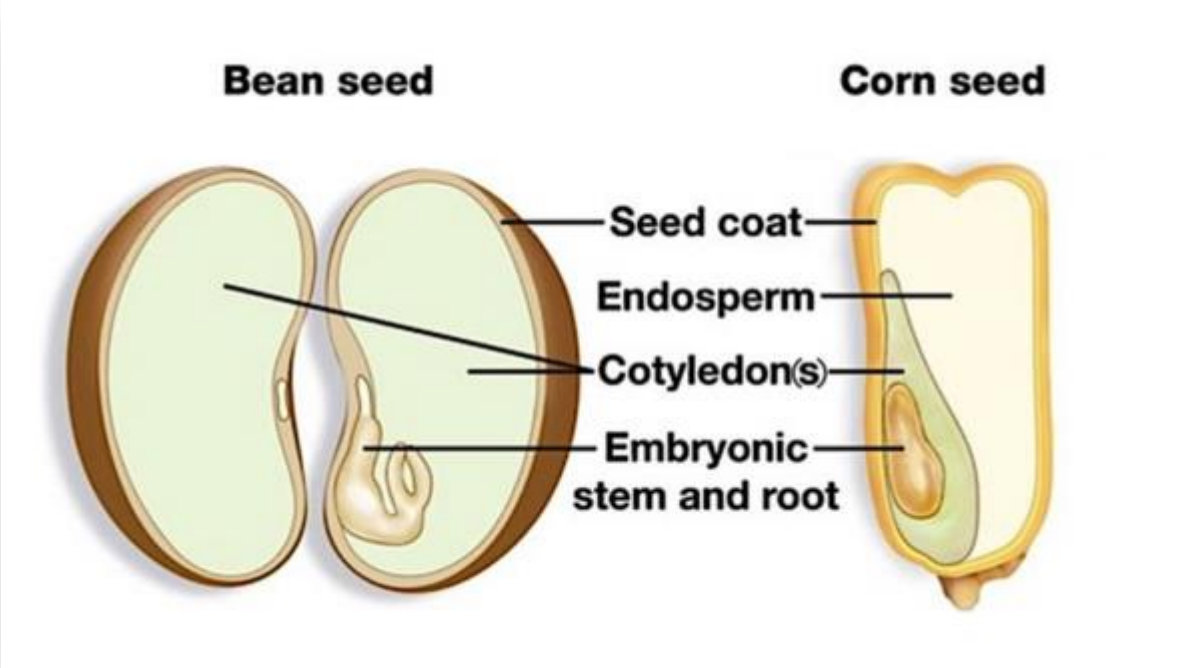
Vermicoat®

www.vermicoat.com

Section 1:

What is a Vermicoat®: *A Vermicoat® is the Biological Priming of seed with living Microbes placed inside the endosperm, as well as the placement of a thin coating of earthworm organic humus material and microbes unto the outside seed surface; in order to enhance plant growth with Plant Growth Promoting Rhizobacteria and Free-living Nitrogen Fixing Microbes.*

Earthworm gut microbes in and on the seed restore soil biological diversity and improve the plant's root health, nutritional reach and raises yield.



Seed is Biologically Primed for higher yields by placing living soil microbes inside the endosperm (Phase 1) and by placing a Soil Earthworm humus coat on the outside of the seed surface (Phase 2).

Placing Living Microbes inside a Seed is called Biological Priming, or Bio-prime® in short.

Placing a Soil Earthworm coat on the outside surface of a seed is called Vermicoating, or Vermicoat® in short, and it is an extension of Bio-priming to magnify the yield gain.

The Vermicoat® Process happens in two phases:

Phase 1:

Seed is first Biologically Primed by a hydrating it in a limited amount of water mixed with Bio-Prime® Earthworm Soil Microbes, Plant Growth Promoting Bacteria and Plant Growth Promoting Fungi. The dry seed suck up the moisture and Bio-Prime® living microbes and the process of germination begins, but it is not completed. There is a separate website www.bioprime.co.za *explaining Biological Priming in greater detail.*

Phase 2:

Once seed has been Biologically primed with living microbes and some moisture inside the endosperm, the process of priming is magnified by coating the outer seed surface with in-soil earthworm microbes, earthworm humus, organic growth stimulants and biological boosters called bio-stimulants.

A Vermicoat ® is a magnified form of Bio-priming of seed; and is regenerative agriculture in action, restoring soil biodiversity by means of expanding the diversity of soil microbes (bacteria and fungi) for maximum soil nutrient use functionality and greatest yield gains.

Bio-Prime® is what you need to place living soil microbes inside the endosperm.

Vermicoat® is the same inside the seed, but with an additional expanded outer coating as well- what you need to additionally place living soil microbes and organic nutrients as a coating on the outside of the seed surface, over and above the internal endosperm Microbes. It magnifies the biological boost during the germination process, and result in a much larger root system, much quicker, resulting in bigger yields from higher nutrient uptake efficiency.

Typically, bio-priming Canola, Soybean or Maize seed adds up to 500 kg of yield per ha per year on average, while Vermicoat® adds another up to 500 kg of yield per ha, for a potential combined 1-ton yield gain. Where does the extra yield come from? It comes from a higher microbial population which is more diverse, and which can make existing nutrients in the soil more plant available.

Why are Bio-Prime® and Vermicoat® needed inside and outside seeds?

- *Long term use of herbicides such as Round-up/Glyphosate/2-4D, Triazine etc has serious negative health effects for soil microbial diversity lowering yield potential of commercial crops such as Canola and Soybean (https://www.frontiersin.org/articles/10.3389/fenvs.2021.763917/full).*
- *Long term use of chemical fertilizers negatively affects the microbial diversity of agricultural soils also lowering yield potential. If you Google the name of the herbicide you use active ingredient, and its effect on soil microbial diversity and soil function, you will only get bad news results in terms of soil health. You will see that your soil loses certain types of microbes that are critical to the optimal health of your soil and thus limit yields. With long term commercial herbicide use soil microbial diversity is lost.*
- *Example: Canola and Soybean both have 4–6-ton ha year genetic yield potential, but average harvests are in the 2.5-ton ha year range. The reason for this is due to the loss of microbial diversity in the soils due to herbicides and chemical fertilizer which hampers the microbial root feeding networks of plants, impairs nutrient use efficiency, and restrict yields. https://foodprint.org/issues/how-industrial-agriculture-affects-our-soil/*
- *A Vermicoat® on commercial seed simulates a visit to the seed by numerous classes of earthworms with all the benefits and soil diversity health restoration that entails, typically adding 500 kg to 1000 kg of additional Canola, Maize, and Soybean yield per hectare per year due to better function root microbial networks.*

Table 1

Different herbicides with their reported effects on soil microorganisms and biochemical reactions.

Herbicides	Effects on Microorganism and Associated Process	References
2,4-D	Adversely affects the activities of *Rhizobium* sp.	[122]
2,4-D	Reduces nitrogenase, phosphatase, and hydrogen photoproduction activities of purple non-sulfur bacteria.	[123]
2,4-D and 2,4,5-T	Adversely affects node-expression disrupting plant *Rhizobium* signaling. 2,4-D also reduces fixation by blue-green algae and nitrifying process impacting *Nitrosomonas* and *Nitrobacter* sp.	[124]
2,4-D, Agroxone, and Atranex	Inhibits activities of *Rhizobium phaseoli* and *Azotobacter vinelandii* (most sensitive).	[122]
2,4-D, Bromoxynil, and Methomyl	Reduces CH_4 oxidation to CO_2.	[125]
Bensulfuron methyl and Metsulfuron-methyl	Decreases N-mineralization.	[126]
Bentazone, Prometryn, Simazine, and Terbutryn	Inhibits N-fixation and decreases the number of nodules and N content overall.	[127]
Isoproturon, Triclopyr	Adversely impacts *Nitrosomonas*, *Nitrobacter*, urea hydrolyzing bacteria, nitrate reductase activity, and growth of actinomycetes and fungi.	[128]
Linuron, Terbutryn, and Methabenzthiazuron	Adversely impacts nitrogenase activity and nodulation at the pre-emergence application.	[129]
Glyphosate	Suppresses phosphatase activity.	[130]
Glyphosate	Reduces the growth and activity of *Azotobacter*.	[131]
Metribuzin	At lower doses, no effects on AM fungi in maize and barley.	[132]
Butachlor	Butachlor (20 µg/g) reduced the population of *Azospirillum* and anerobic nitrogen fixers in a non-flooded alluvial soil.	[133]

Kindly see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8910389/ for more information on the full list of herbicides and their negative effectson soil microbial diversity. The result of this is that with fewer soil microbial diversity, nutrient uptake efficiency is lowered.

Nutrient Use Efficiency in modern Agriculture

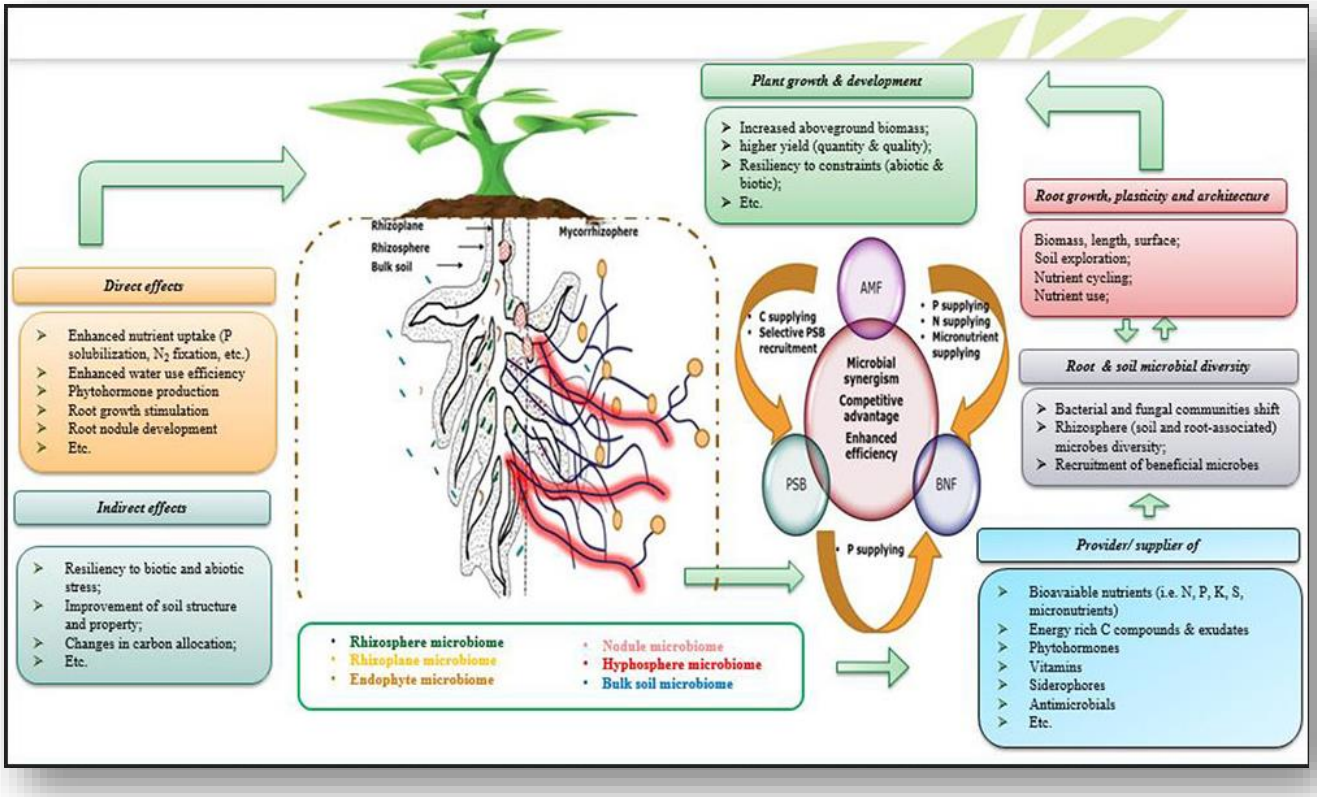
Table 1. Nutrient use efficiency in the agricultural ecosystems [2,26,47].

Nutrient	Efficiency (%)
Nitrogen	30–50
Phosphorus	15–20
Potassium	50–60
Sulphur	8–12
Zinc	2–5
Iron	1–2
Copper	1–2
Manganese	1–2
Boron	2–3
Molybdenum	2–5

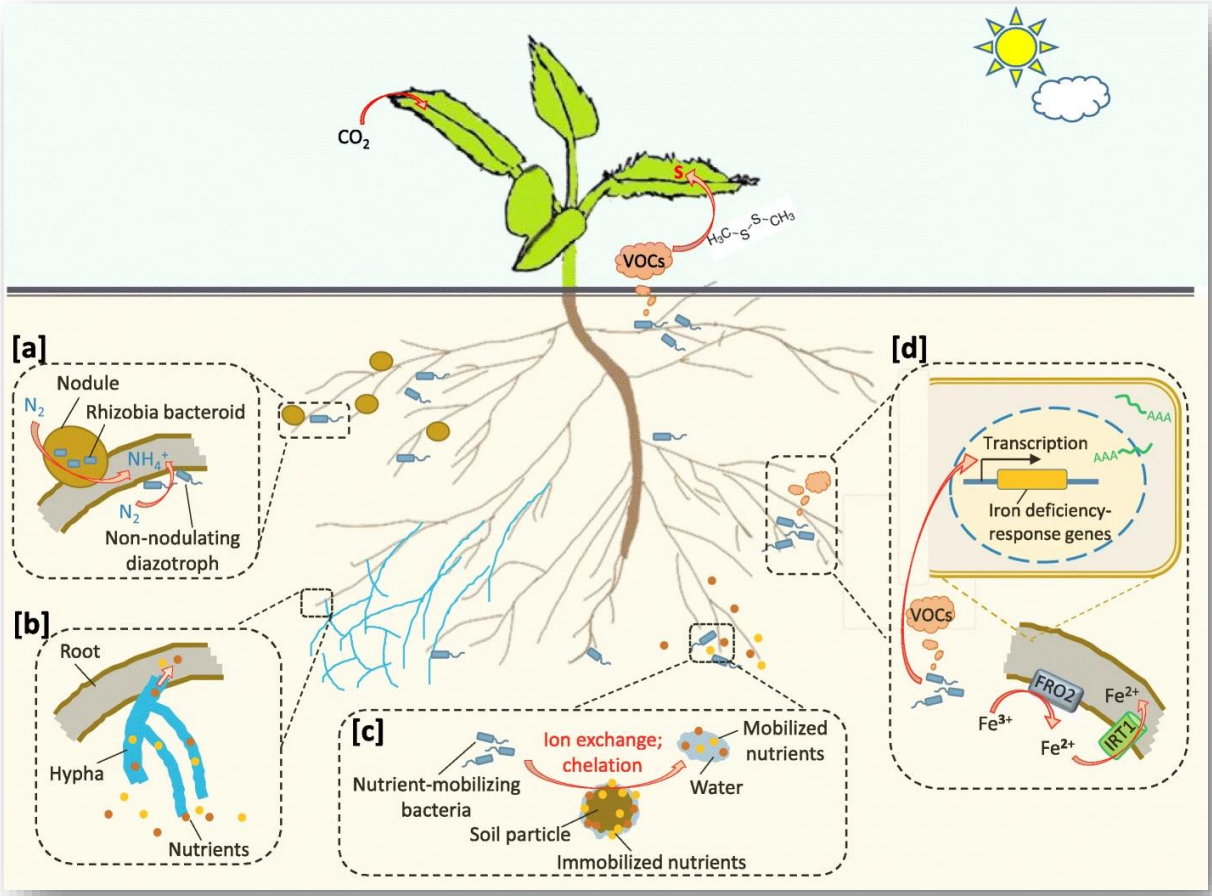
Do you even know what the modern agricultural nutrient uptake efficiency is? Bio-prime® and Vermicoat® improves this drastically by increasing the microbial diversity (bacteria and fungi) and numbers of Soil Microbeson each seed, which can make more nutrients more plant available. It is a shift towards nutrient mining, and using existing nutrients what you already have in your soil, instead of adding yet more chemical fertilizer with ultra-low nutrient use efficiency.

https://www.researchgate.net/publication/351007618_Connecting_Bio-Priming_Approach_with_Integrated_Nutrient_Management_for_Improved_Nutrient_Use_Efficiency_in_Crop_Species

Soybean seed with a Bio-prime® Vermicoat® of earthworm humus and earthworm gut microbes as well as free living nitrogen fixing bacteria, which stimulate plant growth, root function and crop yields. Such a combined Bio-prime® (R500 ha) and Vermicoat® (R500 ha) coating typically cost R1000 per ha, adds 80 N microbially (same as 250 kg of Urea per ha) and adds up to 1 ton of combined Soybean/Canola/Maize yield extra (in an average rainfall year in a 2.5-ton average yield area). It starts germination in healthy microbially diverse functioning soil and rapidly builds up a healthy root microbial trading network improving nutrient uptake. You are looking at both Bio-primed seed (microbes inside the seed) and a Vermicoat® on the outer seed surface.



Simplified illustration of the microbial consortia concept highlighting beneficial rhizosphere PGPM and their direct (i.e., nutrients uptake via fixing N2, solubilizing P, producing plant growth promoting (PGP) substances like indole acetic acid, gibberellin, and cytokinin, etc.) and indirect effects (i.e., alleviation and/or protection against biotic and abiotic constraints) on root growth, symbiotic (rhizobial and mycorrhizal, etc.) and aboveground (plant growth, productivity, etc.) plant performance. Heterogeneity of the rhizosphere and root beneficial microbiome influences root growth and plasticity of root architecture that lead to effective exploration of soil and thus efficient nutrient uptake with positive consequences on growth and yield of the plant host. This all leads to higher nutrient uptake efficiency. For more info kindly see https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2018.01606/full



Microbe-enhanced plant acquisition of macronutrients and micronutrients. Beneficial microbes enhance plant nutrient acquisition via multiple mechanisms, including but not limited to [a] N2 fixation by rhizobia in nodules or by non-nodulating diazotrophs; [b] Nutrient uptake and delivery through mycorrhizal mycelia that reaches additional soil beyond the root; [c] Mobilization of soil-fixed nutrients through ion exchange or chelation by bacterial or fungal secretions, such as organic acids and siderophores; [d] Microbe-induced transcriptional regulation of plant genes involved in nutrient uptake, such as Arabidopsis Fe deficiency responses that are induced by bacteria volatile organic compounds (VOCs). Microbes may also enhance plant S nutrition via certain S-containing VOCs, such as dimethyl disulfite, which can be assimilated by the aerial portion of plants.

What is the purpose of this Vermicoat® Website:

This website overviews the logic chain and use of Vermicoat® for any type of seed, specifically Canola, Soybean, fine seed and (round seed) Maize production and explains on farm Do-It-yourself Vermicoat® application -in order that you get better nutrient uptake in your soil from a wider diversity of Soil Microbes for better yield.

If you want to get 1 ton per ha year additional yields, do your homework and master this improved nutrient uptake value and logic chain.

To study Bio-prime® of Seeds in detail kindly see our sister website www.bioprime.co.za to better understand where half of the yield gain comes from in Phase One; and see how to Do It

Yourself. Once you have mastered Bio-priming conceptually you can further study this www.vermicoat.com website for Phase 2 and proceed to order the material.

How can a Bio-prime® and Vermicoat® be used?

I. You can order the "Do It Yourself"-Bio-prime® and Vermicoat® material by courier and biologically prime and coat your seed yourself. It is easy to do and pretty like adding Rhizobium unto legume seed, with step-by-step instructions and premix liquid and coating material. No special skills required. This is ideal if you want to hydrate the seed with microbes, coat it and test on a few seed bags of 20-25 kg each. You order it and get it delivered by courier overnight, prime and coat it by hand and once you see that it works from the yield gain, you can take it further with your next harvest.

II. For large commercial farmers planting a huge number of tons of seed we can send out mobile seed coating machines and help you coat the seed in your shed on your farm – for instance 180 tons of soybean seed for 1000 ha. You order it months in advance and pay a 50% deposit on order, and the seed is coated in the 30 days before the rain starts on your farm using custom mobile coating machines.

Mobile Seed Coating Machine for Industrial volumes of Soybean or Canola seed.

What are the technical advantages of using a Vermicoat® on Seed?

- Canola, Soybean, and any fine seed can be planted 1-2cm deeper than normal and will still emerge due to the additional nutrients and microbes on the seed surface boosting growth. There is a lot more moisture and nutrients 3-4cm deep in the soil profile, instead of in the top 1-2 cm of the soil that dries out easily. With a Vermicoat®, seed is planted in the wet soil at 4 cm and seedlings can survive much longer between rainfall events, lowering climatic risk.
- A Vermicoat® is a solution against erratic rainfall, heatwaves and La Nina climatic extremes making conventional planting in the top 2 cm of the dry soil risky-if you do not have regular rainfall plant population densities drop quickly and losses mount.
- A Vermicoat® plant will grow a larger root system and the soil biology in and on the seed will immediately integrate the plant into a common microbial market; trading nutrients over the entire field for plant sugars and carbon- leading to faster root and plant growth. Instead of roots having a 15-30 cm reach they can now have 3-10 meters wide reach.
- The earthworm gut microbes on the seed will increase the biological size and reach of the plant root system by up to 700% accessing nutrients far from the physical plant roots and bringing those nutrients to the plant by means of microbial action-both bacterial as well as fungal.
- 20-60% higher yield is possible due to earthworm Plant Growth Promoting Rhizobacteria stimulating plant growth as per https://www.nature.com/articles/srep06365

Normal germination of Russian Grass at 14 days only 20mm – meaning seed can not be planted deeper than 20mm otherwise it will not be able to emerge. The problem is the top 20mm dries out easily within a day with high heat and high wind conditions.

Russian Grass with a Bio-Prime® Vermicoat® at 14 days -with the ability to emerge from a planting depth of 40mm. The difference is that there is a lot more moisture for much longer at 40mm soil depth. The Vermicoat® nutrition and microbial boost enable the seedling to emergence from the deeper depth and to have much faster root development down to subsoil moisture, and eventually a much bigger root system with much further extended biological reach. Note the root difference between the two seedings at 14 days already. This is the famous Vermicoat® effect.

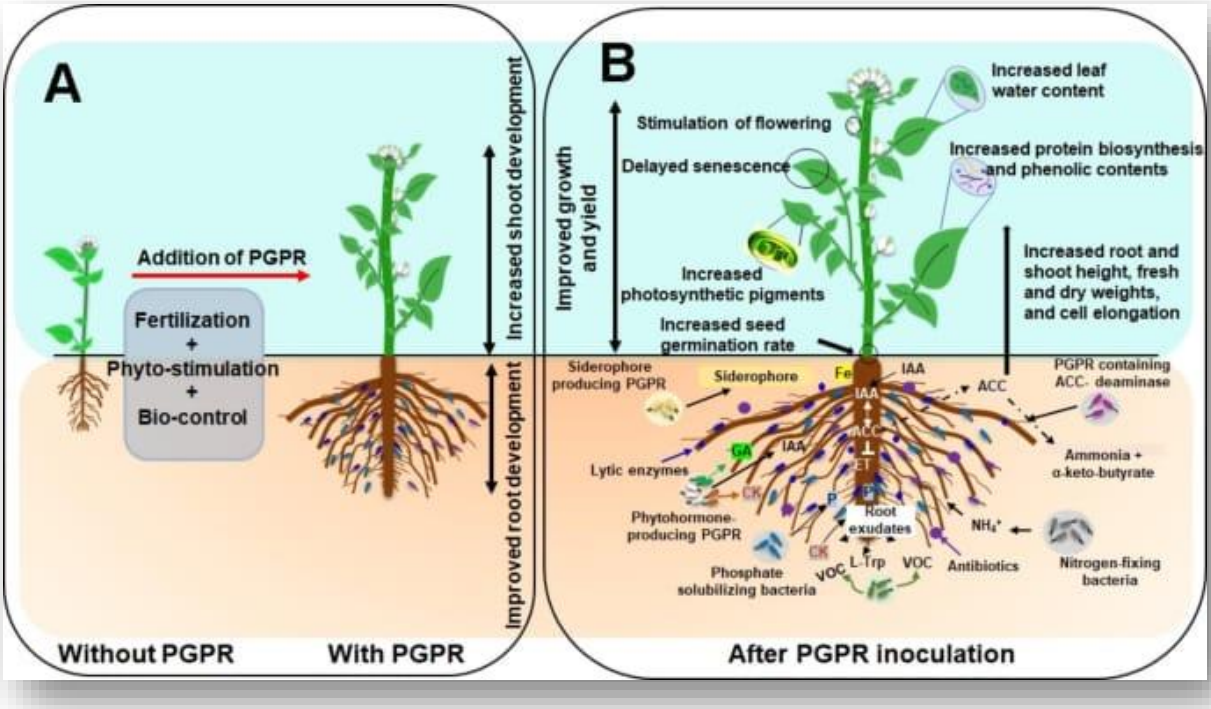
What does Vermicoat® in-soil earthworm gut microbes do to Plant Growth?

I. **20-40% higher yields**. (Canola and Soybean yields are typically increased by 500 kg to 1 ton ha year when planted with a Vermicoat®)
II. **20-40% increased plant hardiness** against water stress, heat stress and disease challenge.
III. **20-40% increased grain quality**.
IV. Nitrogen fertilizer use can be cut by up to 100% in the case of Canola and Soybean when earthworm gut microbes are combined with free living biological nitrogen fixing bacteria

producing 80 N ha (250 kg Urea/KAN equivalent) in addition to Rhizobium. The following photos are from Vermicoat® Soybean with zero Nitrogen or Phosphate fertilizer added. (in-furrow micro elements from Kelp at planting and normal Rhizobium inoculation).

V. Example of upside potential-what you save on Nitrogen fertilizer per ha pays for the Vermicoat® soil biology: R1000 per ha cost, additional 0.5 to1 ton of Canola or Soybean yield = R8500per ha extra. Every R1 turns into R4 to R8.50.

Soybean with a Bio-Prime® Vermicoat® growing in average rainfall conditions 1.6m high (with 1.6m deep roots) due to having an extended microbial root system, full microbial symbiosis, and an integrated capability to trade plant sugars for nutrients with distant soil microbes averaging out nutrients from locations of surplus to areas of demand. Typically, a Vermicoat® increase yields of Canola and Soybean in normal rainfall conditions by up to 1 ton ha year. This is a picture of 3.5-ton Soybean potential in a Magaliesburg area where 2.5-ton ha year yield is the norm. Zero fertilizer was used. Soybean biological Nitrogen fixation only provides 60% of the plants needs, while the rest normally comes from Nitrogen fertilizer. In this case it came from Free living Nitrogen Fixers provided with the Vermicoat®. In such a production system the savings from not applying traditional ammonium sulphate Nitrogen fertilizer pays for the Vermicoat® yield biological gain. If you look carefully at the picture, you will see the biologically active Soybean is growing like Kakiebos!



What you are really seeing in the above Soybean Picture - Plant Growth Promoting Rhizobacteria from the gut of in-soil earthworms.

This is Soybean growing in 38-degree heat without rain for 6 weeks, it is surviving better than anybody else in the district because the Vermicoat® microbes could trade plant sugars derived from photosynthesis for water molecules with the deep soil microbes, mining previous years water. The soil biology basically mined the entire soil profile for all available moisture and extended the time that the Soybean survived -in this case 2 x 6 weeks periods without rain in 38-degree heat. The first 6-week 38-degree Celsius heatwave was when plants were 15 cm high in

November and the latter February March. This is an example of the increased plant hardiness against heat and moisture stress in adverse La Nina conditions due to the Vermicoat® soil biology lowering climatic risk biologically.

This is an example of Vermicoat® Soybean after 8 weeks without any rain in 38-degree heatwaves during the 2024 North West Province drought-late March. The Vermicoat® microbes mined the soil profile until all moisture was exhausted and kept the Soybean yield potential high the longest in the district, to the extend the soil moisture allowed. It can not save the entire harvest (good harvest in a bad year), but it can make possible an average harvest in a bad year, or a minimal harvest in a total crop failure year. It improves you chances by lowering the climatic risk. Good years take care of themselves, it is in bad years you need biological help.

New Season Seed Germination trials in an Earthworm Soil Bath

- Note how the seed respond to the Earthworm Plant Growth Promoting Rhizobacteria in the bath.
- We cannot plant your commercial Canola and Soybean seed in the bath due to a lack of space, but we can extract the soil biology from the earthworm gut and place it on every seed you wish to plant and get the same effect.

Note the 7-day old seedlings and vigorous growth due to earthworm gut microbes in the soil in the bath. What is in this soil in this bath is what we place on your seed as a Vermicoat ®.

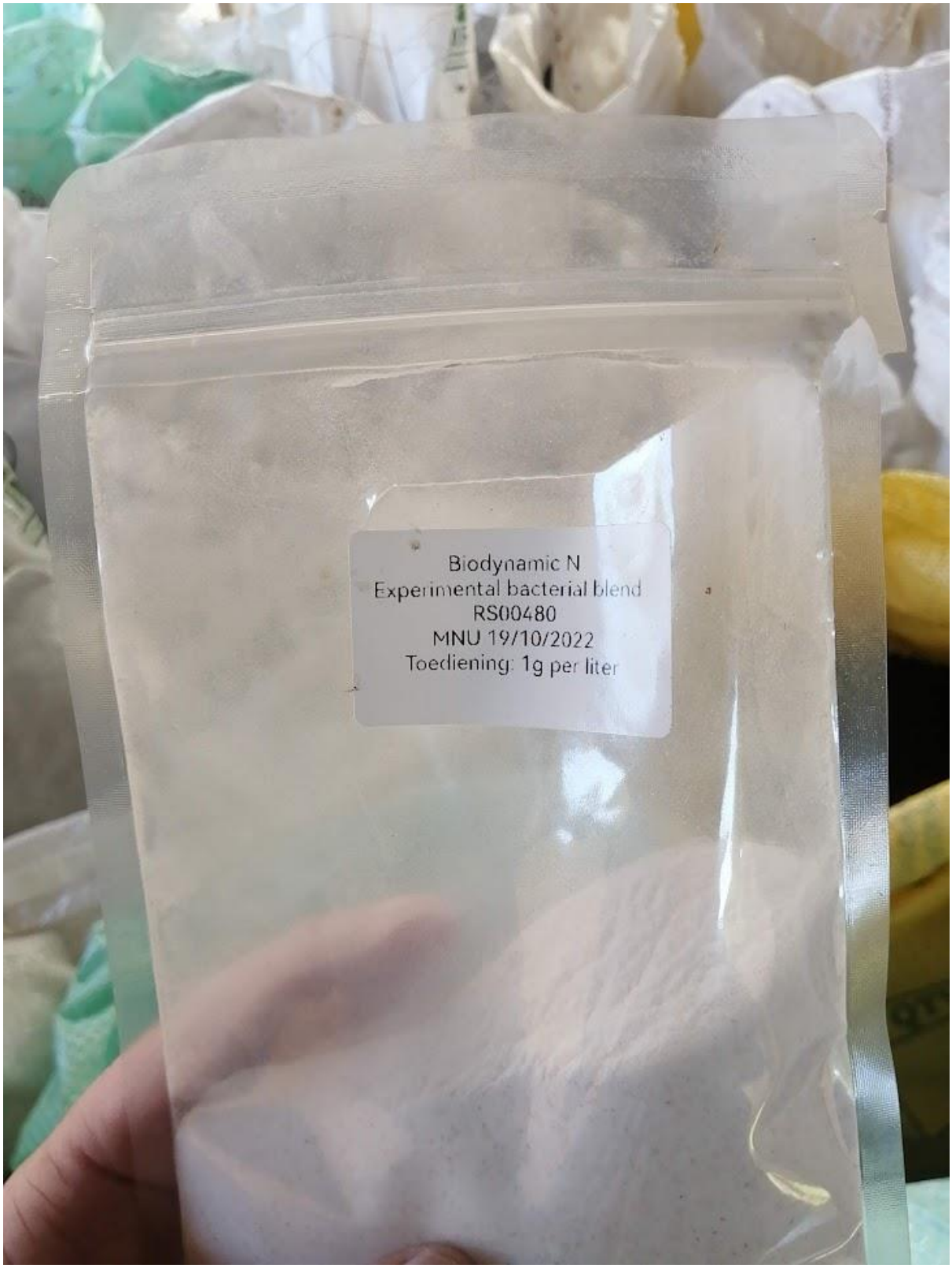
VID_20240307_144434.mp4

Which type of soils benefit most from a Bio-Prime® Vermicoat® in and on the Seed?

- Any soil with a heavy herbicide application history which negatively affects soil biology, and in which chemical residues builds up in the soil over time.
- Any soil with a long history of heavy chemical fertilizer use, especially ammonium sulphate and nitrate-which tend to deplete soil humus and microbiology with long term NPK use and which alter the soil biology, leading to a loss of microbial diversity, especially in the beneficial fungi.
- Tilled and ploughed soil where soil structure, soil organic matter and soil biology is not ideal.
- In such soils the Bio-Prime® Vermicoat® microbes bring back the microbial diversity, restoring root trade network capabilities, and are thus able to mine many historic leached nutrients that are normally not plant available in the full soil profile. The microbes also break down and neutralise herbicide residues; and allow humus formation with high soil microbial activity and fast crop residue decomposition.
- The second season of Vermicoat ® typically yield very good to better results, as the legacy microbes on the roots in the first year remain after the harvest and can transport mined nutrients and water to the new young plants in year 2 creating an even bigger trading network down to deeper depth quicker, than in year 1.

Summary of Bio-Prime® Vermicoat® Cost Breakdown of R1000 per ha:

a. Bio-Prime® cost R500 and contains in-soil earthworm gut liquid (not vermiwash from Red Wrigglers) which can be mixed with up to 40 Liters of water and a 1kg microbial inoculant that is mixed with water and sucked into the seed endosperm.
b. Vermicoat® cost R500 per ha for the -In Soil Earthworm Powder Coatings x 2 and Microbial spray x 1. It includes:
c. The free-living Nitrogen Microbes applied to the seed of 80 N ha equal to 250 kg of Urea/KAN x 1. (Remember that 100 kg of KAN is only 28 N).
d. The Vermicoat® combined cost benefit analysis is basically R1000- for an additional 500kg to 1000 kg of yield per ha in normal commercial farming soils in an average year. If Canola or Soybean is R8500 per ton, a 500 kg yield increase is worth R4250 and a 1-ton worth R8500 ton (Example price).



Free living Nitrogen Microbes producing 80 N (250 Kg Urea or KAN equivalent). The Nitrogen powder is mixed with the earthworm gut liquid and some water and mixed unto the seed surface, after which earthworm powder and binder is added and the Vermicoat® is dried in the shade in a cool breeze.

In- Soil Earthworm powder bag x 1 kg. Three such bags are used to Vermicoat® the seed, one being moist, one being dried and a third being a dry binder premix material setting the Vermicoat®. The customer only needed to add it in sequence as per the instructions.

1 Liter In-soil Earthworm gut microbial liquid to Bio-Prime®. Also, atomiser to spray unto 20-25 kg seed during Vermicoat®.

How does one Bio-Prime® and Vermicoat® your seed yourself?

I. Order the Bio-prime® Vermicoat® materials online from us and get it at your closest Postnet or Pep.

II. The material is marked 1 to 5 and you apply it in sequence from 1 to 5. You get full instructions and support, for example:

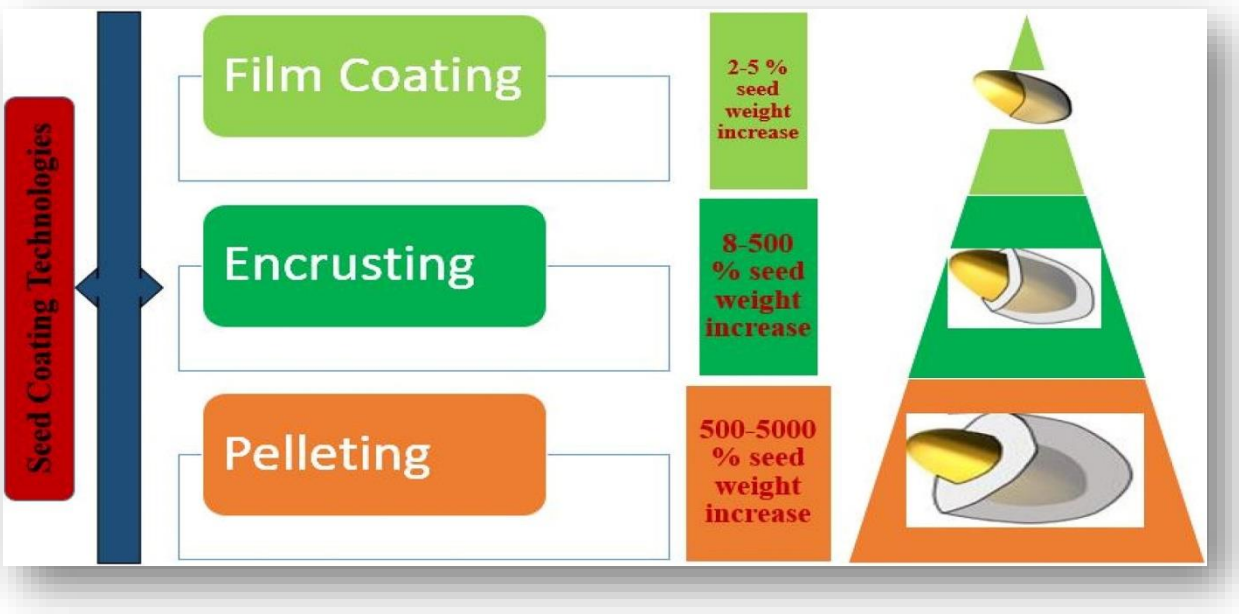
III.

Step one: Nitrogen powder is mixed into the specified amount of water together with Bio-Prime® liquid and gently mixed.
Step Two: Some moist Earthworm inoculation powder is also mixed into the water.
Step Three: The specified amount of moisture mix is carefully applied to the seed during mixing, and the dry seed is allowed to suck up most of the biologically activated moisture.
Step Four. Once the seed has suck up most of the moisture during mixing, the dry bag of earthworm powder and then the dry bag of red binder material is added gently mixing it in. It will add a thin film coating layer on the surface of the seed called a Vermicoat® and will set after a few minutes of mixing.
Step Five: The binder is added to the seed coating making it loose and friable so that it will flow easily through the planter. As it dries you can make sure no pebbles form by breaking up any pebbles between your hands.
Step 6: The seed is put in a bag and dried out in the shade in a cool breeze before planting.

IV. Each seed type has a specific recipe depending on the volume per ha and it gets a custom mix and specified amount of moisture. Check in with us. Fine seed is typically mixed by hand while large volume soybean seed or round seed is mixed by machine - from cement mixers to custom machinery.

V. The general principle is to wet all the seed with a specified amount of moisture not allowing full germination, and then to dry it out using the bone-dry earthworm powders and dry binder to keep it in a biologically primed status.

VI. Once planted when the Vermicoat® seed gets rain- it will germinate as if in the earthworm soil bath, and immediately activate microbial feeder networks stimulating plant growth as per the pictures.



The ideal is to customise your Vermicoat® so that it still flows easily without clogging through your planter. We send you enough Vermicoat® premix material so that you can either do a light film coating or a heavier encrusting depending on what your planter can handle in terms of seed flow. It is something you finetune based on your equipment.

Example of DIY Bio-Prime® Vermicoat® for Canola 20 kg bag:

Canola Vermicoat® package per 20 kg seed bag for 8 ha @R8000:

a. 1 x 1 kg moist earthworm powder.
b. 1 x 1 kg dry earthworm powder.
c. 1 x 1 kg dry red binder powder.
d. 8 x 100-gram package of Nitrogen fixing microbes,
e. 1 Liter of Earthworm gut liquid in a spray bottle to also use during Bio-Prime® process.
f. Total weight about 5 kg. Cost to deliver R100 Postnet or PEP.
g. Enough material for 8 ha worth of Canola seed in either a light film coating or heavier encrusted coating depending on what the planter can handle without clogging.

This website will further explain the Vermicoat® Ecotechnology, with the fundamental concepts and the definitions overviewed in the following short video:

Why do my plants always struggle and not give their genetic yield potential of 3-4 tons ha? Fungi & bacteria are missing!

https://youtu.be/_HO86JjtB2c

Video of 4.8 ton to 5-ton Soybean Harvesting after a Free-living Biological Nitrogen microbe trial on the seed:

WhatsApp Video
2024-02-29 at 10.24.

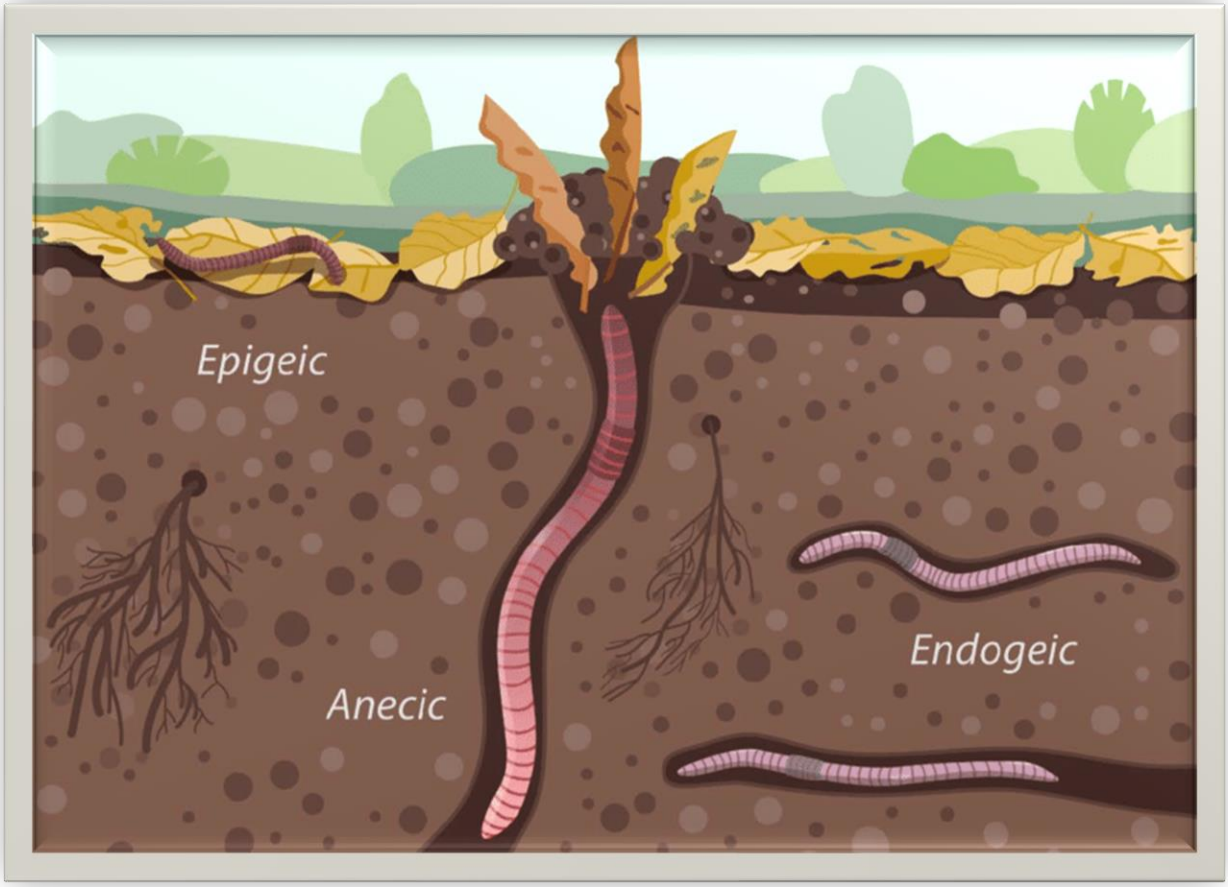
Definitions and Ecotechnology further explained.

Section 2:

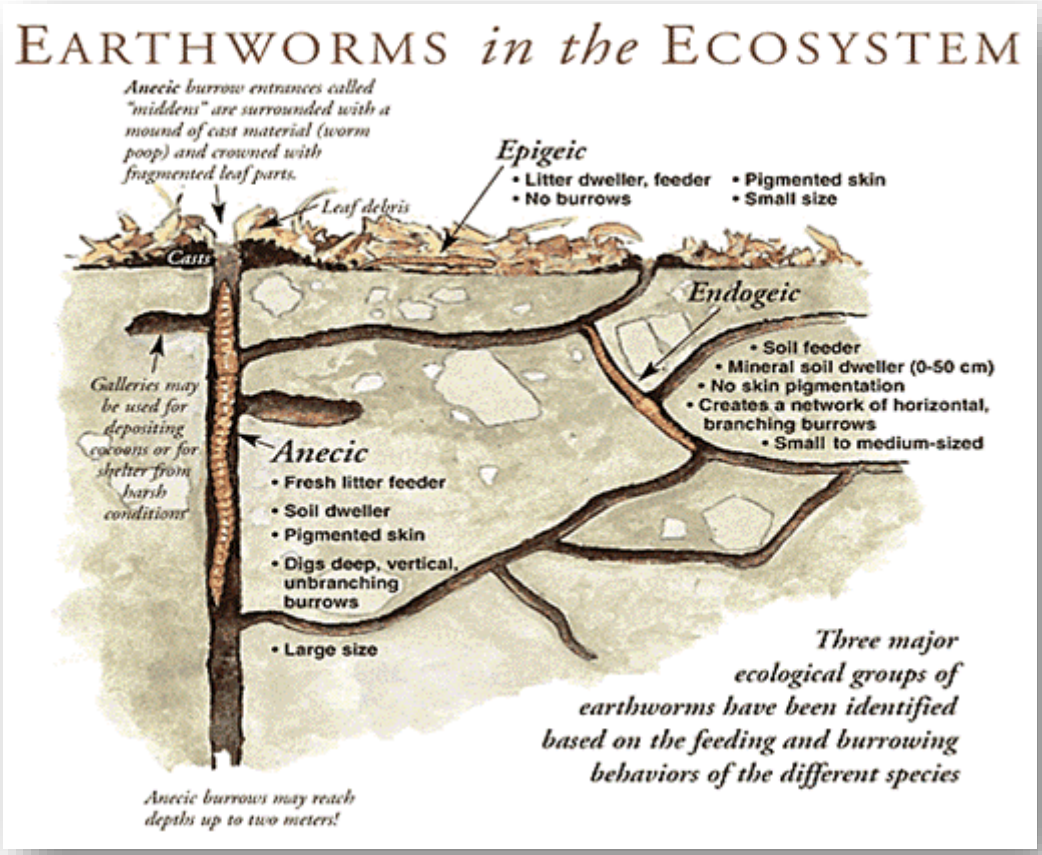
Vermi: *refers to Earthworms*.

Vermiculture:

The scientific breeding of Eisenia Fetida/Red Wriggler compost worms to produce humus rich vermicompost. Compost worms are epigeic and occur in the rich organic litter layer above the soil, decomposing organic material microbially. Worm compost is a very good seed coating material as it contains lots of humus and humic acids stimulating plant growth.



The 3 classes of earthworms from which Bio-Prime® Vermicoat® microbes come. We also include Plant Growth Promoting Rhizobacteria, Plant Growth Promoting Fungi as well as Free Living Nitrogen fixers.



The 3 classes of Earthworms

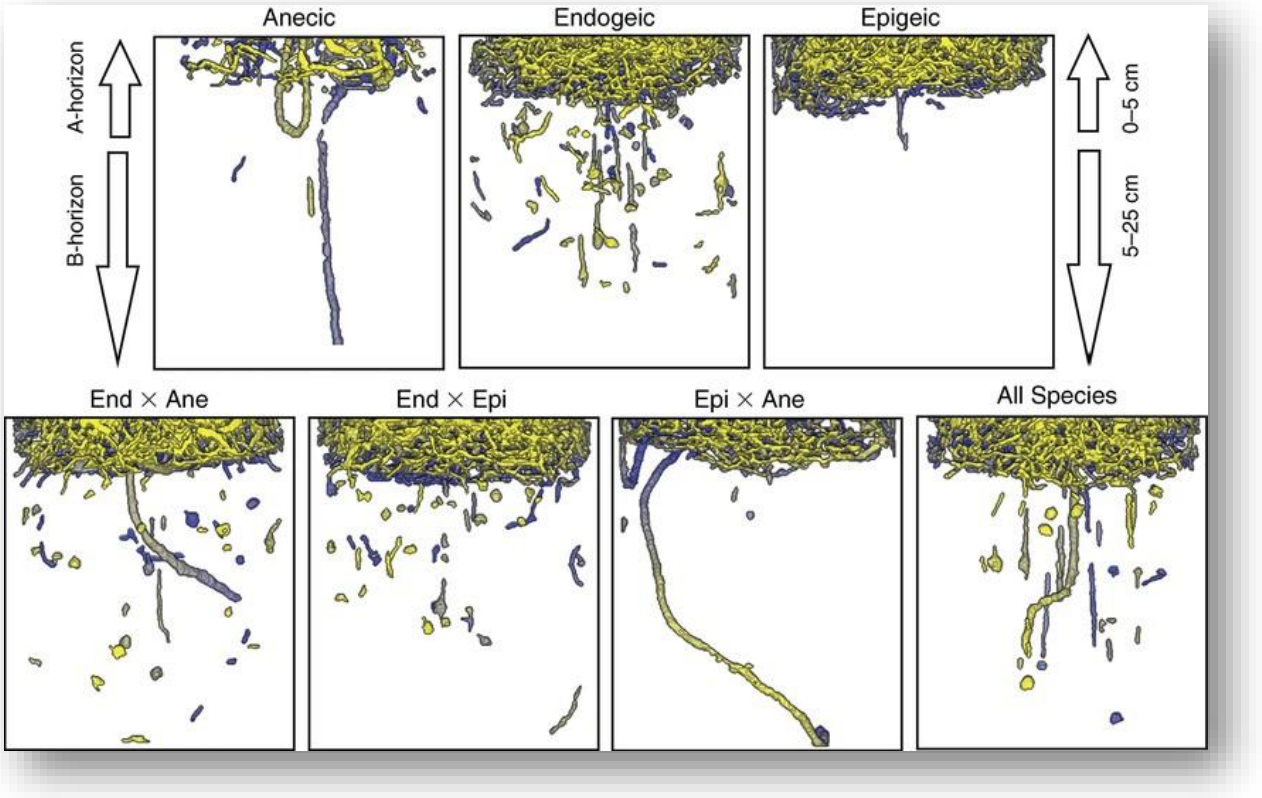
In-Soil Vermiculture:

The scientific breeding of below ground earthworms in the soil to increase soil fertility and promote plant growth. In Soil-Earthworms are of the Endogeic and Anecic earthworm class and they live in the soil at various depths, with Endogeic earthworms building a humus rich layer in the top 5 cm of the soil and Anecic earthworms building vertical tunnels/ burrows up to 1.8m deep.

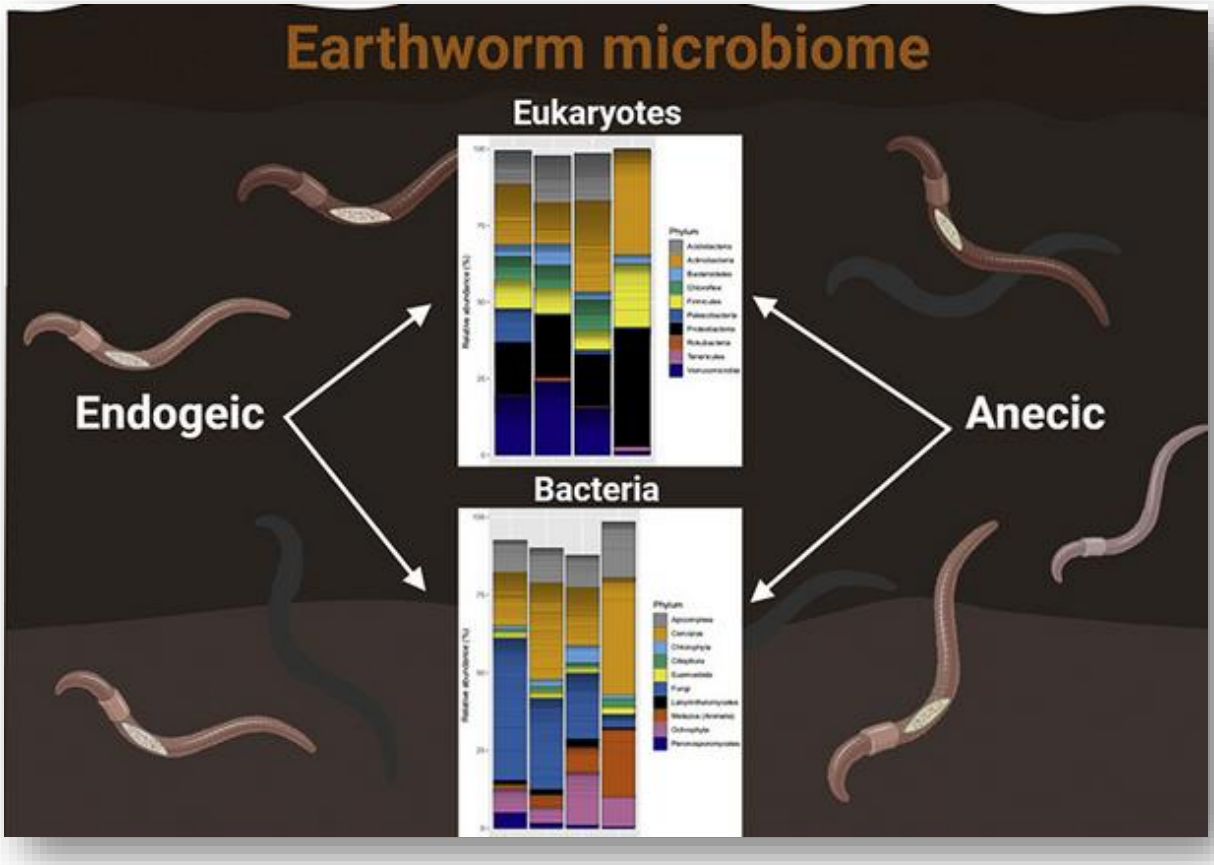
Endogeic earthworms mainly move horizontally and form microbial feeding networks between feeder plant roots and nutrient hotspots in the top 40 cm of the soil, with most activity in the top 5 cm of the soil. Endogeic earthworms build interconnected networks of microbes (bacteria and fungi) feeding the plant in the horizontal dimension mainly linking Plant Growth Promoting microbial hotspots with plant roots. These horizontal microbial feeding networks trade plant sugars and liquid carbon derived from plant photosynthesis and exuded by plant roots, for nutrients mined by soil microbes in the deeper soil layers. Endogeic earthworms spread many Plant Growth Promoting Rhizobacteria which stimulate root and plant growth.

Anemic earthworms mainly move vertically between the soil surface and 60-90 cm deep and create microbial feeding and trading networks in the vertical dimension, between the deeper soil microbial communities and the nutrient hungry topsoil microbial feeder root systems in the

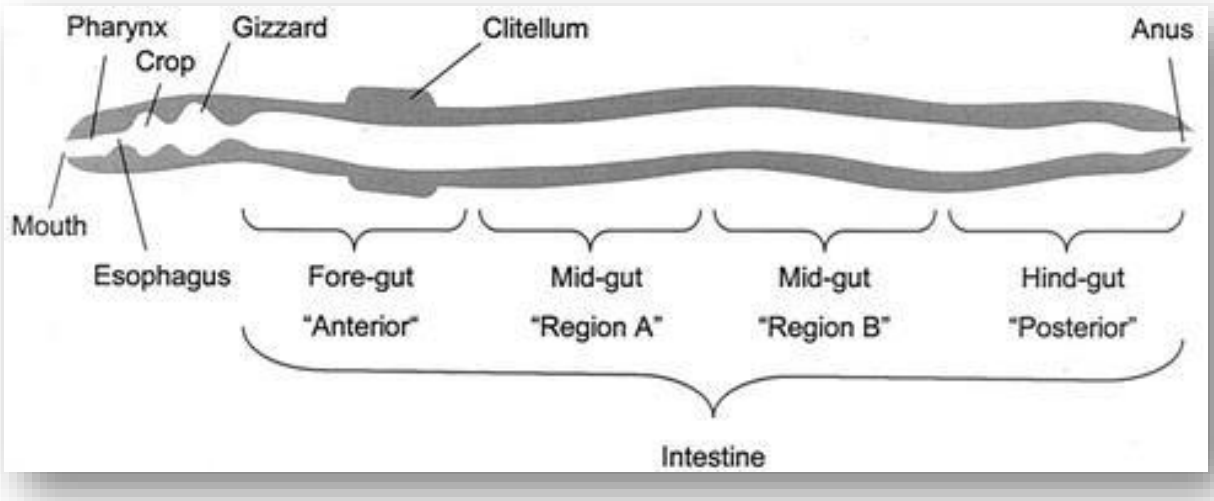
top 40 cm of the soil profile. With Canola and Soybean, Anecic earthworms love to move up and down the taproot of the plants creatin g burrows teeming with microbial life. The topsoil microbes trade plant sugars for moisture with the deep soil microbes. A Vermicoat® enables the plant to trade for both nutrients and deep soil moisture, with shallow nutrients more favoured during good times and deep moisture more favoured during bad times.



Earthworm activity insights and microbial trading networks



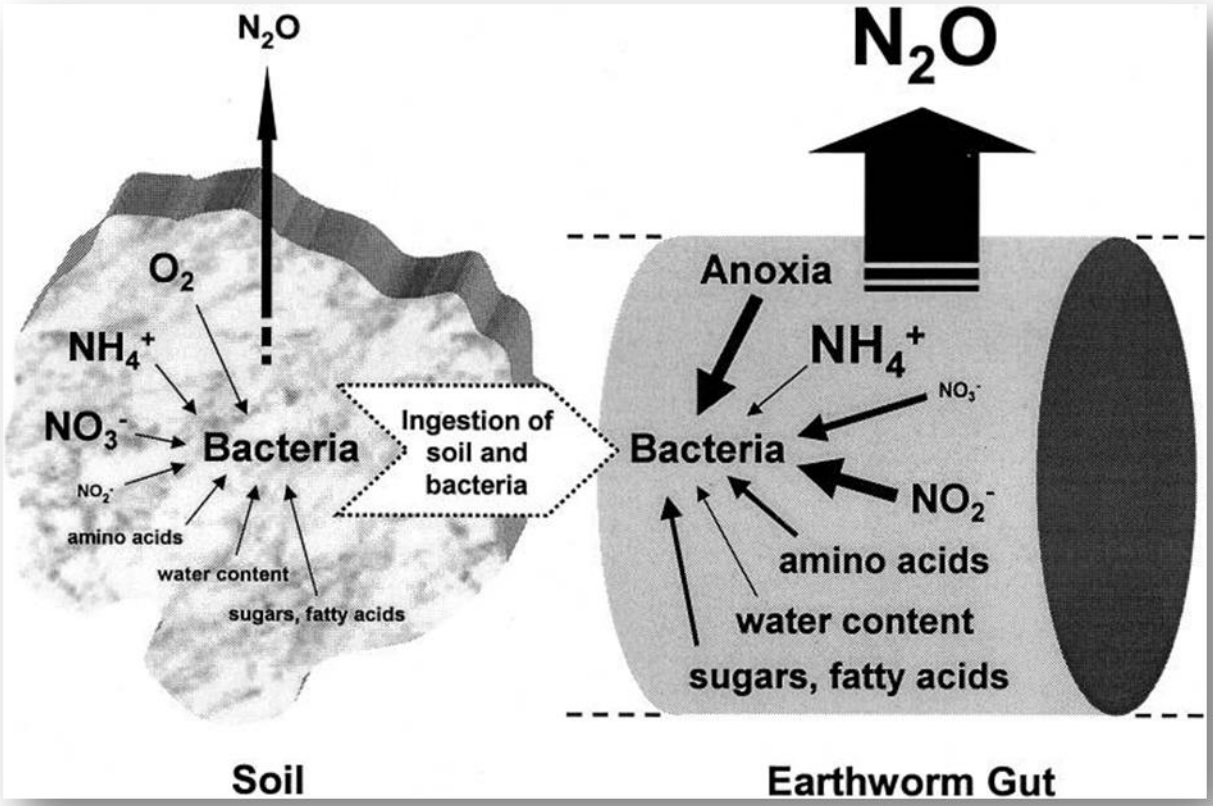
Different classes of Earthworms have different gut microbes, and the best soil health and plant yield is when you have a full diverse range of soil microbes from all 3 classes as we have with Vermicoat®-restoring microbial diversity and functionality. In commercial agriculture long term use of chemical fertilizer and herbicide has broken down the soil microbial diversity and full root feeder networks are no longer optimised as the microbial link is broken between the roots and deeper soil. We need to put the earthworm microbes back into the soil and link up again.



Overview of the intestine/gut of an earthworm containing Billions of Microbes. This is where the Bio-Prime® Vermicoat® microbial diversity come from. This is what true Soil biodiversity looks like.

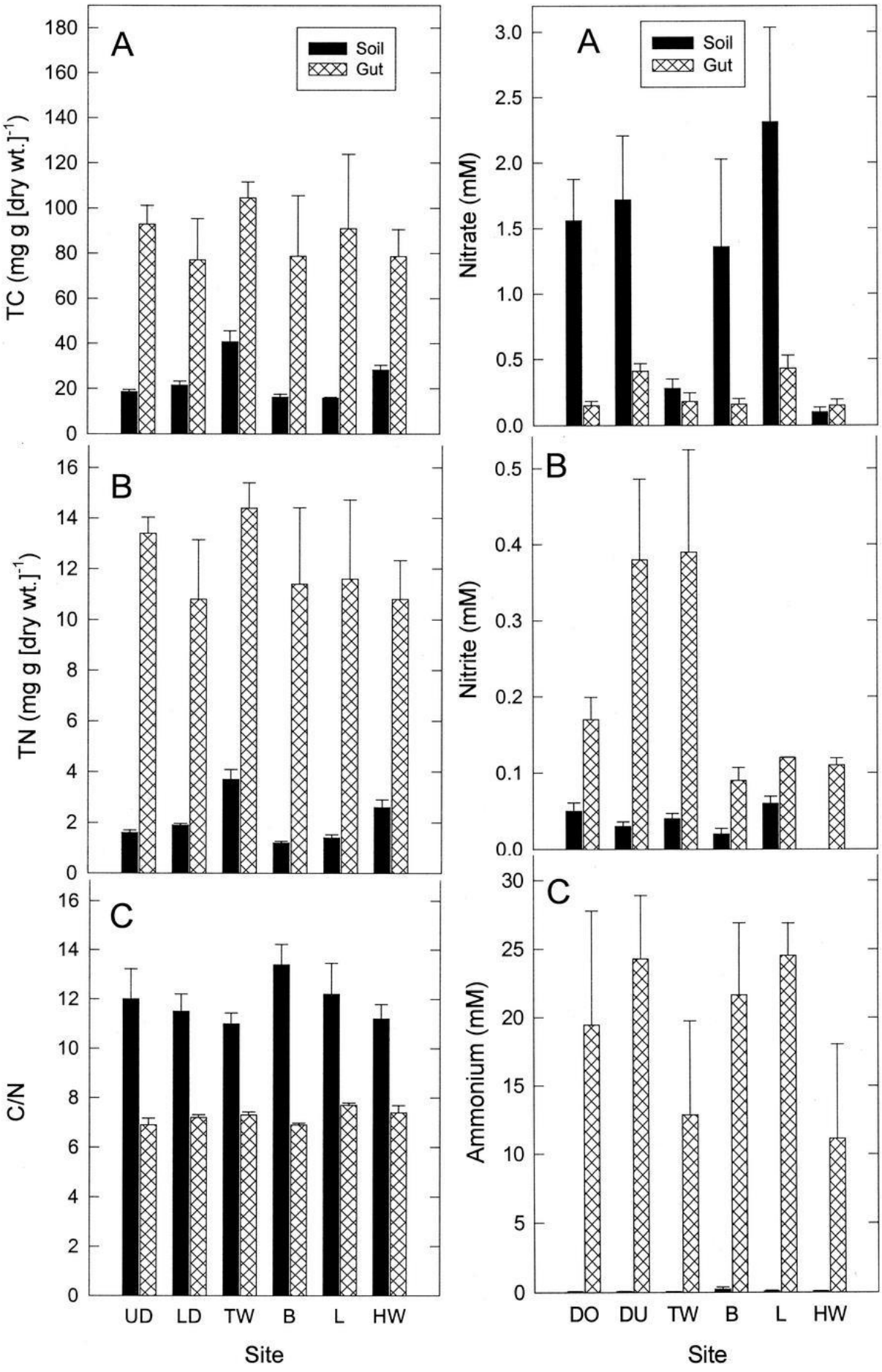
Characteristics			
Soil-benevolent Bacteria in ONE worm	Foregut	Midsection	Tail section
	475 million	32 900 million	474 billion
Available minerals in the soil after earthworm activity:			
Phosphorous	7 times more		
Nitrogen	6 times more		
Magnesium	3 times more		
Carbon	2 times more		
Calcium	1.5 times more		

What does this mean? It means that one of the greatest miracles of soil life is that what comes out the back end of an earthworm is typically 3-6 times more valuable and more fertile than what goes into the front end of the earthworm in a raw form. This is nature's way of high plant yields and diverse soil microbiology. These microbes are what needs to be placed on each seed with the Bio-prime® Vermicoat® process.



Earthworm Gut microbes enable Free living Nitrogen Fixing Microbes an extremely elevated level of performance as per https://pubmed.ncbi.nlm.nih.gov/12620857/ .

This is the essence of the magic that happens with seed inoculated with Bio-Prime® and covered with a Vermicoat®.

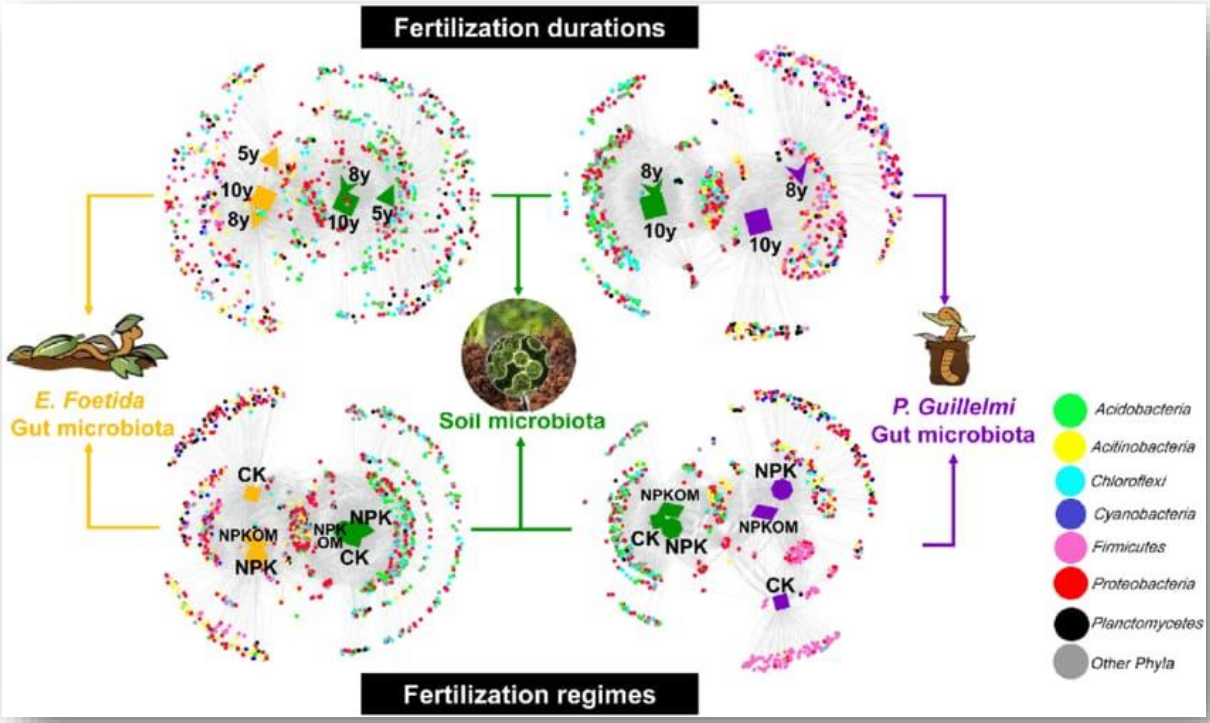

A
Soil
Gut
TC (mg g [dry wt.]$^{-1}$)
B
TN (mg g [dry wt.]$^{-1}$)
C
C/N
UD
LD
TW
B
L
HW
Site
A
Soil
Gut
Nitrate (mM)
B
Nitrite (mM)
C
Ammonium (mM)
DO
DU
TW
B
L
HW
Site

Total carbon contents (TC) (A), total nitrogen contents (TN) (B), and C-to-N ratios (C/N) (C) of soil (n = 5) and earthworm gut contents (n = 3 to 5).

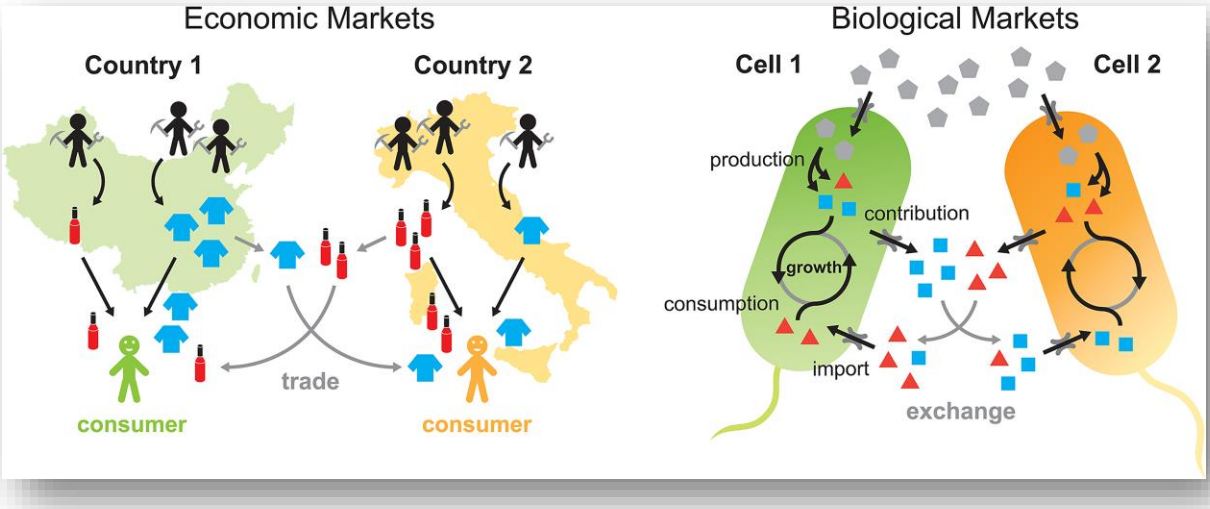
Nitrate contents (A), nitrite contents (B), and ammonium contents (C) of the aqueous phase of soil (n = 3) and earthworm gut contents (n = 3 or 4)

What happens when you combine Earthworm gut microbes with Free Living Nitrogen Fixing Microbes in a Bio-Prime® Vermicoat®?

I. You restore soil microbial diversity and use the plants roots to rapidly increase the soil microbial population back to a healthy diverse status and high microbial population.
II. You trigger a Biological Trading Network able to mine deep soil nutrients and average out nutrients to all plants that have a Bio-Prime® Vermicoat®.
III. You enable 700% further root reach.
IV. You enable 20-40% higher yields.
V. You have 20-40% increased plant hardiness.

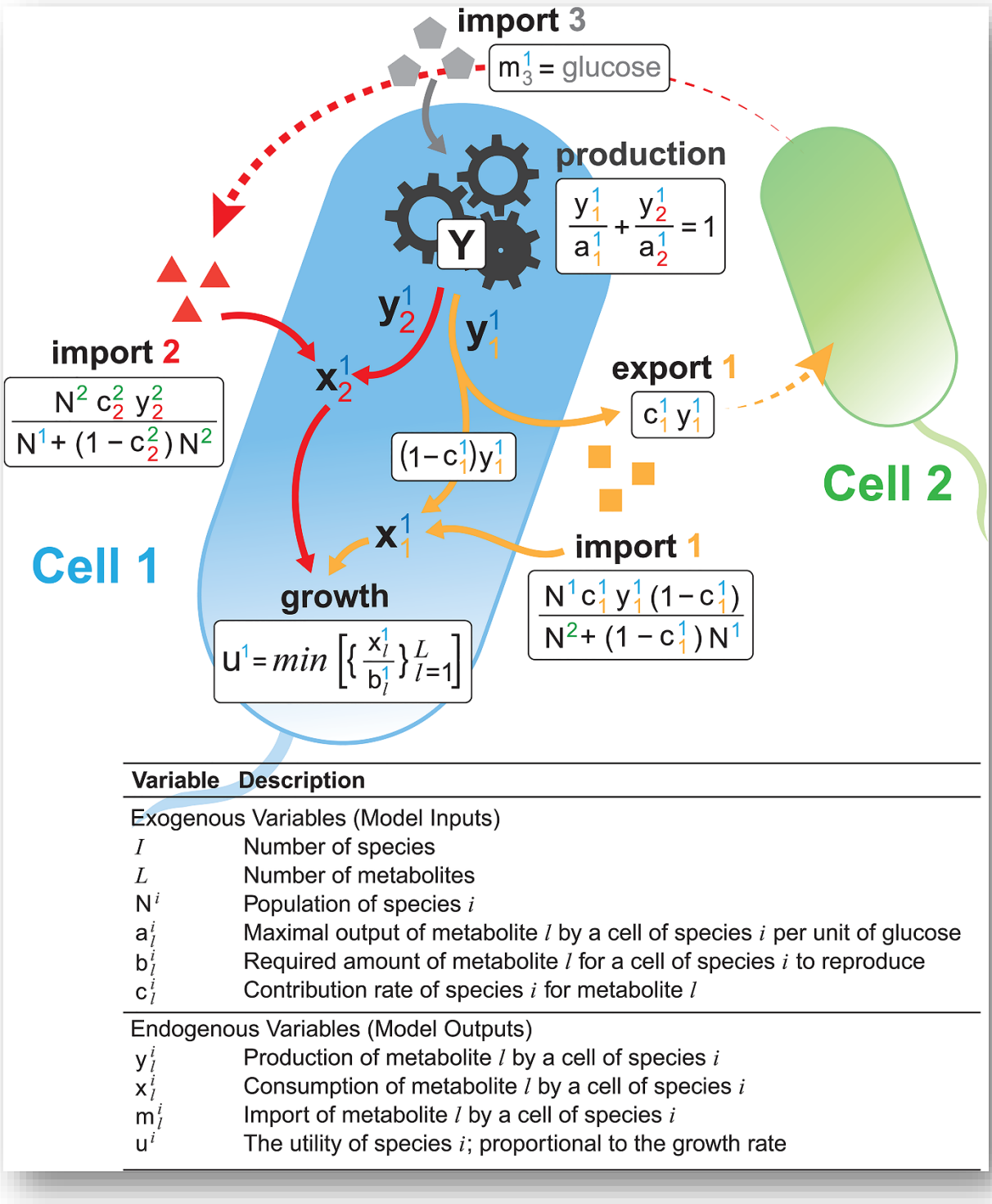


The type and duration of chemical fertilizer regimes changes the composition of agricultural soil microbial populations negatively in commercial agriculture. A Bio-Prime® Vermicoat® is a way to restore the microbial population diversity in order that the plant roots can once again have an unbroken link and biological trading network with all types of soil microbes, the effect of which is increased yield.



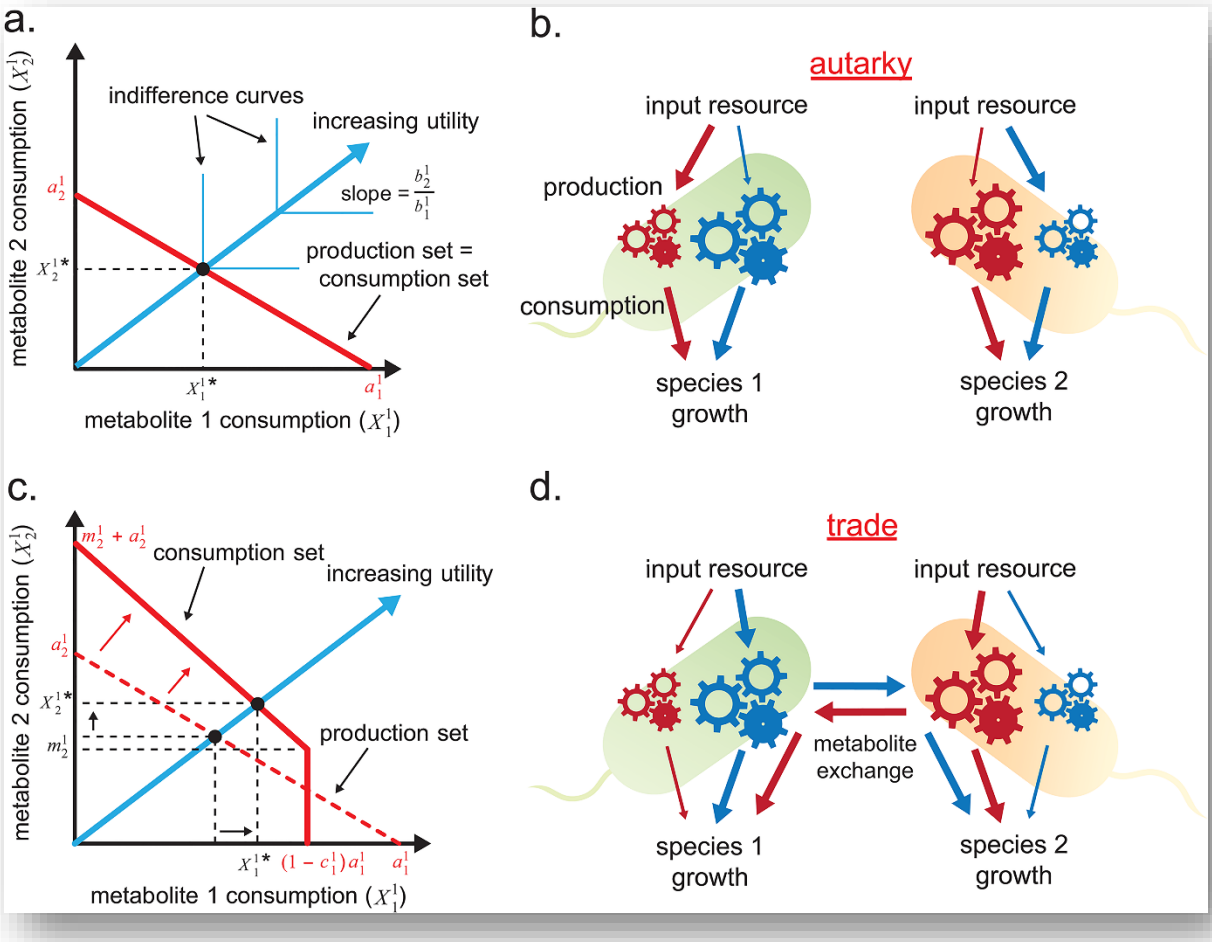
Once you have the full diversity of soil microbes restored, Biological Trading Networks spring up exchanging nutrients and metabolites leading to much greater specialisation and market scale efficiencies. This is what a Bio-Prime® Vermicoat® allows to happen on every seed, and then between every root and between every plant in the field.

Kindly see https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0132907

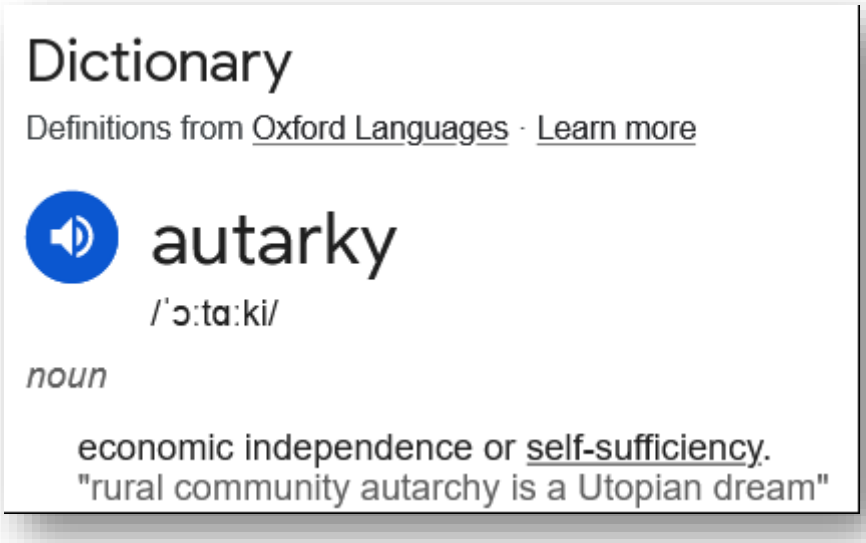


Variable	Description
Exogenous Variables (Model Inputs)	
I	Number of species
L	Number of metabolites
N^i	Population of species i
a_l^i	Maximal output of metabolite l by a cell of species i per unit of glucose
b_l^i	Required amount of metabolite l for a cell of species i to reproduce
c_l^i	Contribution rate of species i for metabolite l
Endogenous Variables (Model Outputs)	
y_l^i	Production of metabolite l by a cell of species i
x_l^i	Consumption of metabolite l by a cell of species i
m_l^i	Import of metabolite l by a cell of species i
u^i	The utility of species i; proportional to the growth rate

Biological Markets with full diverse soil microbes unlock a much higher level of soil activity and production potential with the amount of plant available nutrients rising rapidly.



With biological trade networks next level production kicks in triggering an additional 500kg to 1000kg of Canola/Soybean/Maize yield potential per ha year as some examples.



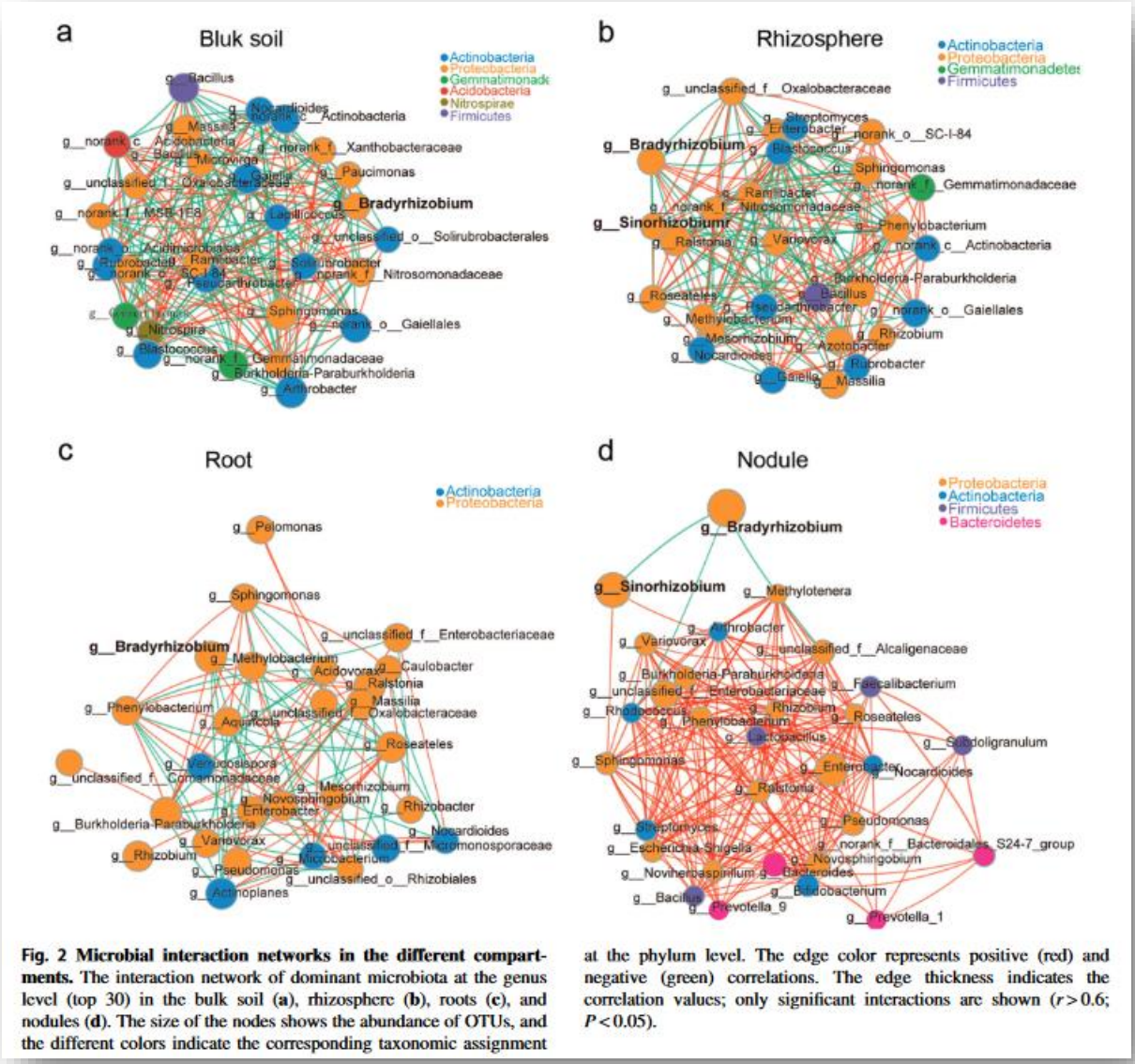


Fig. 2 Microbial interaction networks in the different compartments. The interaction network of dominant microbiota at the genus level (top 30) in the bulk soil (**a**), rhizosphere (**b**), roots (**c**), and nodules (**d**). The size of the nodes shows the abundance of OTUs, and the different colors indicate the corresponding taxonomic assignment at the phylum level. The edge color represents positive (red) and negative (green) correlations. The edge thickness indicates the correlation values; only significant interactions are shown ($r > 0.6$; $P < 0.05$).

In such a diverse Bio-Prime® Vermicoat® Biological Trading Network great leverage is possible when Free Living Nitrogen Fixing Bacteria attain critical mass and can trade with each other and with other plants, other Plant Growth Promoting Bacteria and with fungae.

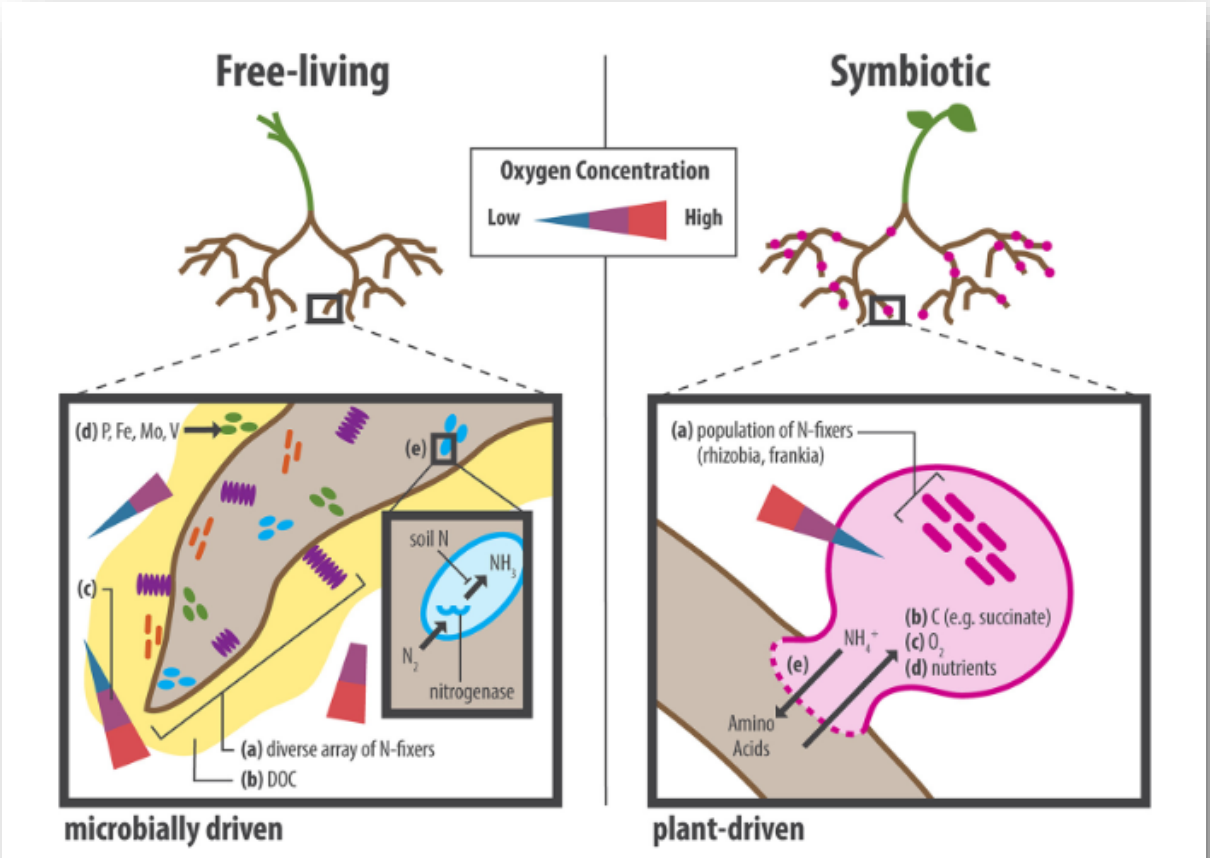


FIG 1 Contrasting habitats of free-living and symbiotic nitrogen fixation. (a) FLNF is carried out by a diverse array of N fixers living in a community, while symbiotic N fixation is performed only by a few bacteria (e.g., rhizobia and *Frankia*) living in a population. (b) FLNF is supported by dissolved organic carbon (DOC) in the soil, a variable and complex C source, while symbiotic N fixers receive a constant supply of simple C compounds (i.e., succinate) directly from the host plant. (c) Oxygen concentration in the rhizosphere is highly variable and driven by soil structure and texture and respiration by microbes and roots. Conversely, symbiotic N fixers are supplied oxygen at low concentrations by their host plant. (d) Nutrients necessary to support FLNF (e.g., P, Fe, Mo, and V) must be acquired by the diazotroph. However, these nutrients are delivered to symbiotic N fixers by the host plant. (e) Diazotrophs in the rhizosphere can access N from soil and FLNF, while all symbiotically fixed N is delivered to the plant.

Normal Rhizobium derived nitrogen is produced for a single plant only- and not released into the wider biological trade network as is the case with Free Living Nitrogen Fixing Bacteria. In the Vermicoat® process we enable the full potential of Free-living Nitrogen Fixing bacteria due to the earthworm class microbial diversity and full diverse range of soil microbes and fungae placed on each seed during the Bio-Prime® Vermicoat® process.

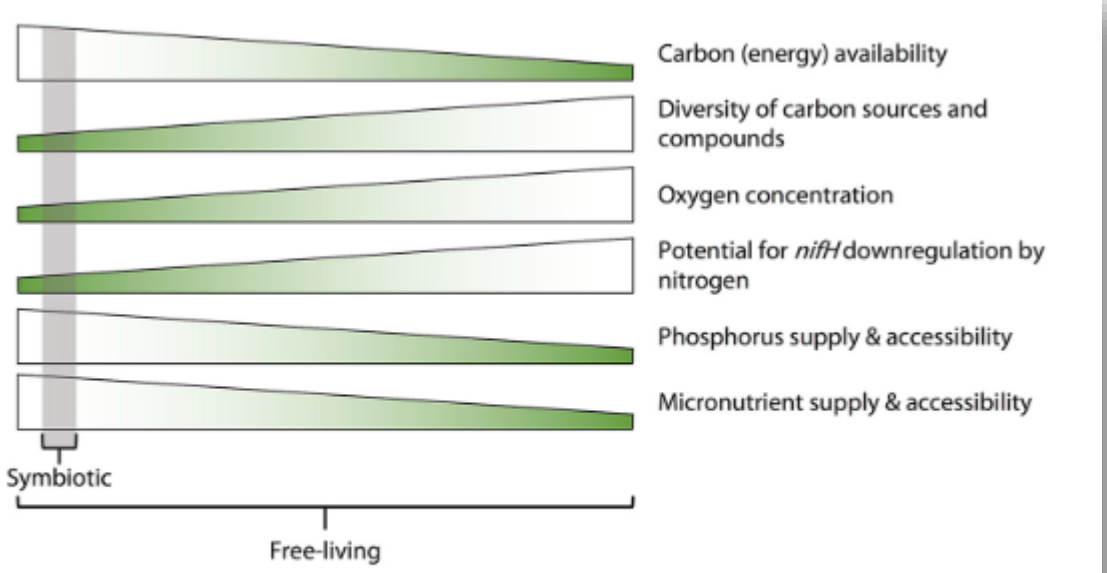


FIG 2 Environmental factors known to impact FLNF presented with triangles representing a theoretical range for each factor, low (narrow, dark-colored) to high (broad, light-colored). In contrast, symbiotic N fixation, represented by vertical hatched bar, only occurs in a narrow range of each of the environmental conditions. For example, FLNF can occur over a wide range of oxygen concentrations from low to high, while symbiotic N fixation occurs only at low oxygen concentrations.

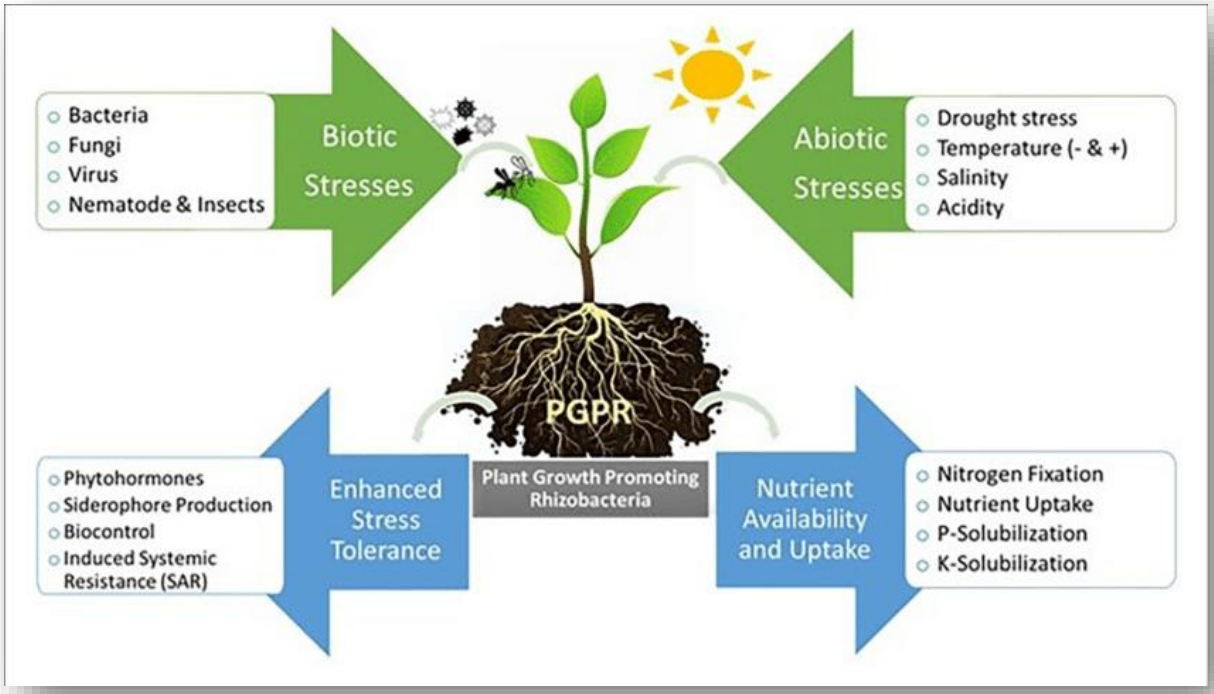
Free Living Nitrogen Fixing Bacteria are able to produce much more nitrogen, from many more sources, in a wider range of conditions than legume Rhizobium-and makes it available for a wider range of soil health actors such as the Bio-Prime® Vermicoat® Plant Growth Promoting Rhizobacteria and Plant Growth Promoting Fungi.

Plant Growth Promoting Rhizobacteria:

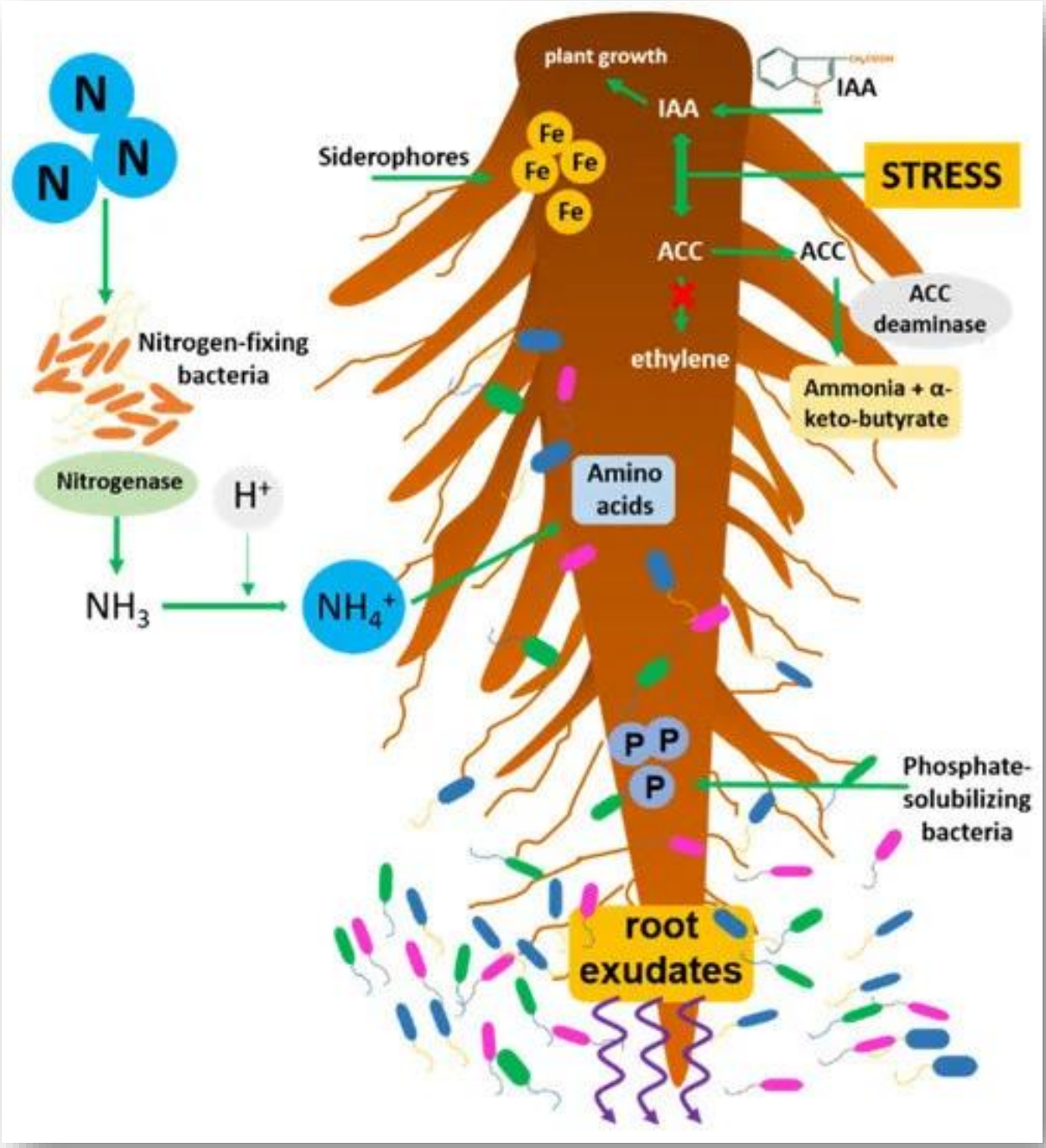
https://en.wikipedia.org/wiki/Rhizobacteria#Plant_growth-promoting_rhizobacteria

Plant growth-promoting rhizobacteria (PGPR) were first defined by Kloepper and Schroth to be soil bacteria that colonize the roots of plants following inoculation onto seed and that enhance plant growth.

The following are implicit in the colonization process: ability to survive inoculation onto seed, to multiply in the spermosphere (region surrounding the seed) in response to seed exudates, to attach to the root surface, and to colonize the developing root system.

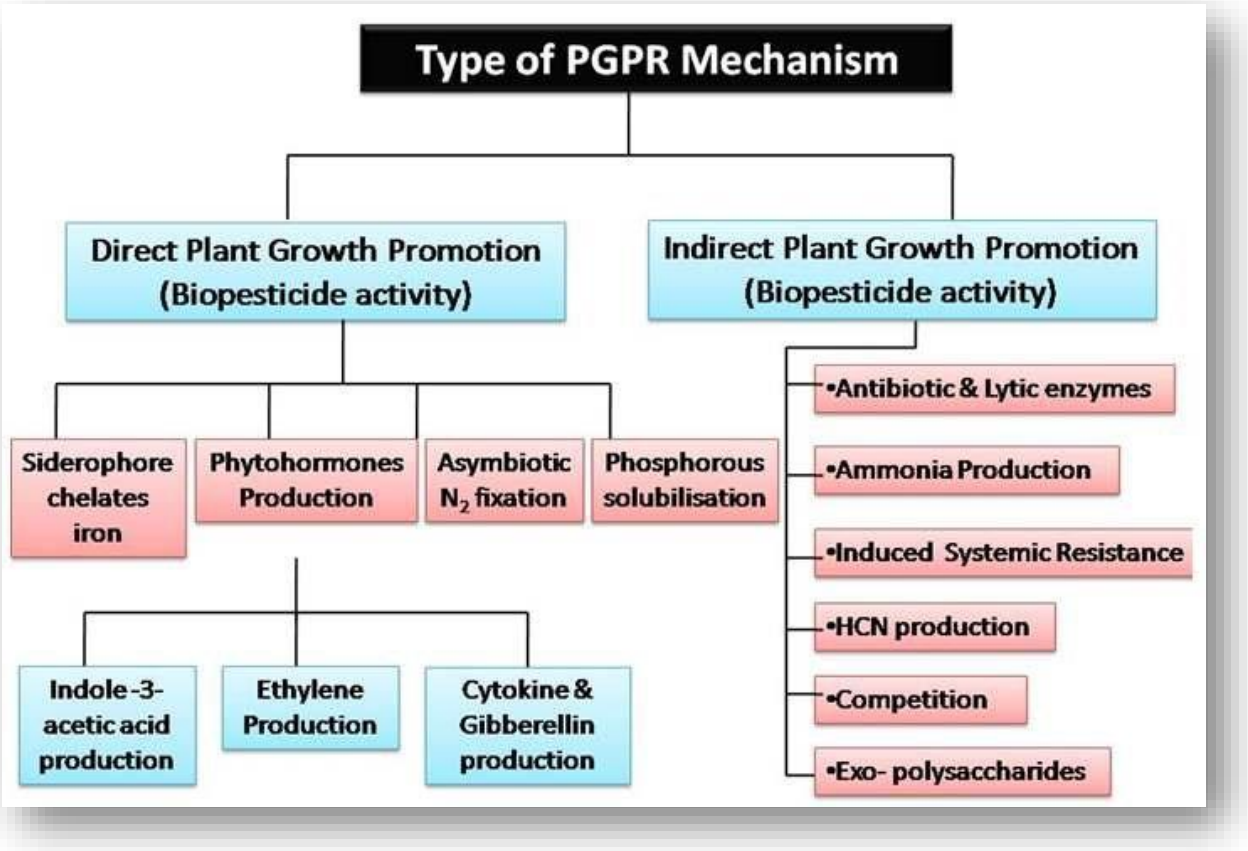


Plant Growth Promoting Rhizobacteria role and function.



Simplified scheme of the main activities of PGPR and their interactions with the root system; nitrogen-fixation, phosphate solubilization, iron uptake by siderophores, ACC deaminase activity lowering ethylene levels, IAA production stimulating plant cell growth.

For more info kindly see
https://microbewiki.kenyon.edu/index.php/Plant_Growth_Promoting_Bacteria



There is symbiosis between earthworm gut microbes and PGPR.

Biofertilizer:

https://en.wikipedia.org/wiki/Biofertilizer

A biofertilizer is a substance which contains living micro-organisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances. The micro-organisms in biofertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of biofertilizers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Biofertilizers can be expected to reduce the use of synthetic fertilizers and pesticides.

Priming of Seed:

Seed Priming:

"Seed priming is a controlled hydration technique in which seeds are soaked in water or low osmotic potential solution to a point where germination related metabolic activities begin in the seeds but radical emergence does not occur."

Bio-Priming:

Bio-Priming is a new technique of seed treatment that integrates biological (inoculation of seed with beneficial organism to protect seed) and physiological aspects (seed hydration) for disease control and yield increase. https://enviromicro-journals.onlinelibrary.wiley.com/doi/full/10.1111/1751-7915.14322

Seed Coating:

Seed coating is a technique in which an active ingredient (e.g. earthworm microbial inoculant containing Plant Growth Promoting Rhizobacteria) is applied to the surface of the seed. With a Vermicoat® earthworm microbes are placed on the seed using earthworm compost to form a thing habitat layer.

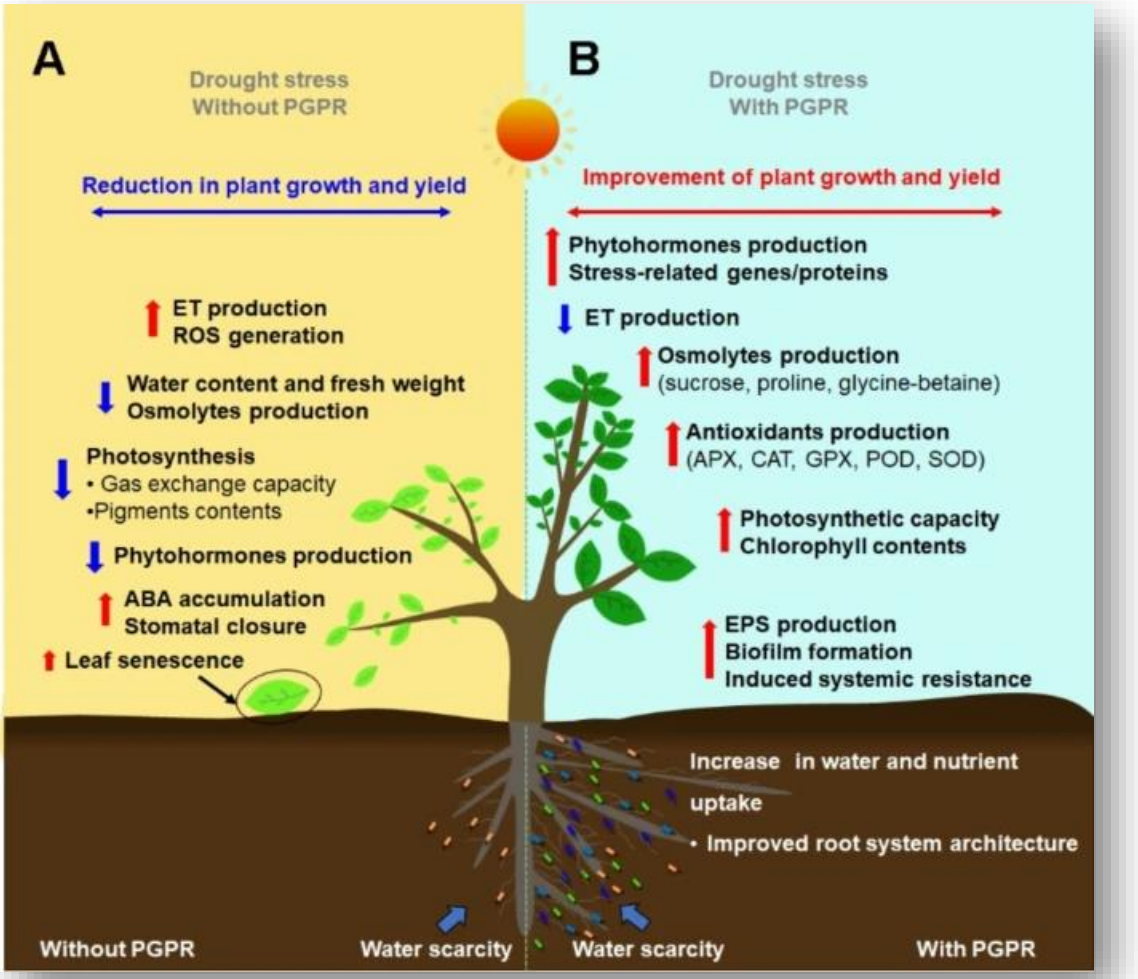
Vermicoat®:

A Vermicoat® is the establishment of a thin layer of living earthworm gut microbes and natural organic material unto the seed surface as a Biofertilizer that does not significantly change the size of the seed. Upon germination of the seed, a signal is provided by the plant roots to the applied earthworm microbes that this plant is home base; and that a microbial trading network should be set up trading Nitrogen, exchanging plant sugars and liquid carbon (produced from photosynthesis) for microbially mined soil nutrients, moisture, and metabolites.

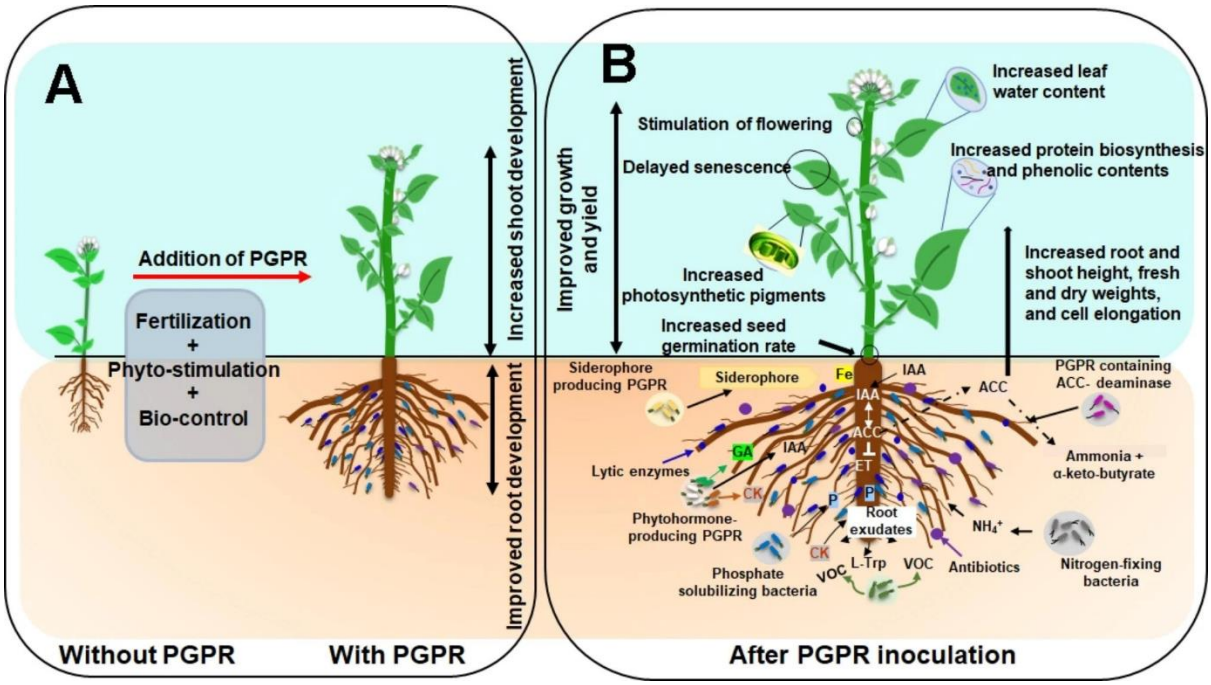
Vermicoating simulates all 3 types of earthworms having visited the seed prior to germination, and upon germination intimately integrates the plant roots into the soil biological trading networks, both horizontally and vertically. The larger plant root feeder networks extend the reach and trading capability of the root system dramatically, which result in increased growth and yield.

The role of plant growth promoting rhizobacteria in plant drought stress responses

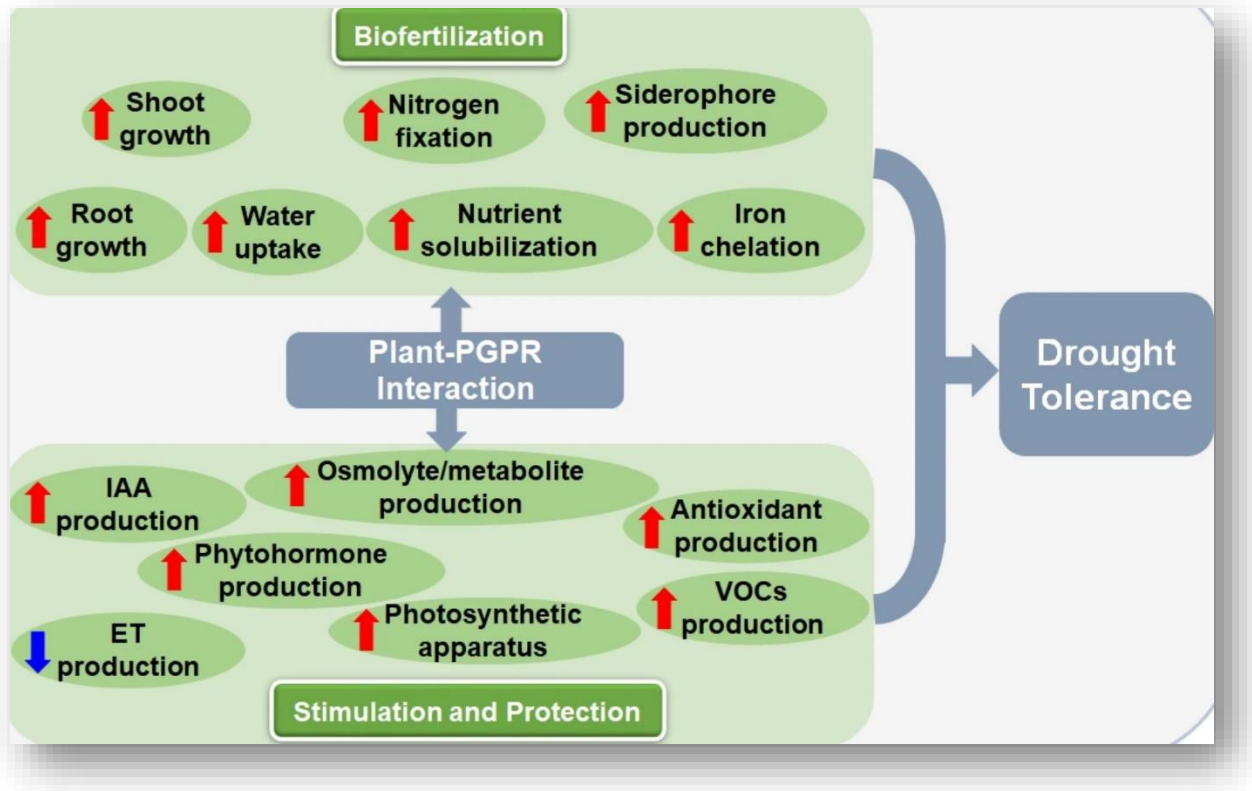
https://bmcplantbiol.biomedcentral.com/articles/10.1186/s12870-023-04403-8



The is what a Vermicoat® enables in adverse La Nina climatic conditions.



A schematic overview of the processes used by plant growth promoting rhizobacteria to alleviate drought stress and promote plant growth. A. Plant growth promoting rhizobacteria improve general traits of plant growth. Inoculation with PGPR increased the growth rate and general developmental of plants compared to the non-inoculated control (on the left). PGPR enhance root system architecture, root and shoot growth and weight, height, and early plant flowering. B. Functional processes used by plant growth promoting rhizobacteria to promote plant growth: PGPR colonization of plant roots enlarges root architecture and enhances, nutrient and water uptake, nitrogen fixation, phytohormone production, enzyme production, photosynthetic activity and other processes. PGPR: Plant Growth Promoting Rhizobacteria; ACC: 1- AminoCyclopropane-1-Carboxylate; CK; Cytokinin; ET: Ethylene; Fe; Iron; GA: gibberellic acid; IAA: indole-3-acetic acid; N: Nitrogen; NH3: ammonia; NH4+: ammonium; P: Phosphate; L-Trp: L-tryptophan; VOC: volatile organic compound



Thematic diagram showing mechanisms adopted by plant growth-promoting rhizobacteria to induce drought tolerance in plants. Plant growth-promoting rhizobacteria (PGPR) interact with host plants through several mechanisms to promote drought tolerance in the host. These mechanisms fall into two broad categories: biofertilization, and stimulation and protection. PGPR: Plant Growth Promoting Rhizobacteria; ET: Ethylene; IAA: indole-3-acetic acid; Vocs: volatile organic compounds

OASIS
ADVANCED AGRICULTURAL SCIENCE

Rand Value to a Depth of 15 cm per hectare

LAB#		03 000 7129	03 000 7130	03 000 7131
Reference		SPO1 A-Kontrole	SPO01 Erdwurm Proef	Fanus A
P	R/15 cm	R 56 201,13	R 96 680,11	R 105 854,7
K	R/15 cm	R 211 648,46	R 231 824,74	R 266 423,4
		R 267 849,59	**R 328 504,85**	**R 372 278,2**

AVAILABLE NPK

kg/ha to 10 cm

LAB#		AAA-000-0874	AAA-000-0875	AAA-000-0876
Reference		SPO1 A-Kontrole	SPO01 Erdwurm Proef	Fanus A
N	kg/ha	6948	7232	6365
P	kg/ha	134	228	134
K	kg/ha	211	403	394

Rand Value to a Depth of 10 cm per hectare

LAB#		AAA-000-0874	AAA-000-0875	AAA-000-087
Reference		SPO1 A-Kontrole	SPO01 Erdwurm Proef	Fanus A
N	R/10 cm	R 125 056,51	R 130 175,57	R 114 561,0
P	R/10 cm	R 7 303,00	R 12 426,00	R 7 303,0
K	R/10 cm	R 9 410,60	R 17 973,80	R 17 572,4
		R 141 770,11	**R 160 575,37**	**R 139 436,4**

Rand Value to a Depth of 15 cm per hectare

LAB#		AAA-000-0874	AAA-000-0875	AAA-000-087
Reference		SPO1 A-Kontrole	SPO01 Erdwurm Proef	Fanus A
N	R/15 cm	R 187 584,76	R 195 263,36	R 171 841,6
P	R/15 cm	R 10 954,50	R 18 639,00	R 10 954,5
K	R/15 cm	R 14 115,90	R 26 960,70	R 26 358,6
		R 212 655,16	**R 240 863,06**	**R 209 154,7**

Rand Value to a Depth of 15 cm per hectare

LAB#		AAA-000-0874	AAA-000-0875	AAA-000-087
Reference		SPO1 A-Kontrole	SPO01 Erdwurm Proef	Fanus A
P	R/15 cm	R 10 954,50	R 18 639,00	R 10 954,5
K	R/15 cm	R 14 115,90	R 26 960,70	R 26 358,6
		R 25 070,40	**R 45 599,70**	**R 37 313,1**

% Available and Unavailable P & K

		SPO1 A-Kontrole	SPO01 Erdwurm Proef	Fanus A
% Available	P	19,5	19,3	10,3
	K	6,7	11,6	9,9

Now when you look at a Soil Analysis of our Vermicoat® earthworm and microbe trial you understand why after 30 days the value of the available nutrients were so much more. If you study this value chain, logic chain and ecotechnology and trial it, you will be able to leverage the higher nutrient availability into higher yield. It is Soil science.

Section 3:

Herbicide application issues-practical experience:

1) A Vermicoat® performs best with the minimum of herbicides.
2) After germination your plants roots will be covered with a thin film of living microbes protecting it against disease and pathogens.
3) If you must use Round-up of any other herbicide, a pre-emergence application is better than post-emergence when the plant is already living, and its roots covered by microbes.
4) When herbicide is applied to a growing plant, some of the chemicals are absorbed through the leaves and exuded by the roots, killing about 50% of the root microbes and wiping out most living microbes of certain specific classes. To get those microbes back you will need to buy 10 times more volume of microbes and spray it after the herbicide application. It would be more elegant to use mechanical weed control where possible or to plant your rows closer to form a canopy and starve the weeds of sunlight, rather than use Glyphosate and other chemical herbicides.
5) You need to balance the nutrient use efficiency of living microorganisms giving you an additional 500to 1000 kg of yield ha yr. with the potential benefit of a single herbicide application killing 50% of the microbial diversity once again and halving your yield gain potential.
6) You need to realise that having the living root microbes increases your plants root system reach by up to 700%, and it is very unlikely that the weeds will steal as much water as you will lose by halving your biological root trading network. Is the moisture the weeds use worth losing 50% of the microbial nutrient gain? That is the question.
7) We can supply additional living microbes to be applied with a normal tractor spray or via irrigation, but you need to seriously think about it.
8) If you just do a pre-emergence herbicide and do a Bio-Prime® Vermicoat® two years in a row, the yield potential increases naturally due to legacy microbial populations performing in the off season and in year 2. You basically use the natural increase of the microbial population due to living on a large healthy root system as your method of microbial multiplication. Minimize your herbicide use as much as possible and maximise your microbial biodiversity as much as possible.
9) Sometimes it is better to speak to us and let us look at the level of weed challenge and make a call with you, and look at plan B and C.
10) Minimise your chemical fertilizer user as much as possible as well as your herbicide use and rather focus on a larger root network finding nutrients you already have in the soil, as well as in the deeper soil profile moisture. If you have the larger root system, you don't need to worry so much about weeds stealing a bit of moisture in the shallow topsoil, because you have access to the full soil profile and all its microbial helpers. It is

a different perspective. Make the nutrients in your soil plant available and make up for the moisture the weeds use by using deep soil profile moisture biologically.

Kindly see our Facebook page: https://www.facebook.com/profile.php?id=61557456995326

Kindly see our www.bioprime.co.za page

Downloads for further study:

1. *Connecting Bio-Priming Approach with Integrated Nutrient Management for Improved Nutrient Use Efficiency in Crop Species https://www.mdpi.com/2077-0472/11/4/372*
2. *Improving Crop Yield and Nutrient Use Efficiency via Biofertilization—A Global Meta-analysis https://www.frontiersin.org/journals/plantscience/articles/10.3389/fpls.2017.02204/full*
3. The effect of Earthworms on Plant Growth – https://www.nature.com/articles/srep06365

Contact us:

Justice 0722534773

Riaan 082 3018934

www.vermicoat.com

info@vermicoat.com

We ship countrywide via Postnet or PEP.

Bio-Prime®
www.bioprime.co.za