario 2 Compost	Scenario 3 Microbiological inoculation + Compost	% Dif. **Scenario 3.** Vs **Scenario 1**	% Dif. **Scenario 2** vs **Scenario 1**
64	Rutabaga	1532	1353	2658	73%	-12%
78	Onions	1835	1784	2059	12%	-3%
64	Salad	3083	2236	5773	87%	-27%
70	Swiss Chard	1211	1619	1968	63%	34%
73	Celeriac	1434	1378	3570	149%	-4%
73	Fennel	3421	2791	5416	58%	-18%
92	potatoes	1049	596	1492	42%	-43%
81	Purple Kale	742	326	1680	126%	-56%
	Total	**1925**	**1582**	**3188**	**72%**	-16%

(Source: Flor.ès.Sens Systems, 2017)

Date of monitoring: 17/07/2017 onward.

4.1 Pre-production status:

Making a baseline for our remediation case, we analysed all indicators at our reach: Soil Organic matter content, commercial compost organic matter content, Commercial compost used for seedlings, our soil's microbiological status, the pond water microbiological analysis, the commercial compost microbiological status. After that, we could put together a relevant microbiological inoculation solution.

Note that all the below microbiological analysis have to be compared to table 12 in section 3.1.2: soil microbiological targets.

4.1.1 Soil pre production's Organic matter content analysis: Date 20/04/2017.

Table 14: Pre production field's organic matter analysis

Pre production field Organic matter analysis

INDICATORS	PRE-PRODUCTION FIELD
TOTAL CARBON CONTENT	1,35%
TOTAL NITROGEN	0,14%
TOTAL DRY MATTER	5,30%

(Source: Lennart Månsson International AB, 2017)

FACTS :
Low carbon content – Low Nitrogen content – low dry matter content

Total amount of dry matter, carbon and Nitrogen are at very low level. We see a very poor soil condition to begin with, and at a critical status to produce good quality crops (yield and health).
These numbers might be the result of previous years field's human management: overgrazing, ploughing, no organic matter residue management.
Some examples of no till, high residue field management, with well managed grazing, show level of carbon above 9% with related high yield.[12]

4.1.2 Commercial Compost's Organic matter content: Date 20/04/2017.

Table 15: Commercial compost organic matter analysis

Commercial Compost Organic matter analysis

INDICATORS	COMMERCIAL COMPOST
TOTAL CARBON CONTENT	12%
TOTAL NITROGEN	0,56%
TOTAL DRY MATTER	75,70%

(Source: Lennart Månsson International AB, 2017)

FACTS :

High carbon content – High Nitrogen content – High dry matter content

In comparison to the current soil organic matter, commercial compost shows higher indicators at all 3 levels.

From these facts, disregarding soil microbiology status, and looking at nutrient input only, this compost shows potential benefits for our plant growth.

4.1.3 Seedling commercial Compost's Microbiological analysis: Date 02/06/2017.

Table 16: Seedling Compost microbiological analysis

Seedling compost microbiological analysis

Ref. Native Environment	Targeted F:B ratio	F:B Biomass ratio	above ground response
mid grasses & Vegetables	0,75	3,285	Healthy seedling growth

1st Trophic level: Bacteria & Fungal µg / g soil

	Fungi (µg/ g soil)	Bacteria (µg / g soil)	Avg. Fungi Diam. µm
Results	428	130	3,49
Expected range	0	0	3 < 12
Comments	In target	slightly low	N/A

2nd & 3rd Trophic level: protozoa number / g soil

	Flagelates	Amoebae	Ciliates
Results	0,20	1,30	0,00
Expected range	1 -- 1,5	1 -- 1,5	0
Comments	Too low	in target	in target

2nd & 3rd Trophic level: Nematode number / g soil

ANAEROBIC MARKERS

	Bacterial feeder	Fungal Feeder	Predatory	Root Feeder
Results	0	0	0	0
Expected range	1 -- 2	1 +	0	0
Comments	Too low	Too low	in target	in target

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
No anaerobic markers. Fungi :Bacteria ratio way above our needed target. 2nd & 3rd trophic level in target. Favorable conditions for seedlings.

While assessing compost microbiology we saw: loads of organic at low magnification (100X total), good amount of humics and fulvics aggregates, no disease causing bacteria, a good bacterial diversity (long rods, bacillus, fat rods, bacterial clumping, lactobacillus), Flagellates & Amoebae cysts.

Current fungi:bacteria ratio here is in the upper limit for human crops.

Note Seedling compost analysis got done after the trial started. Fact being the producers had already bought this compost, and had already started their seedling production.

4.1.4 Pre production's soil microbiological analysis:
Date: 20/04/2017.

Table 17: Pre production Soil Microbiological Status

Pre production Soil Microbiological status

Ref. Native Environment	Targeted F:B ratio	Measured F:B ratio	above ground response
mid grasses & Vegetables	0,75	0,006	pre season - no growth

1st Trophic level: Bacteria & Fungal µg / g soil

	Fungi (µg/ g soil)	Bacteria (µg / g soil)	Avg. Fungi Diam. µm
Results	95,74	16987,11	4,00
Expected range	N/A	N/A	3 < 12
Comments	too low	too high	not relevant

2nd & 3rd Trophic level: protozoa number / g soil

	Flagelates	Amoebae	Ciliates
Results	0,00	0,00	0,00
Expected range	1 -- 1,5	1 -- 1,5	0,00
Comments	Too low	Too low	in target

ANAEROBIC MARKERS

2nd & 3rd Trophic level: Nematode number / g soil

	Bacterial feeder	Fungal Feeder	Predatory	Root Feeder
Results	0	0	0	0
Expected range	1+	1	0	0
Comments	Too low	Too low	in target	in target

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
No anaerobic markers. Fungi:Bacteria ratio corresponding to soil food web development. Very high number of bacteria. No 2nd & 3rd trophic level present.

While assessing soil microbiology using low microscopic magnification (100X), we saw a tremendous and unusual amount of large minerals. We know that the farmer situated up the production plots where we did the trial has been amending his soil with non-organic salts (nitrogen based) & hormones. Current topography tells us that there may have been a drift from the neighbouring fields to the producers' fields.
We also saw a very low amount of fulvics & humics, and a low bacterial diversity. Still, there was no presence of disease causing organism.

The high total number of bacteria is linked to the absence of 2nd & 3rd trophic level (beneficial protozoa and/or bacterial feeding nematodes), but also because of the field geographical position next to a Wetland/marsh (favourable conditions for bacteria to thrive).

On the top of that, we also witnessed a very low amount of fungi contributing to a weaker soil structure.

These numbers are most probably the results of previous years field human management: overgrazing, ploughing, no organic matter residue management. We know from the current owner that a previous owner was selling this field's top soil to anyone interested.

We want to remind the reader of table 7 on Biological succession: we can say our field microbiological status was at a stage of "soil food web development", being not very favourable for vegetable growing.

4.1.5 Pond water microbiological analysis:
Date: 07/05/2017.

Table 18: Pond water Microbiological Analysis

Pond water Microbiological analysis

Ref. Native Environment	Targeted F:B ratio	Measured F:B ratio	above ground response
no detrimental Bacteria	0	0,00	N/A

1st Trophic level: Bacteria & Fungal µg / g soil

	Fungi (µg/ g soil)	Bacteria (µg / g soil)	Avg. Fungi Diam. µm
Results	0,00	0,86	0,00
Expected range	0	0	3 < 12
Comments	in target	in target	N/A

2nd & 3rd Trophic level: protozoa number / g soil

	Flagelates	Amoebae	Ciliates
Results	2,00	1,50	0,00
Expected range	1,5 -- 5	1,5 -- 5	0,00
Comments	In target	In target	in target

ANAEROBIC MARKERS

2nd & 3rd Trophic level: Nematode number / g soil

	Bacterial feeder	Fungal Feeder	Predatory	Root Feeder
Results	0	0	0	0
Expected range	0	0	0	0
Comments	in target	in target	in target	in target

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
No anaerobic markers. No detrimental organisms present. Good level of 2nd & 3rd trophic level.

Pond water quality is good for production.

4.1.6 Commercial compost Microbiological status: Date 17/04/2017.

Table 19: Commercial compost Microbiological Analysis

Commercial compost Microbiological analysis

Ref. Native Environment	Targeted F:B ratio	Measured F:B ratio	above ground response
0,75	mid grasses & Vegetables	0,372	Field amendment

1st Trophic level: Bacteria & Fungal µg / g soil

	Fungi (µg/ g soil)	Bacteria (µg / g soil)	Avg. Fungi Diam. µm
Results	327,18	798,34	3,38
Expected range	N/A	N/A	3 < 12
Comments	In target	Slightly high	N/A

2nd & 3rd Trophic level: protozoa number / g soil

	Flagelates	Amoebae	Ciliates
Results	0,30	0,00	0,00
Expected range	1,5 -- 5	1,5 -- 5	0,00
Comments	Too low	too low	In target

2nd & 3rd Trophic level: Nematode number / g soil

ANAEROBIC MARKERS

	Bacterial feeder	Fungal Feeder	Predatory	Root Feeder
Results	0	0	0	0
Expected range	1 -- 2	1 +	0	0
Comments	Too low	Too low	in target	In target

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
No anaerobic markers. Fungi:bacteria in the low range of our targets. Absence of 2nd & 3rd trophic level.

While assessing soil microbiology we saw: Actinobacteria present, lot of Bacteria, fruiting fungi & spores, cysts (ciliates, amoebae, flagellate), lot of decomposing plant residue (confirmed by Soil organic matter analysis), and humic acid.

4.2 Remediation decision & Microbiological inoculant

FROM PRE PRODUCTION STATUS:

1. No overall anaerobic markers.
2. Compost for seedling set the right conditions for our crops to start: good F:B ratio, "acceptable to good" 2nd & 3rd trophic level.
3. Commercial compost will be good enough to amend our very poor soil: bringing beneficial 1st trophic level (fungi), excellent carbon & nitrogen content.
4. Pond water is very good.
5. **Soil initial microbiological status will not support vegetable production: too high bacterial level, not enough fungi, absence of 2nd & 3rd trophic.**

REMEDIATION DECISION:

Produce a microbiological inoculant bringing:

- **A high fungal biomass (bring the fungi:bacteria ratio up).**
- **A high volume of 2nd & 3rd trophic level predators. We will focus on beneficial protozoa first. Enable a good nutrient cycling**

From the remediation decision taken, our posture is 3 fold:

1. Increasing fungal biomass will help build up soil structure. At the same time it will help build up aerobic conditions supporting aerobic organism growth, that in turn will wipe the detrimental organisms out.
2. Increase aerobic protozoan number which in turn will increase predation on bacteria, decrease the bacterial number, and finally accelerate nutrient cycling for our plant health and productivity.
3. Both point 1 & 2 will contribute to increase Fungi:bacteria ratio toward conditions supporting optimum vegetable growth.

IMPORTANT CONTEXTUAL NOTES HERE:

While we have analysed and screened the missing microbiology in our soils, and while we produced an adequate microbiological inoculation for our soils, we want to acknowledge the following: we may probably not reach optimum targeted microbiological biomass numbers the first season.

We are dealing with complex ecosystem relationships, and the main purpose here may indeed be to set the right conditions for our agricultural systems to evolve toward what we would like to see happening in the close future: optimum plant health and a resilient organic agricultural system.

4.2.1 59° Degrees compost Microbiological status

Date: 18 & 24/04/2017.

We will produce our compost extract from 59 Degrees compost, which is reputed to be of excellent quality.

Table 20: 59 Degrees Compost Microbiological Analysis

59 Degrees compost Microbiological analysis

Ref. Native Environment	Targeted F:B ratio	Measured F:B ratio	above ground response
mid grasses & Vegetables	0,75	0,893	Compost above target
1st Trophic level: Bacteria & Fungal µg / g soil			
	Fungi (µg/ g soil)	Bacteria (µg / g soil)	Avg. Fungi Diam. µm
Results	415,93	431,69	4,32
Expected range	N/A	N/A	3 < 12
Comments	In target	In target	N/A
2nd & 3rd Trophic level: protozoa number / g soil			
	Flagelates	Amoebae	Ciliates
Results	0,00	0,00	0,00
Expected range	1 -- 1,5	1 -- 1,5	0,00
Comments	Too low	Too low	In target

ANAEROBIC MARKERS

2nd & 3rd Trophic level: Nematode number / g soil				
	Bacterial feeder	Fungal Feeder	Predatory	Root Feeder
Results	0	1	0	0
Expected range	1+	1	0	0
Comments	Too low	In target	In target	In target

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
No anaerobic marker. Fungi:bacteria in target. Absence of most of the 2nd & 3rd trophic level.

59 Degrees compost is proved to be excellent. It shows a good level of fungi at 1st trophic level. At 2nd & 3rd trophic we see a fungal feeding nematode appearing, but no protozoa and bacterial feeding nematode.

That compost will be beneficial to extract fungi and build a highly fungal microbiological inoculant.

While aerobic protozoan are missing, we will add a protozoan infusion to the microbiological inoculant helping the remediation decision *(section 4.2.2)*.

4.2.2 Microbiological inoculant analysis:

We monitored 9 batches out of 20 representing a total of 10'000 L of compost extract inoculant; between the 05 of May and mid June 2017.

Table 21: Microbiological inoculant averages analysis

Microbiological inoculate's averages analysis

Ref. Native Environment	Targeted F:B ratio	Measured F:B ratio	above ground response
a Higher F:B ratio than current soil conditions	>1	3,751	See yield results

1st Trophic level: Bacteria & Fungal µg / g soil

	Fungi (µg/ g soil)	Bacteria (µg / g soil)	Avg. Fungi Diam. µm
Results	99,88	26,63	N/A
Expected range	N/A	N/A	3 < 12
Comments	In target	In target	N/A

2nd & 3rd Trophic level: protozoa number / g soil

	Flagelates	Amoebae	Ciliates
Results	2,92	4,31	0,15
Expected range	N/A	N/A	N/A
Comments			

ANAEROBIC MARKERS

2nd & 3rd Trophic level: Nematode number / g soil

	Bacterial feeder	Fungal Feeder	Predatory	Root Feeder
Results	0	0	0	0
Expected range	Above current	Above current	Above current	Above current
Comments	Too low	Too low	Too low	In target

(Source: Flor.ès.Sens Systems, 2017)

Table 22: Microbiological inoculant averages analysis – Statistic extract

Microbiological inoculate's averages analysis:
Statistic extract

	1st Trophic level			
			Fungi group	
	bacteria	actinobacteria	Fungi hyphae	oomycetes
Average µg	26,63	0,13	96,38	3,38
Standart dv µg	28,99	0,35	26,27	8,00

	2nd & 3rd trophic level			
		Protozoa		
	Flagellates	Amoebae	Ciliates	Nematodes
Average n#	2,92	4,31	0,15	0,00
Standart dv n#	3,97	5,46	ANAEROBIC MARKERS	0,00

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
Non-relevant anaerobic markers. Above target Fungi:bacteria ratio.
Above target 2nd & 3rd trophic level.

All aerobic indicators are present besides bacterial & fungal feeding nematodes. Loads of fungal spores, flagellates & amoebae cyst present. The microbiological inoculant is in line with our remediation decision.

4.3 Weed pressure experiment results:

As remediation inoculant was produced in line with our remediation decision, we could start the trial.
Weed pressure experiment happened from the 10th of June 2017 went through to July 2017. We did not weed during that period and measured weed green weight.
Following our purposes to assess the relationship between multiple factors possibly affecting our plant growth, the below table reports:

- Weed green weight measured in context.
- The related 1st trophic level biomass: fungi, bacteria and fungi:bacteria ratio.
- The related 2nd & 3rd trophic level: 1st level predators as protozoan and nematodes
- The fungal density: fungal distribution in our microscopic analysis. How often we see fungi appearing.
- The compaction levels: at what depth psi went over 100psi.

Table 23: Weed experiment results

Weed Experiment results

INDICATORS			Field pre-growing season	Scenario 1 CONTROL + Microbiological inoc.	Scenario 2 CONTROL	Scenario 1 vs scenario 2	Scenario 3 Compost + Microbiological Inoc.	Scenario 4 Compost	Scenario 3 vs scenario 4
GREEN WEIGHT		Kg/m2	N/A	0,93	1,51	-38%	1,46	2,17	-33%
1st Trophic Level		FUNGI µg	24	320,50	277	16%	204	763	-73%
		BACTERIA µg	12829	8870	6653	33%	5569	6406	-13%
		FUNGI:BACTERIA	0,0019	0,0361	0,0417	-13%	0,0367	0,1191	-69%
2nd & 3rd Trophic level	Protozoan	FLAGELATES	0	0,00	0,06	Too low	0,69	0,00	Too low
		AMOEBAE	0	1,78	0,53	236%	3,00	0,50	500%
		CILIATES	0	0	0,00	In target	0,69	0,00	Not relevant
	Nema.	Root feeding	0	0	1	Anaerobic Cond.	0	1	Anaerobic Cond.
		Bacterial Feeding	0	0	0	Too low	0	0	Too low
		Fungal feeding	0	0	0	Too low	0	0	Too low
		Predatory - omni	0	0	0	In target	0	0	In target
Fungal density	At 100X Total Mag	Total Strands Occurrences	N/A	138	50	176%	105	100	5%
		Strand per field of view	N/A	1,79	0,65		1,36	1,30	
PHYSICAL PROPERTIES		OVER 100 PSI DEPTH CM	N/A	23,83	26,75	11%	25,86	28,83	10%

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
Both inoculant trials display a lower weed biomass production.
Both inoculant trials display a higher protozoan number.
Both inoculant scenarios have no anaerobic markers.

We can see that scenario 1 has a higher bacterial biomass and a higher protozoan number than scenario 2; we see a lower weed pressure; 38% lower weed biomass production.
Scenario 3 has a lower bacteria number than scenario 4 but also a higher protozoan number; it displays a lower weed pressure; 33% lower weed biomass production.

For both scenario 1 & scenario 3, fungal occurrences are higher than control scenarios 2 & 4. Only scenario 4 displays a higher fungal biomass. We hypothesis we may have spread more of the commercial compost, and that the volume allocated may have had a higher fungal presence than the rest of the compost spread in other parts.

Still, both scenario 2 & 4 display root feeding nematodes, which mark anaerobic conditions. The two inoculants scenarios don't.

Compaction remains roughly the same, hence same soil physical properties, same root penetration capacity.

Our microbiological inoculant has a noticeable effect on weed pressure; with or without commercial compost amendment.

Table 24: Main "weeds" appearing on trial

4.4 Yield experiment results:

As remediation inoculant was produced in line with our remediation decision, we could start the trial on our crops.
The experiment started on the 05th may 2017 and ended approximately at mid July 2017.

FIELD CONTEXT:

We want to remind the reader of the field's previous management mentioned in section 4.1.4: the farmer next door amending his fields with non-organic solutions, the current producers having ploughed their field before starting their season, and the field's geographical situation next to a marshland. All of these facts setting the context for a very high bacterial biomass in the soil, very little fungal biomass, no 2nd & 3rd trophic level and very little organic matter in the soil. Referring to table 8, 8' & 8'', we can say our field microbiological status was at a stage of "soil food web development", not favourable to vegetable growing.

Following our purpose to assess the relationship between multiple factors possibly affecting our plant growth, all below tables measure simultaneously:

- Crop's weight in contexts of their scenarios.
- The related 1st trophic level biomass: fungi, bacteria and fungi:bacteria ratio.
- The related 2nd & 3rd trophic level: 1st level's predators (protozoan and nematodes).
- The fungal density: fungal distribution in our microscopic analysis. How often we saw fungi appearing.
- The compaction levels: at what depth psi went over 100psi.

Following the tables, we will also document pictures from the same crops analysed.
In order to provide consistency while looking at the photographs, one will see that all photo are taken with a tape measure to the side.
Also, for the sake of appraising the visual difference, we picked the smallest of the trial in each scenario for each crop.

4.4.1 Cabbage: Purple Kale. Harvest at 81 days.
No leaves picked from transplant till harvest.

Table 25: Cabbage yield results

Cabbage yield results

INDICATORS		Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD	g/m2	N/A	742	326	1680	126%	-56%
1st Trophic Level	FUNGI (µg)	24	189	332	1363	621%	76%
	BACTERIA (µg)	12829	5076	5470	4084	-20%	8%
	FUNGI:BACTERIA	0,0019	0,037	0,06	0,33	792%	not relevant
2nd & 3rd Trophic level – Protozoan	FLAGELATES	0	0,07	0	0	not relevant	not relevant
	AMOEBAE	0	0,57	0,18	1,46	156%	-68%
	CILIATES	0	0,29	0,06	0,01	In Target	In Target
2nd & 3rd Trophic level – Nema.	Root feeding	0	0	2	0	In Target	ANAEROBIC Cond.
	Bacterial Feeding	0	0	0	0	Too low	Too low
	Fungal feeding	0	0	0	0	Too Low	Too Low
	Predatory - omni	0	0	0	0	In Target	In Target
Fungal density At 100X Total Mag	Total Strands Occurrences	N/A	31	80	108	248%	158%
	Av. Strand per field of view	N/A	0,4	1,04	1,4		
SOIL PHYSICAL PROPERTIES	Depth in cm reached under 100psi	N/A	21,78	26,67	21,67	1%	22%

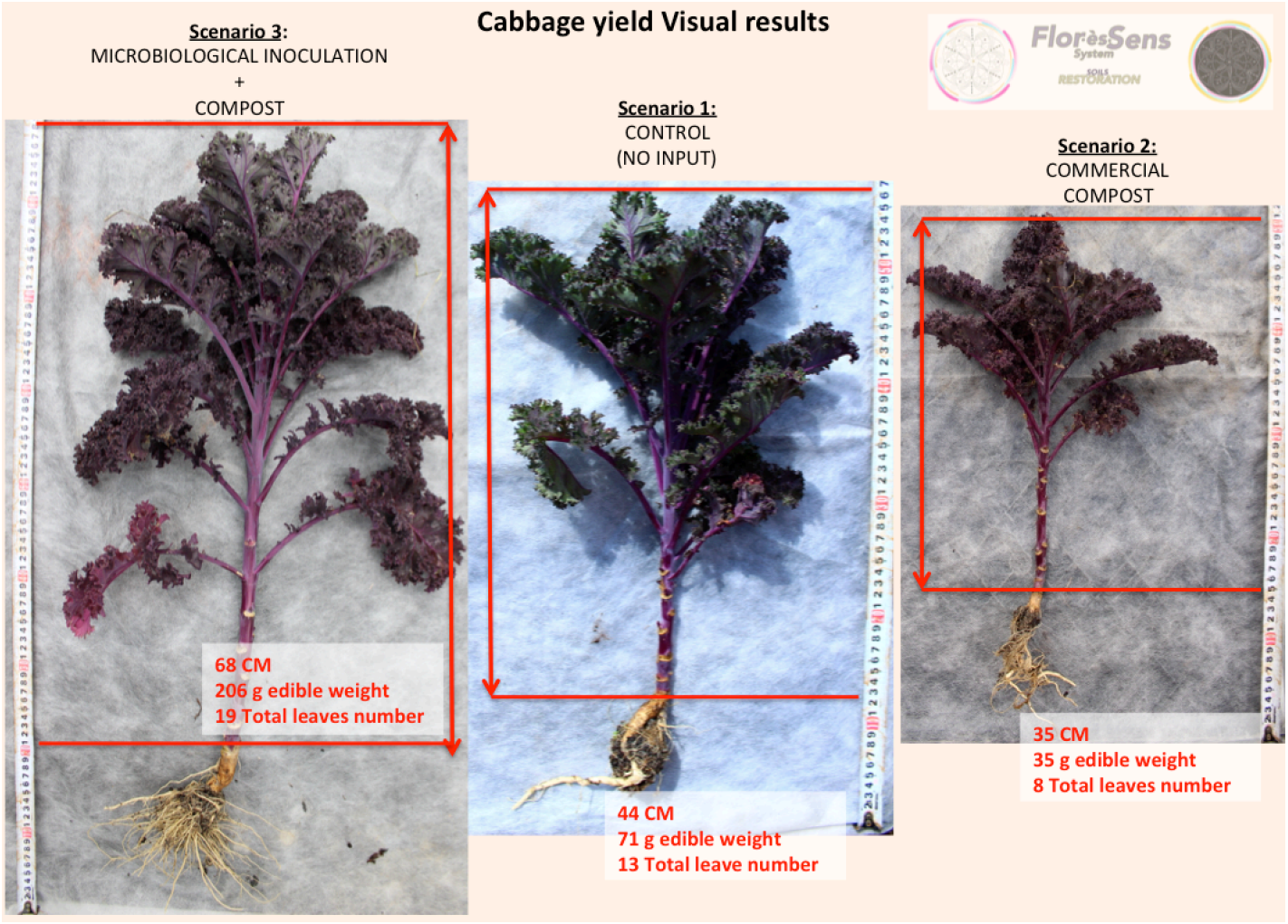
(Source: Flor.ès.Sens Systems, 2017)

FACTS:
Scenario 3 display 126% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level, a higher fungal density and the same soil physical properties than the control scenario 1.

Compared to control Scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,33) in target with the table 8 section 1.4. Kale crops strive in this kind of environment.
Predation by protozoa on the 1st trophic level enable good nutrient cycling resulting in better yields. Fungi biomass helps on keeping an aerobic soil structure (higher biomass and distribution). Bacterial feeding nematode being absent, we can see the effect of protozoa predating on bacteria compared to control scenario 1 (-20%) & scenario 2.
Scenario 2 & 3 received the same amount of compost, but scenario 3 also receiving inoculant loaded with bacterial predators, scenario 3's amount of bacteria is indeed lower. We understand that the protozoan predation effect on the bacterial population helps to increase the fungi:bacteria ratio.

While scenario 2 has a higher fungi:bacteria ratio than scenario 1, it also shows a 2nd & 3rd trophic roughly in the same low range, and appearance of anaerobic markers (root feeding nematodes), hence anaerobic conditions developing. Results being lower crop productivity: -56%.

Table 26: Cabbage yield visual results



(Source: Flor.ès.Sens Systems, 2017)

Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

When the 2nd & 3rd trophic level is not present, we see that commercial compost reputed of good quality can indeed have negative effect on the crop yield while benefiting weed development *(See results in section 4.4)*.

Table 27: Cabbage yield visual unidentified disease

(Source: Flor.ès.Sens Systems, 2017)

4.4.2 Celeriac: Harvest at 73 days.

Total edible biomass is measured by subtracting root-hair weight to the overall weight. Stems and root are considered edible.

Table 28: Celeriac yield results

Celeriac yield results

INDICATORS			Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD		g/m2	N/A	1434	1378	3570	149%	-4%
1st Trophic Level		FUNGI (µg)	24	195	363	1439	638%	86%
		BACTERIA (µg)	12829	11532	8180	6751	-41%	-29%
		FUNGI:BACTERIA	0,0019	0,017	0,044	0,213	1153%	159%
2nd & 3rd Trophic level	Protozoan	FLAGELATES	0	0	0,07	0	Too low	not relevant
		AMOEBAE	0	0,75	0,87	1,72	129%	16%
		CILIATES	0	0	0,07	0	0	not relevant
	Nematodes	Root feeding	0	0	0	0	0	0
		Bacterial Feeding	0	0	0	0	0	0
		Fungal feeding	0	0	0	0	0	0
		Predatory - omni	0	0	0	0	0	0
Fungal density	At 100X Total Mag	Total Strands Occurrences	N/A	71	108	120	69%	52%
		Av. Strand per field of view	N/A	0,92	1,4	1,56		
SOIL PHYSICAL PROPERTIES		Depth in cm reached under 100psi	N/A	22,22	23,89	25,56	15%	8%

(Source: Flor.ès.Sens Systems, 2017)

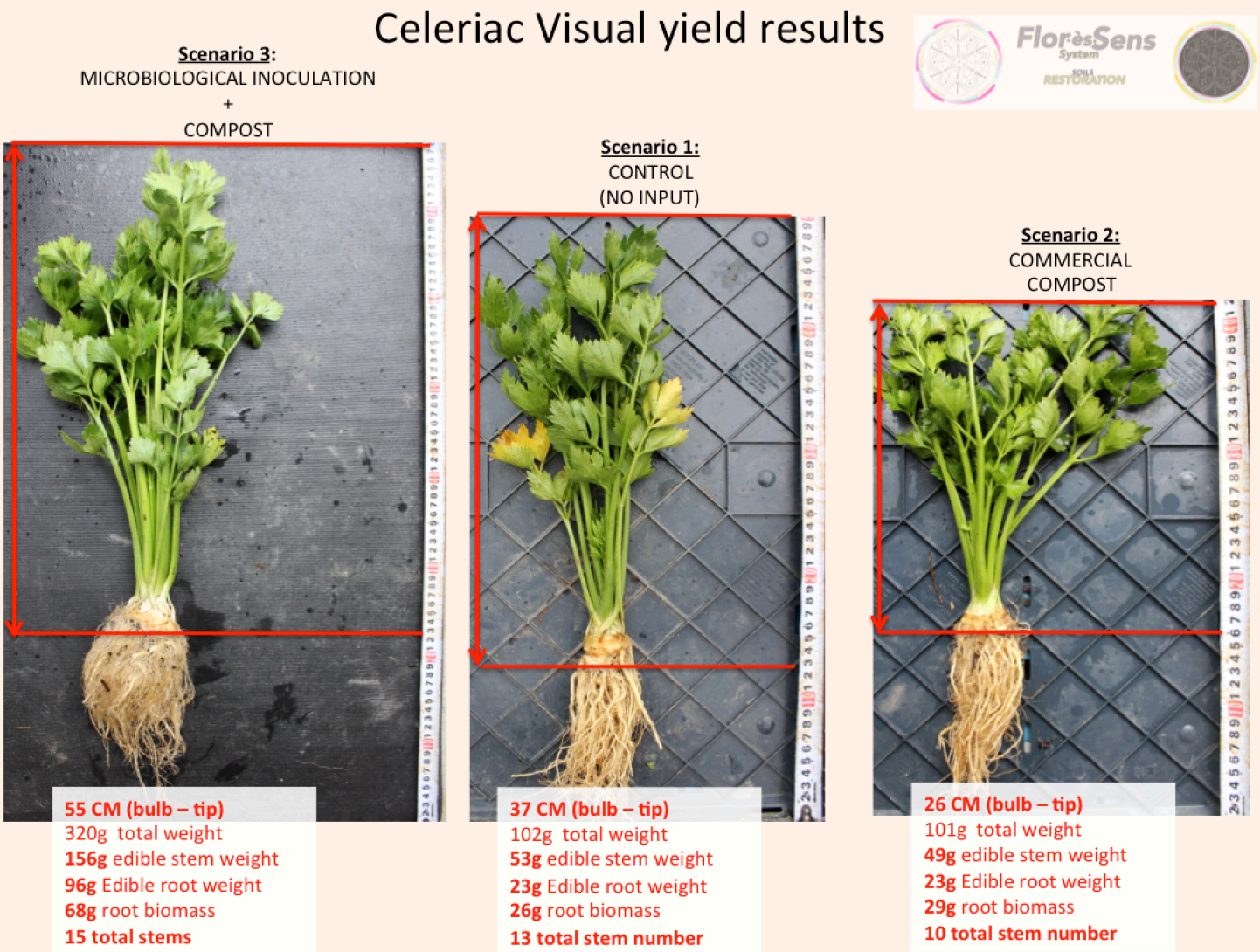
FACTS:

Scenario 3 display 149% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level, a higher fungal density and the same soil physical properties than the control scenario 1.

Compared to control Scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,21) below target with the table 8 & 12. Celeriac crops need F:B ratio around 0,75 in order to grow much better.
Besides the above, predation performed by protozoan on the 1st trophic level enable a good nutrient cycling and better yields than scenario 1.
Higher fungal biomass and distribution help build an aerobic soil structure beneficial to the microorganism our plants need to get the optimum nutrient cycling.
Bacterial feeding nematode being absent, we can see an effect of protozoa predating on the overall bacterial biomass compared to perform scenario 1 & scenario 2.

While scenario 2 have a higher fungi:bacteria ratio than scenario 1, both of them are very low to enable a decent crop growth *(see table 8)*. 2nd & 3rd trophic roughly remaining in the same low range, soil microbiological conditions remain bacterial dominated, then crop production results are low and nearly the same (-4% for scenario 2). We have no relevant anaerobic condition development yet, even though we saw some ciliates (anaerobic marker) showing up in scenario 2.

Table 29: Celeriac Visual yield results



(Source: Flor.ès.Sens Systems, 2017)

Putting the previous holistic observations onto total non-edible root biomass production, our data shows that scenario 3 has 162% bigger root production (vs scenario 1 and scenario 2). (See pictures & results above).
Scenario 2 displays 3 points more of non-edible root biomass production than scenario 1, which is barely significant appraising the context of the respective scenarios.

Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

When the 2nd & 3rd trophic level is not present, we see that commercial compost reputed of good quality have indeed a neutral effect on the crop yield while benefiting other biological development, i.e. weeds *(See results in section 4.4)*.

4.4.3 Fennel: Harvest at 73 days.

Table 30: Fennel yield results

Fennel yield results

INDICATORS		Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD	g/m2	N/A	3421	2791	5416	58%	-18%
1st Trophic Level	FUNGI (µg)	24	149	213	480	222%	43%
	BACTERIA (µg)	12829	8378	7688	3942	-53%	-8%
	FUNGI:BACTERIA	0,0019	0,018	0,028	0,122	578%	not relevant
2nd & 3rd Trophic level	Protozoan FLAGELATES	0	0	0,07	0	too low	Too low
	Protozoan AMOEBAE	0	0,7	0,36	1,2	Slightly low	-49%
	Protozoan CILIATES	0	0	0	0	In target	In Target
	Nema. Root feeding	0	0	0	0	In target	In Target
	Nema. Bacterial Feeding	0	0	1	0	Too low	In Target
	Nema. Fungal feeding	0	0	0	0	too low	Too low
	Nema. Predatory - omni	0	0	0	0	In target	In target
Fungal density	At 100X Total Mag Total Strands Occurrences	N/A	63	99	50	-21%	57%
	At 100X Total Mag Av. Strand per field of view	N/A	0,82	1,29	0,65		
SOIL PHYSICAL PROPERTIES	Depth in cm reached under 100psi	N/A	22,33	23,33	23,11	3%	4%

(Source: Flor.ès.Sens Systems, 2017)

FACTS:

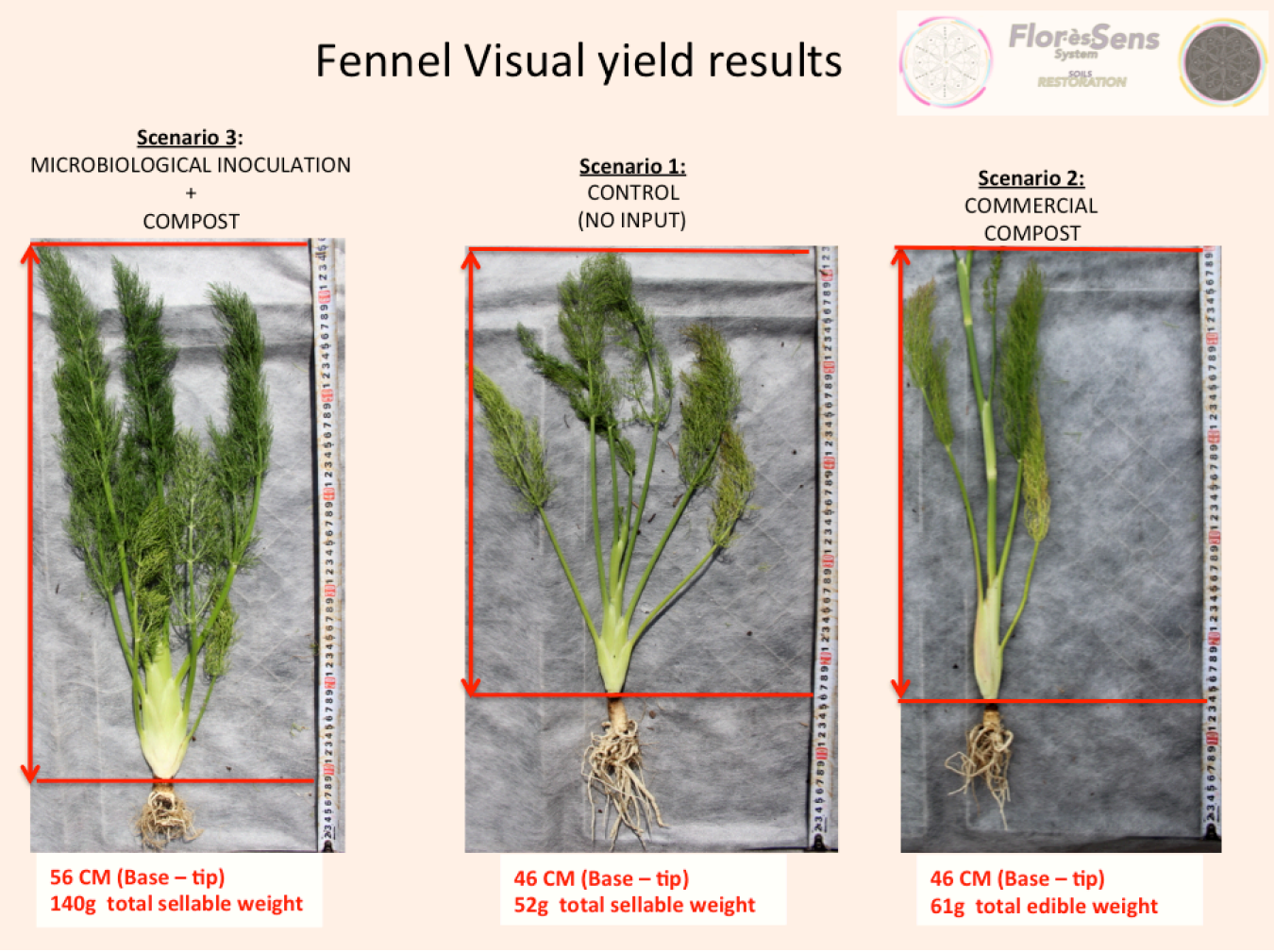
Scenario 3 display 58% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level, a higher fungal biomass and the same soil physical properties than the control scenario 1.

Compared to control scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,122) below target with the table 8, still higher than the other scenarios. Fennel crops need a F:B ratio around 0,75 in order to grow at full potential.
Besides the above, predation done by protozoan on the 1st trophic level enable a decent enough nutrient cycling and better yields than scenario 1 (+58%). Higher fungal biomass, in conjunction with a lower distribution, tell us the overall fungal diameter is bigger than other scenarios and still contribute to build decent enough aerobic soil structure.

Bacterial feeding nematode being absent, we can see an effect of protozoan predating on the overall bacterial biomass (-53%) compared to control scenario 1 & scenario 2.

While scenario 2 have a higher fungi:bacteria ratio than scenario 1, both of them are very low to enable a decent crop growth. In scenario 2, despite appearance of bacterial feeding nematode: 2nd & 3rd trophic is lower than control scenario 1 & scenario 3, soil microbiological conditions remain mainly bacterial dominated, then crop production results are lower (-18% for scenario 2). We have no anaerobic condition development.

Table 31: Fennel Visual yield results



(Source: Flor.ès.Sens Systems, 2017)

Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

Same observation as the previous crop trial, when the 2nd & 3rd trophic level is not present or low, **we see that commercial compost reputed of good quality have indeed a negative effect on the crop yield while benefiting other biological development, i.e. weeds** (See results in section 4.4).

4.4.4 Onion: harvest at 78 days.

Table 32: Onion yield results

Onion yield results

INDICATORS			Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD		g/m2	N/A	1835	1784	2059	12%	-3%
1st Trophic Level		FUNGI (µg)	24	71	918	314	342%	1193%
		BACTERIA (µg)	12829	18365	14587	7908	-57%	-21%
		FUNGI:BACTERIA	0,0019	0,004	0,063	0,04	900%	not relevant
2nd & 3rd Trophic level	Protozoan	FLAGELATES	0	0,001	0,05	0,24	not relevant	not relevant
		AMOEBAE	0	0,47	0,45	1,19	153%	-4%
		CILIATES	0	0	0	0,06	No relevant	In target
	Nematodes	Root feeding	0	0	0	0	In target	In target
		Bacterial Feeding	0	0	0	0	Too low	Too low
		Fungal feeding	0	0	0	0	Too low	Too low
		Predatory - omni	0	0	0	0	In target	In target
Fungal density	At 100X Total Mag	Total Strands Occurrences	N/A	50	80	125	150%	60%
		Av. Strand per field of view	N/A	0,65	1,04	1,62		
SOIL PHYSICAL PROPERTIES		Depth in cm reached under 100psi	N/A	21,22	21,22	19,89	-6%	0

(Source: Flor.ès.Sens Systems, 2017)

FACTS:

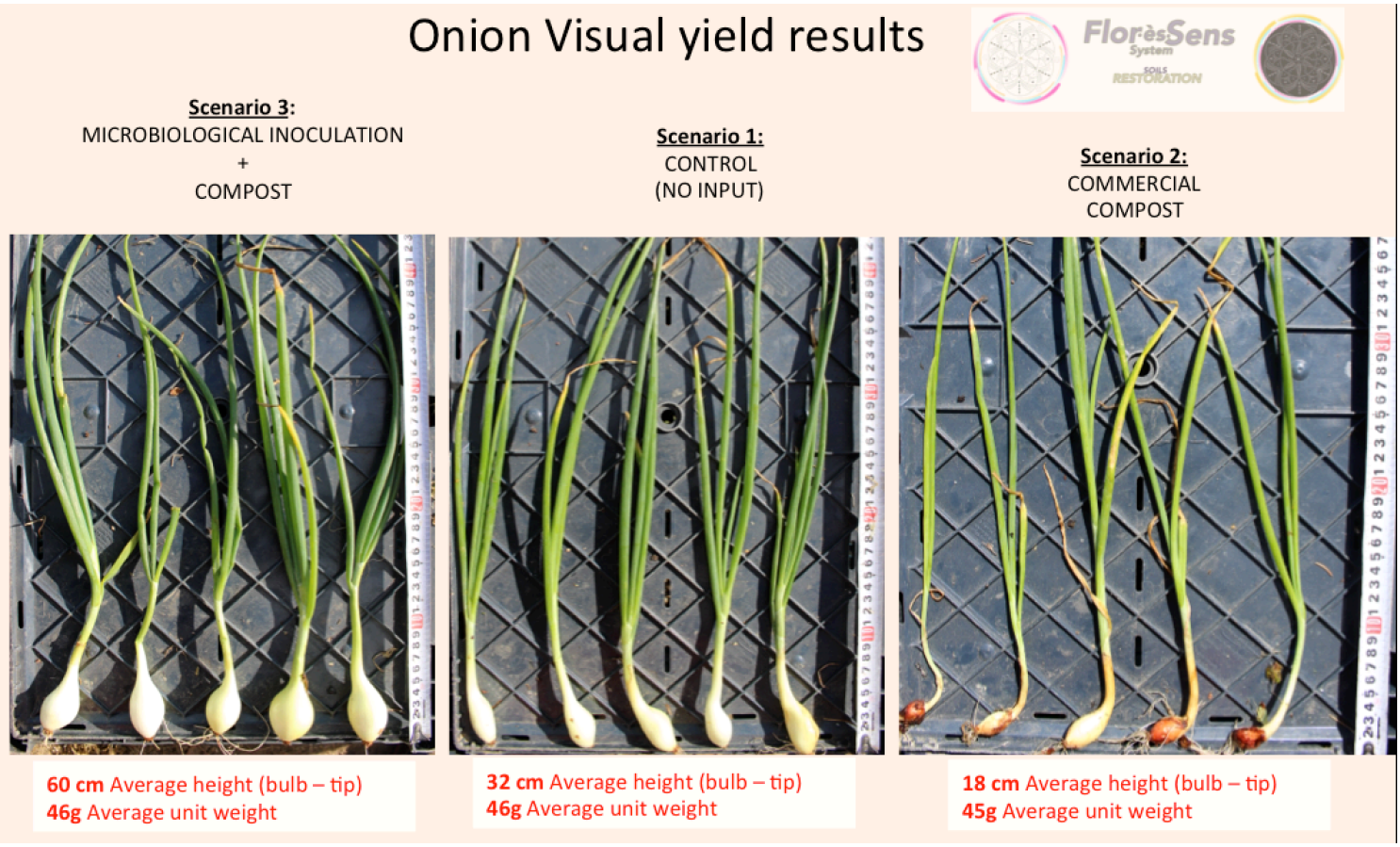
Scenario 3 display 12% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level, a higher fungal biomass and the same soil physical properties than the control scenario 1.

Compared to control scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,04) much below target with the table 8, still higher than scenario 1. Onion crops need a F:B ratio between 0,5 & 0,75 in order to grow at full potential.
Protozoan and flagellate number is slightly lower than required, and still could affect the 1st trophic level bacterial biomass. It enabled a low, still decent enough nutrient cycling and better yields than scenario 1 (+12%). The overall bacterial biomass remained too high to reach a decent enough Fungi:bacteria ratio. *Another microbiological inoculation would have been necessary here.*
Bacterial feeding nematodes being absent, we can still see the effect of protozoan predating on the overall bacterial biomass compared to control scenario 1 & scenario 2 (-57%).

Both pre-growing season and control scenario 1 bacterial biomass level are insanely high, reminding us of the field's previous management and surroundings.

While scenario 2 has a higher fungi:bacteria ratio than scenario 1 & 3, both of them remained very low to enable a decent crop growth. In scenario 2, 2nd & 3rd trophic is roughly equal to control scenario 1, soil microbiological conditions remain mainly bacterial dominated, then crop production results are equally low (-3% for scenario 2). It could be attributed to original poor soil conditions topped up with commercial compost favouring bacterial growth and low 2nd& 3rd trophic level in comparison with scenario 3. No anaerobic condition development.

Table 33: Onion Visual yield results



Our microbiological inoculant has a positive effect on 1st trophic level biomass, still was insufficient to take the initial bacterial biomass to level enabling decent nutrient cycling.

Same observation than for the previous crop trial, when the 2nd & 3rd trophic level is not present or low, we see that commercial compost reputed of good quality has a neutral effect on the crop yield while benefiting other biological development, i.e. weeds (See results in section 4.4).

4.4.5 Potatoes: Harvest at 92 days.

Table 34: Potatoes yield results

Potatoe yield results

INDICATORS		Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD	g/m2	N/A	1049	596	1492	42%	-43%
1st Trophic Level	FUNGI (µg)	24	170	491	523	208%	189%
	BACTERIA (µg)	12829	5667	6653	3992	-30%	17%
	FUNGI:BACTERIA	0,0019	0,03	0,074	0,131	337%	not relevant
2nd & 3rd Trophic level – Protozoan	FLAGELATES	0	0	0	0,08	Not relevant	not relevant
	AMOEBAE	0	0,6	0,55	1,45	142%	Too low
	CILIATES	0	0,56	0	0,08	In target	In target
2nd & 3rd Trophic level – Nematodes	Root feeding	0	1	0	0	In target	In target
	Bacterial Feeding	0	0	0	0	Too low	Too low
	Fungal feeding	0	0	0	0	Too low	Too low
	Omnivore	0	0	0	1	In target	In target
Fungal density – At 100X Total Mag	Total Strands Occurrences	N/A	45	42	77	71%	-7%
	Av. Strand per field of view	N/A	0,58	0,55	1		
SOIL PHYSICAL PROPERTIES	Depth in cm reached under 100psi	N/A	21,89	20,11	19,67	-10%	-8%

(Source: Flor.ès.Sens Systems, 2017)

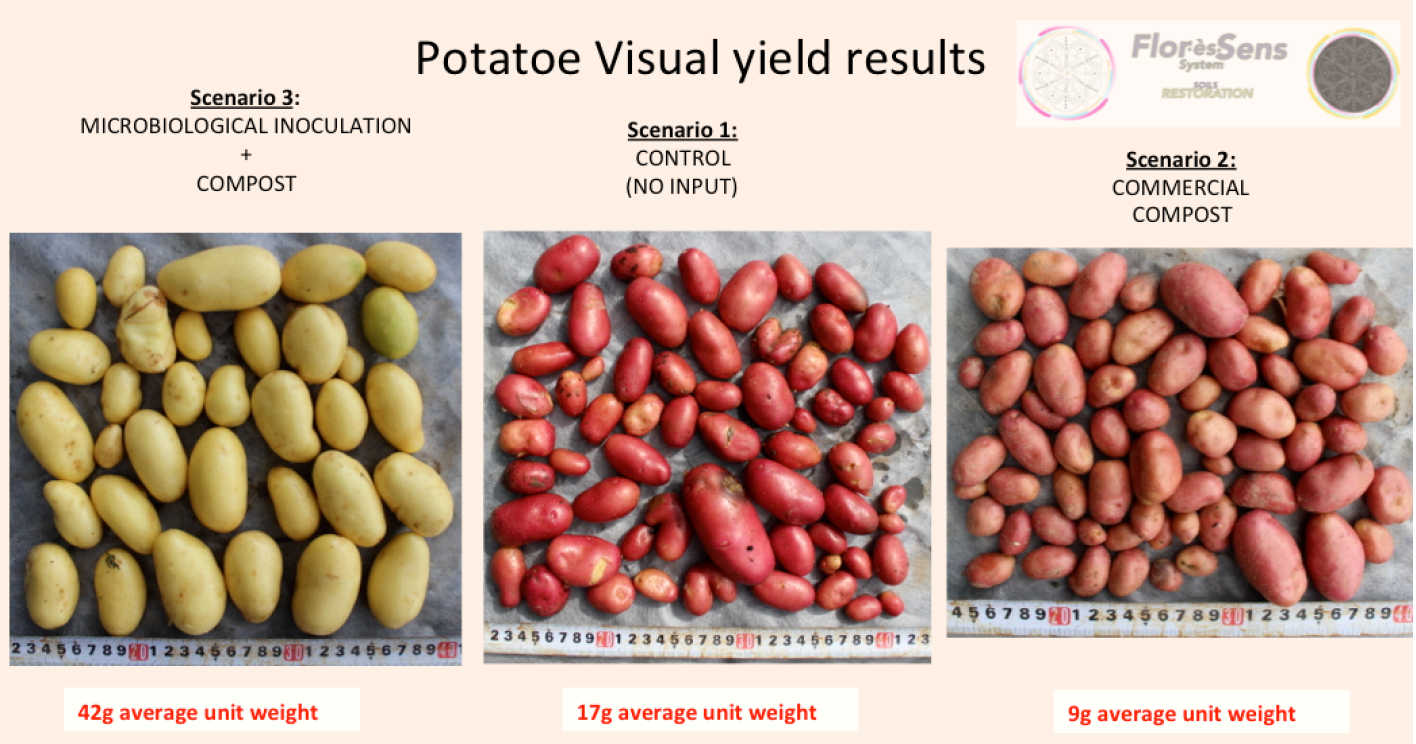
FACTS:

Scenario 3 display 42% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level, a higher fungal biomass and the same soil physical properties than the control scenario 1.

Compared to control scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,131) below target in regards to table 8, still higher than the other scenarios 1 & 2. Potato crops need a F:B ratio around 0,75 in order to grow at full potential.
Furthermore, protozoan predation on the 1st trophic level enabled a decent enough nutrient cycling and better yields than scenario 1 (+42%). Higher fungal biomass & distribution continue supporting the soil aerobic structure building up; beneficial to the microorganisms our plants need to get the optimum nutrient cycling.
Bacterial feeding nematode being absent, we can see an effect of protozoan predating on the overall bacterial biomass (-30%) compared to control scenario 1 & scenario 2. On the top of that, we also witnessed omnivorous nematode feeding both on bacteria and fungi. Current soil conditions enabled this one to be, which is a sign of aerobic conditions, thus favourable for our crops.

While scenario 2 has a higher fungi:bacteria ratio than scenario 1, both of them remained very low to enable a decent crop growth. In scenario 2, 2nd & 3rd trophic is roughly equal to control scenario 1, soil microbiological conditions remain mainly bacterial dominated. Scenario 2 drop in production (-43% for scenario 2) could be attributed to the higher number of bacteria compared to scenario 1 (+17%). It could be attributed to original poor soil conditions topped up with commercial compost favouring bacterial growth and low 2nd& 3rd trophic level. Control scenario 1 display anaerobic condition development (ciliates & root feeding nematodes).

Table 35: Potatoes Visual yield results



Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

Same observation for the previous crop trial, when the 2nd & 3rd trophic level is not present or low, we see that commercial compost reputed of good quality has a neutral or negative effect on the crop yield, while benefiting other biological development, i.e. weeds (See results in section 4.4).

4.4.6 Rutabaga: harvest at 64 days.

Table 36: Rutabaga yield results

Rutabaga yield results

INDICATORS			Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD		g/m2	N/A	1532	1353	2658	73%	-12%
1st Trophic Level		FUNGI (µg)	24	76	243	281	270%	220%
		BACTERIA (µg)	12829	6653	8220	4879	-27%	24%
		FUNGI:BACTERIA	0,0019	0,011	0,03	0,058	not relevant	not relevant
2nd & 3rd Trophic level	Protozoan	FLAGELATES	0	0	0,09	0	Too low	Too low
		AMOEBAE	0	0,25	0,18	2,6	940%	-28%
		CILIATES	0	0	0,36	0	In target	Anaerobic marker
	Nematodes	Root feeding	0	0	0	0	In target	In target
		Bacterial Feeding	0	0	0	0	Too low	Too low
		Fungal feeding	0	0	0	0	Too low	Too low
		Predatory - omni	0	0	0	0	In target	In target
Fungal density	At 100X Total Mag	Total Strands Occurrences	N/A	N/A	N/A	N/A	Not measured	Not measured
		Av. Strand per field of view	N/A	N/A	N/A	N/A		
SOIL PHYSICAL PROPERTIES		Depth in cm reached under 100psi	N/A	20,22	21,89	22,78	13%	8%

(Source: Flor.ès.Sens Systems, 2017)

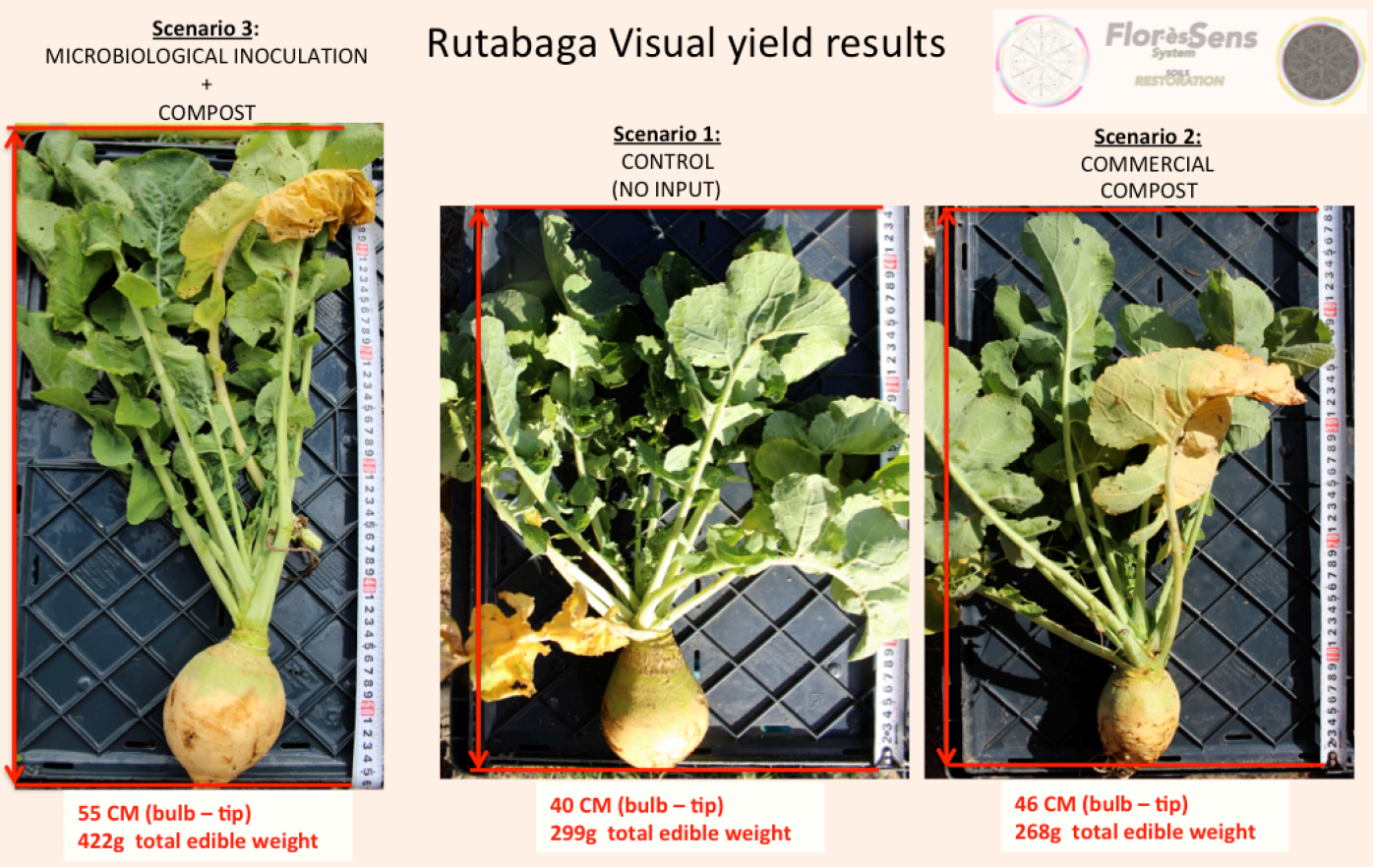
FACTS:
Scenario 3 display 73% better yields, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level (+940%) and the same soil physical properties than the control scenario 1.

Compared to control scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,058) below target in regards to table 8, still higher than the other scenarios 1 & 2. Rutabaga crops need F:B ratio around 0,75 in order to grow at full potential.
Protozoan predation on the 1st trophic level enabled a good nutrient cycling and better yields than scenario 1 (+73%), and a decrease on overall bacterial biomass(- 27%).
Higher fungal biomass & distribution continue to support the soil's aerobic structure building up the beneficial microorganisms our plants need to get the optimum nutrient cycling.

While scenario 2 has a higher fungi:bacteria ratio than scenario 1, both remained very low to enable a decent crop growth. In scenario 2, 2nd & 3rd trophic is roughly equal to control scenario 1 (-28%).

Scenario 2 bacterial biomass is higher than Control scenario 1 (+24%). At this level of microbiological life, Scenario 2 production dropped (-12%), and also developed anaerobic conditions (Ciliates appearing). It could be attributed to original poor soil structure conditions, topped up with commercial compost favouring bacterial growth and nearly absent 2nd& 3rd trophic level.

Table 37: Rutabaga Visual yield results



Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

Same observation than for the previous crop trial, when the 2nd & 3rd trophic level is not present or low, we see that commercial compost reputed of good quality has a neutral or negative effect on the crop yield, while benefiting other biological development, i.e. weeds (See results in section 4.4).

4.4.7 Salad: Harvest at 64 days.

Table 38: Salad yield results

Salad yield results

INDICATORS			Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD		g/m2	N/A	3083	2236	5773	87%	-27%
1st Trophic Level		FUNGI (µg)	24	156	129	790	406%	-17%
		BACTERIA (µg)	12829	15113	15572	5569	-63%	3%
		FUNGI:BACTERIA	0,0019	0,01	0,008	0,142	1320%	no relevant
2nd & 3rd Trophic level	Protozoan	FLAGELATES	0	0	0	0	Too low	Too low
		AMOEBAE	0	0,83	0,2	1,63	96%	-76%
		CILIATES	0	0,17	0	0,13	not relevant	In target
	Nematodes	Root feeding	0	0	0	0	In target	In target
		Bacterial Feeding	0	0	0	0	Too low	Too low
		Fungal feeding	0	0	0	0	Too low	Too low
		Predatory - omni	0	0	0	0	In target	In target
Fungal density	At 100X Total Mag	Total Strands Occurrences	N/A	80	110	134	68%	38%
		Av. Strand per field of view	N/A	1,03	1,42	1,74		
SOIL PHYSICAL PROPERTIES		Depth in cm reached under 100psi	N/A	22,78	23,44	32,22	41%	3%

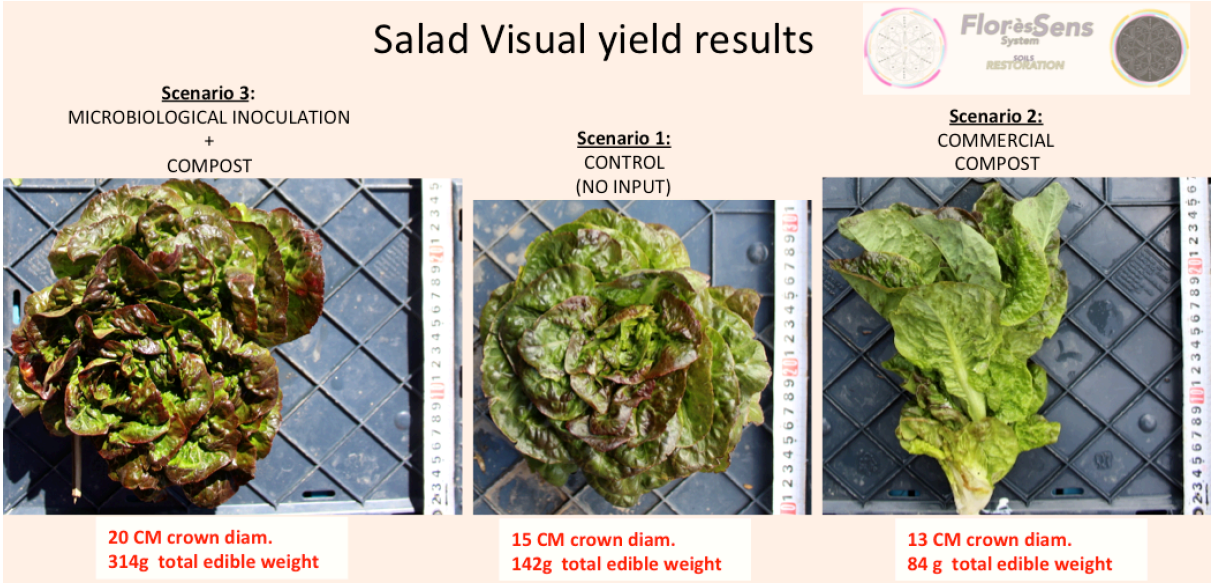
(Source: Flor.ès.Sens Systems, 2017)

FACTS:
Scenario 3 display 87% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level (+96%), and soil physical properties enabling +41% depth in cm than the control scenario 1.

Compared to control scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,142) below target in regards to table 8, still higher than the other scenarios 1 & 2. Salad crops need F:B ratio between 0,5 & 0,75 in order to grow at full potential.
Higher beneficial protozoan number (+96%) effect on the 1st trophic level enabled a good nutrient cycling and better yields than scenario 1 (+87%), and a decrease on overall bacterial biomass (- 63%).
Higher fungal biomass & distribution continue to support soil aerobic structure, building up the beneficial microorganisms our plants need to get the optimum nutrient cycling. Soil physical conditions may help the above yield.

While scenario 2 has a lower fungi:bacteria ratio than scenario 1, both of them remained very low to enable a decent crop growth. In scenario 2, 2nd & 3rd trophic is lower than control scenario 1 (-76%).
Scenario 2 bacterial biomass is roughly equal to that of Control scenario 1 (-3%). At this level of microbiological life, of Fungi:bacteria ratio, Scenario 2 production dropped by -27%.

Table 39: Salad Visual yield results



Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

Same observation than for the previous crop trial, when the 2nd & 3rd trophic level is not present or low, we see that commercial compost reputed of good quality has a negative effect on the crop yield, while benefiting other biological development, i.e. weeds (See results in section 4.4).

4.4.8 Swiss Chard: harvest at 70 days.

No leaf harvest has been done from field transfer till end of trial.

Table 40: Swiss Chard yield results

Swiss Chard yield results

INDICATORS			Field pre-growing season	Scenario 1 Control (No input)	Scenario 2 Compost Only	Scenario 3 Microbiological inoc + Compost	Scenario 3 vs Scenario 1	Scenario 2 vs Scenario 1
TOTAL CROP YIELD		g/m2	N/A	1211	1619	1968	63%	34%
1st Trophic Level		FUNGI (µg)	24	46	283	465	911%	515%
		BACTERIA (µg)	12829	7491	5716	7146	-5%	-24%
		FUNGI:BACTERIA	0,0019	0,006	0,05	0,065	983%	No relevant
2nd & 3rd Trophic level	Protozoan	FLAGELATES	0	0	0,15	0	Too low	Too low
		AMOEBAE	0	0,18	0,82	1,17	550%	356%
		CILIATES	0	0	0	0,07	Not relevant	In target
	Nematodes	Root feeding	0	0	0	0	In target	In target
		Bacterial Feeding	0	0	0	0	Too low	Too Low
		Fungal feeding	0	0	0	0	Too low	Too low
		Predatory - omni	0	0	0	0	In target	In target
Fungal density	At 100X Total Mag	Total Strands Occurrences	N/A	47	96	95	102%	104%
		Av. Strand per field of view	N/A	0,61	1,25	1,23		
SOIL PHYSICAL PROPERTIES		Depth in cm reached under 100psi	N/A	20,44	25,22	23,56	15%	23%

(Source: Flor.ès.Sens Systems, 2017)

FACTS:

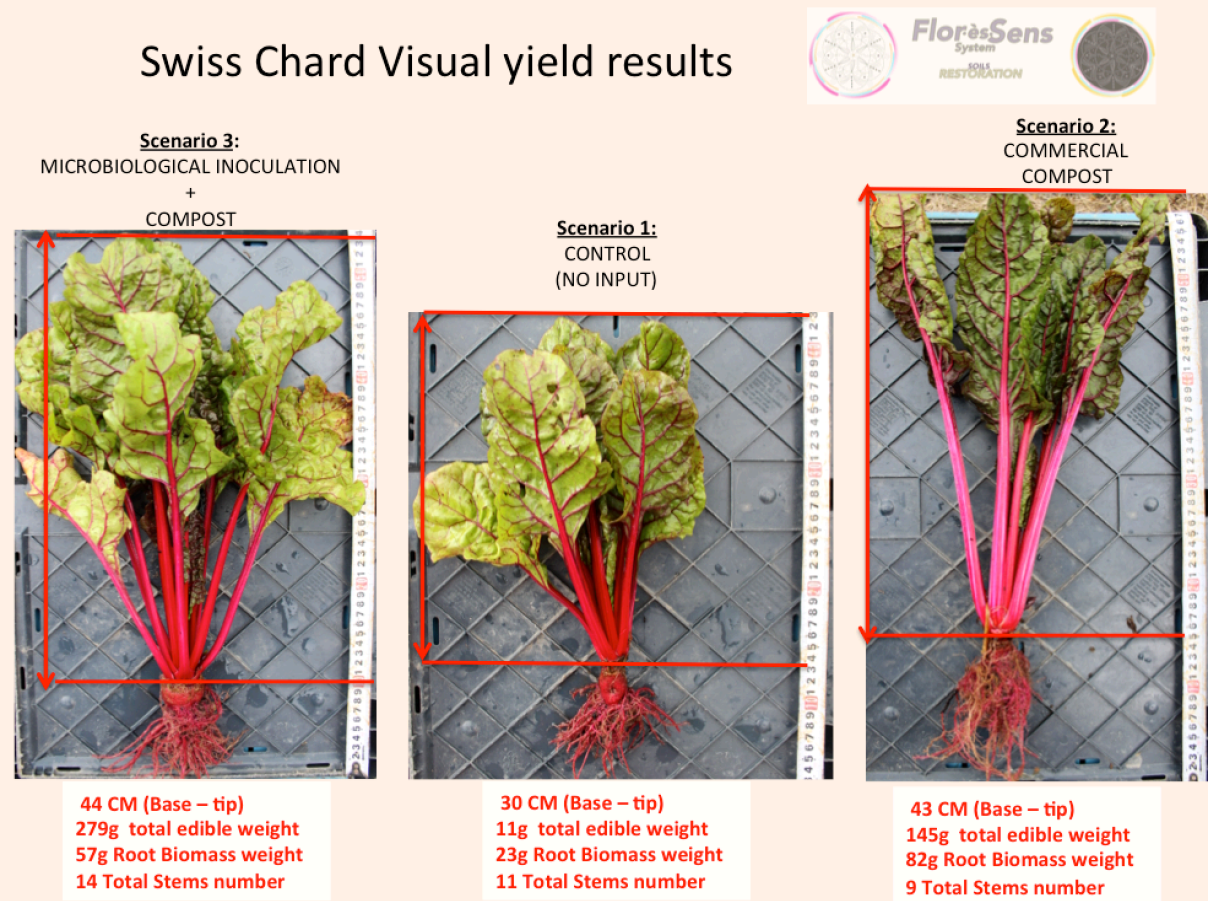
Scenario 3 display 63% better yield, a higher Fungi:bacteria ratio, a higher 2nd & 3rd trophic level (+550%), and same soil physical properties the control scenario 1.

Compared to control scenario 1: scenario 3 displays a Fungi:bacteria ratio (0,065) below target in regards to table 8, still higher than the other scenarios 1 & 2. Swiss Chard crops needs a F:B ratio between 0,5 & 0,75 in order to grow at full potential.
Higher beneficial protozoan number (+550%) effect on the 1st trophic level enabled a good nutrient cycling and better yields than scenario 1 (+63%) while bacterial biomass remained nearly the same (- 5%).
Higher fungal biomass & distribution continue to support soil aerobic structure, building up beneficial microorganisms our plants need to get the optimum nutrient cycling.

While scenario 2 has a higher fungi:bacteria ratio than scenario 1, both remained very low to enable a decent crop growth. Still, in scenario 2,

2nd & 3rd trophic is higher than control scenario 1 (+356%) and enabled a better crop yield (+34%).
Besides the fact that we did not inoculate scenario 2 with microbiological life, naturally occurring 2nd & 3rd trophic level growth confirmed our predictions and as a consequence enabled better crop yield.

Table 41: Swiss Chard visual yield results



Our microbiological inoculant has a positive effect, cycling up the commercial compost carbon & nitrogen content, on our crops.

When the 2nd & 3rd trophic level is present, we see better results in yield.

4.5 Compaction measurements:

Date 17/07/2017.

The sampling has been done taking 10 measurements for each crop tried, in each scenario while monitoring the yield results. A total of 240 points measured with the "john Dickey tool".
The penetrometer displays both a psi gauge and a depth scale in cm. Process was the following: when the psi gauge was reaching 100 psi, depth in cm was recorded.

Table 42: Average measured depth in cm under 100 psi

Average measured depth in cm under 100 psi

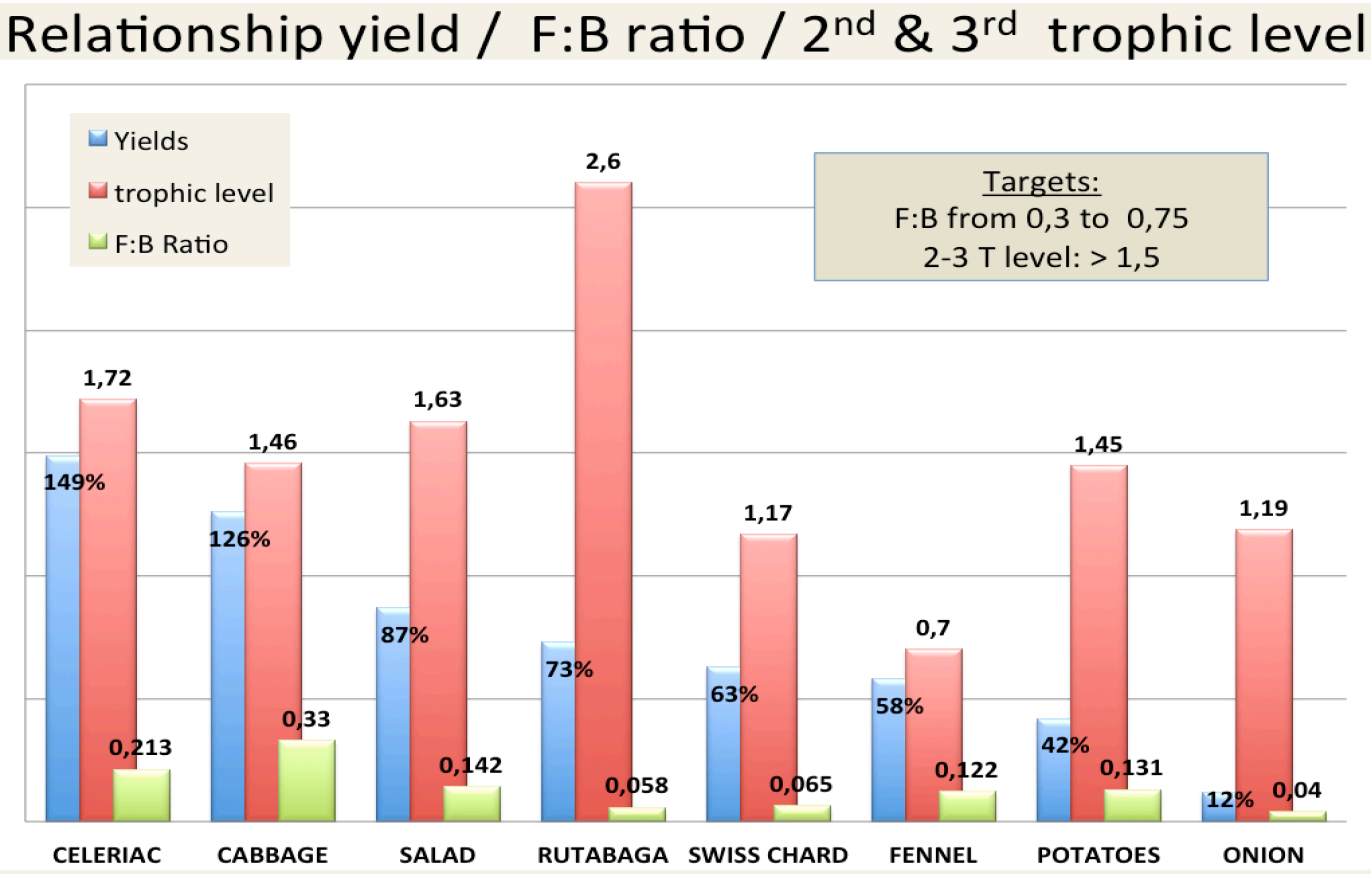
Vegetables	Scenario 1 Control (No input)	Scenario 2 Commercial Compost	Scenario 3 Microbiological inoc + Compost
Fennel	22,33	23,33	23,11
Onions	21,22	21,22	19,89
Salad	22,78	23,44	32,22
Swiss Chard	20,44	25,22	23,56
Cabbages	21,78	26,67	21,67
Potatoes	21,89	20,11	19,67
Origano / Dill	22,00	23,22	24,22
Celeriac	22,22	23,89	25,56
Rutabaga	20,22	21,89	22,78
Average depth	21,65	23,22	23,63

(Source: Flor.ès.Sens Systems, 2017)

FACTS:
Average soil depth in cm remained the approximately the same for all the crops, for all the scenarios; enabling similar physical root penetration.

5. CONCLUSIONS:

Table 43: Relationship Yield / F:B Ratio / 2nd & 3rd trophic level for microbiological inoculation & commercial compost amendment.



(Source: Flor.ès.Sens Systems, 2017)

Using R.E. Ingham, J.A. Trofymow, E.R. Ingham and D.C Coleman work[13], and applying it to our vegetable production trial, we confirmed their predictions and at the same time we proved ours to be relevant.

We reach better crop productivity when soil microbiological community is more complete both at 1st 2nd 3rd trophic level. More precisely, our data shows that there are better crop yields and lesser weed pressure when the previous trophic levels reach certain levels mention in table 8.

Starting with very weak soil microbiological status, 1st 2nd & 3rd trophic level not present or low, our trial shows that soil amendment along with material reputed to be "good" we may indeed be ineffective or detrimental.

This trial makes a clear point on how beneficial aerobic microbiology performs on our crops yield and overall health. As a consequence, we have to give relevant soil microbiological management in a context of soil restoration, soil microbiological health, i.e soil health.

6. DISCUSSIONS

In the perspective of this trial, when one wants to remediate or regenerate soil, the process must start by monitoring what the current microbiology is in order to address what is potentially missing, in an informed manner.
After having assessed the current soil microbiology status, and before amending it with "organic compost reputed of good quality", the same compost must be assessed microbiologically in order to check if it will be beneficial or detrimental; looking at aerobic or anaerobic markers.

In terms of aerobic compost, we also want to mention that its maturity will make a difference in terms of microbiological diversity, thus on plant health and productivity. In this regard, organic matter diversity used for the compost making is crucial as well.

Looking at plant response from fungal presence, we observed a limited effect on plant growth. We hypothesize fungi play a crucial in accelerating the broader aerobic soil structure build-up.

From data gathered, 2nd & 3rd trophic level play an essential role in plant productivity and health; i.e beneficial protozoa such as amoebae & flagellates. Beneficial protozoan are the kick-starter of any healthy and productive vegetable production.

In the same manner as per initial soil microbiological status, farmers have to consider the actual carbon and nitrogen content present in their soils. Our analysis confirms this. It triggers from the farmer side a brainstorming about soil residue strategy, cover crop strategy, or compost amendment addressing the crops needs for carbon and nitrogen.

Soil compaction is another important indicator to consider when looking at crop productivity.

Considering the diversity of microbiological status in one field, we also want to highlight our limited capacity to address all of the fields in the same way.
However, we are insisting on our purpose being giving the soil ecosystem a direction, a beneficial trend. We are not fixing a car part.

TABLE LIST:

REFERENCES:

[1] Ecological Monograph Vol 55, No.1. Interaction of bacteria, fungi and there nematodes grazers : effects on nutrient cycling and plant growth.
[2] Environment Celebration Institute : www.environmentcelebration.com
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[5] Elaine Ingham CV plus references.
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[8] Sir Albert Howard works on compost.
[9] Dr. Elaine Ingham, soil Food web inc, 2014.
[10] Ecological Monograph Vol 55, No.1. Interaction of bacteria, fungi and there nematodes
[11] Lennart Månsson International AB in Helsingborg
[12] See Gabe Brown and Ray Archuletta cases.
[13] Ecological Monograph Vol 55, No.1. Interaction of bacteria, fungi and there nematodes grazers : effects on nutrient cycling and plant growth.