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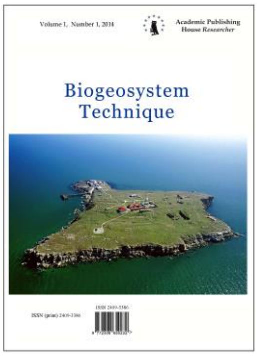

How Healthy are Our Vegetables? Contours of a New Fertilizing Paradigm. Minerals and non Protein Nitrogen in Vegetables, Grown Organically and Respectively Conventionally. A Quality Assessment (Review)

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Abstract

The last hundred and fifty years food and fodder scientists did a lot of – mostly forgotten – balance studies. As a general rule we can say that the ratios of potassium, calcium, sodium, phosphor and magnesium should not be too wide. The more one of these elements dominates in food and fodder the higher the health risks. The health authorities see only the risks of too much sodium. They negate the risks of too much potassium in vegetables and too much calcium and (added) phosphate in a.o. dairy products and meat. For the correct regulation of many processes in our bodies we need much more magnesium. A further complication is that we assimilate too much ammonium and nitrate through our food, and too little trace elements.

This situation is partly brought about by the way we fertilize our crops. Most farmers – conventional and organic – have learnt that plants need in the first place nitrogen, potassium and phosphor. And some extra calcium for a good pH. Corrections for other elements are only necessary if the plants give visible signs of shortages. Part of the fertilizing theory is that organic nitrogen from plant residuals or animal dung must 'mineralize' into ammonium and nitrate before plants can take up the nitrogen. Also the other elements must be anions and cations before the plants can take them up.There is little attention for the role of the symbiontic microbes in the rhizosphere and at the other parts of the plants. And the risks of nitrate and ammonium for plant health and human health are taken as part of the game.

This view on plant feeding is a mechanistic one, dominated by chemistry and physics. Biology is missing. Although this paradigm is still the dominant one, we see the contours of a new paradigm, in which the plants and their symbionts regulate their own feeding, their own growth. With the help of their symbionts around their roots and on their leaves and stems the plants take up from the soil or the air what they need: organic nitrogen; organic sulphur, and metals and non metals connected with carbon – not inorganic ions. The symbionts in the cells help to built up or break down complex organic compounds. All enzymatic reactions are performed by living entities in and around the cells. And we know: without (trace) elements no enzymatic reactions. Magnesium is responsible for at least 600 enzymatic reactions. Zinc for 400.

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If we look at the conventional and organic products we see that the balance is lacking, and the amount of nitrate and ammonium is high. Only the products which are fertilized with a.o. sea minerals (Normandy, 1869) are better in balance than the products today. The data on ammonium and nitrate in this period are not available. Even today we normally don't measure ammonium and nitrate in our food. And only a few trace elements…

Keywords: plants, fertilizing, vegetables, food, organic paradigm.

1. Introduction

Human beings and animals become sick when their food is not in balance. But they don't become sick and die in one or two weeks. It takes sometimes years to become sick from food which is not in balance. But the proces of getting ill accelerates if our food is more out of balance. If, for instance, potassium would be completely lacking in someone's food, he or she would problably die within weeks. Especially if we get much too little magnesium our health is at risk. Magnesium is a key element for our health, and very low in most foods. In order to understand why many organic products and even much more the conventional products are not in balance and have such a high amount of nitrate and ammonium (non protein nitrogen or NPN*) I give a characterisation of the two fertilizing systems which we have today in many parts of the World. And I finish this part with an overview of the building blocks for a new fertilization paradigm.

2. Quality criteria

I will start with the quality criteria which I have found during the last ten years.

These criteria result to a great extend from the findings of colleagues (Table 1).

Table 1. Quality criteria for food

Ratios in the combined daily food and fodder	optima	Regulation of:
Potassium/Sodium	2–5 (max 7)	Acid base balance; water retention; blood pressure (with the help of magnesium) (Bunge, 1874).
Potassium/magnesium	2–5 (max 7)	Uptake of magnesium; Electrolyte balance; citric acid cycle; energy production; protein,carbohydrate and fat metabolism; impulse conduction;
Calcium/Magnesium	1–2	Uptake of calcium; regulation of calcium metabolism; bone health; (de)calcification of the weak tissues; electrolyte balance; health of the hearth, and of cells (cancer);
Calcium/Phosphor	1–2	Rickets; bone health; (de)calcification of bones and weak tissues; Stone formation; fertility; kidney disturbances;
Mg/(K+Na+Ca+P)	0.15–0.25 min 0.10	Magnesium is necessary for electrolyte balance; energy production; impulse conduction; protein,carbohydrate and fat metabolism; for K/Na balance; Ca/Mg balance; Ca/P balance; breakdown of proteins, carbohydrate and fats; prevention of stone formation; health of vital organs (brains; hearth; liver; kidney; pancreas; stomach); the immune system; prevention of depression; aggression regulation; prevention of cancer; removal of heavy metals and fluorine; 600 enzymes are magnesium dependent;
K/(Ca+Mg) in mEq	< 2–2.2	This measure is developed to see if cows are at risc of grass tetany. Tetany is a neurological disorder and has many traits in common with for example epilepsy in humans.

* In fact NPN is more than ammonium and nitrate, but the other NPN compounds – amides, amines, and others – are never measured.

nitrate	< 2.1–3.5 g/kg ds	McCreery et al., 1966 'the 0.21 % to 0.35 % [is the] lower limit for toxicity to ruminants'. High levels of nitrate plus potassium cause the nitrate potassium syndrome (Swerczek, 2002, 2007).
sulphur	< 2–3 g/kg ds	(Olson Rutz, 2014; Crawford, 2012) Many diseases are caused by too high levels of sulphur, for instance strokes (Kobayashi, 1957).

3. The conventional fertilization paradigm

In conventional farming there are different approaches. And the differences between some of them are big. For instance the work of Albrecht and his followers is a reaction against the potassium dominance among the cations when it comes to fertilizing (Albrecht, 1938). Albrecht developed a theory about a necessary balance between the cations at the clay complex. Today Nutri-tech solutions which have its base in Australia have worked out this theory and are selling lots of products in order to rebalance the soils. These products are used to reach nutrient rich crops with a high brix index. Their focus is on soil balance. Not on crop balance (Nutri-tech solutions, 2019).

In this paper I focus myself on the classic NPK paradigm as it is learnt in many agricultural universities, high schools and secondary schools (Mengel, 1978; Rinsema, 1981).

The dominant conventional NPK paradigm for fertilizing is built on the following assumptions:

- The plant roots take their mineral nutrients and nitrogen from the soil. But in the 19th century many leading agricultural scientists were of the opinion that plants in nature take their nitrogen from the air. But in agriculture extra ammonium is necessary via the soil according to Lawes and Gilbert. Lawes and Gilbert had a heated debate on this issue with von Liebig (Lawes and Gilbert, 1856). Schanderl solved the problem in 1947. He has proven that, like the leguminous plants, also non leguminous plants need a certain amount of nitrogen from the soil to build up themselves, before they are able to take nitrogen from the air. Some non leguminous plants get even more nitrogen from the air than leguminous plants (Schanderl, 1947);
- In the soil moisture the minerals and inorganic nitrogen compounds are split in ions, and the plants take up these ions from the soil moisture;
- Clay particles and humus give new ions into the soil moisture if the soil water is emptied by the plant roots;
- Most plants thrive well in a soil with a pH between 5.5 and 6.5. When the soil becomes too acid the farmer has to give (lots of) calcium carbonate;
- The plants are able to take up the needed ions selectively from the soil moisture;
- The plants take up the necessary carbonic acid and oxygen from the air. In the ninetheenth century some agricultural scientists, among whom Baron Liebig, still were of the opinion that the plants took all their nitrogen also from the air (Lawes and Gilbert, 1856).
- Already in the same period Lawes and Gilbert concluded also that only roughly 40 percent of the given nitrogen was recovered in the crops. And the remainder was not found back the next year in the soil (Lawes, Gilbert, 1856: 484, 485). See annex 3.
- If one or more elements are not available in the soil moisture the plants can't thrive well. By adding the missing elements the problem is solved.
- And there are some exceptions on these rules: a too high level of potassium hinders the uptake of calcium, sodium and magnesium; high levels of potassium and nitrogen hinder the uptake of silicium; high levels of nitrogen results in watery plants and less vitamin C; high levels of calcium and phosphor hinders the uptake of magnesium (Farmer Verschoor J.: *"After 40 years of fertilization with broiler dung the soil was full of calcium and phosphor. The magnesium uptake was blocked",* verbal communication).
- In fact there are many more exceptions and with the help of Mulder (Mulder, 2019) a farmer can find out which elements block or hinder other elements, and which elements support

the uptake of other elements (see annex 1). But … with the help of Mulder's Chart farming becomes a rather complicated question;

- Compacted soils have to be opened or broken with all kinds of machinery;
- Sodium is not really an important plant food; and silicium is also neglected. But today there is a really very interesting debate going on regarding sodium (Kronzucker, 2013). And Epstein has recently done research regarding the role of silicium in plants and he demonstrated its defensive role in biotic and abiotic stress (Epstein, 2009);
- Plants become sick because insects, nematodes, and micro-organisms attack them. In this view farming is like a poker game: sometimes you are Lucky, sometimes not;
- Fertilizing too much is not really an issue. The fertilizer industries push farmers to use hughe amounts of potassium, nitrogen and phosphor far beyond the necessary levels;
- The soil itself is not a source of fertility for the crops, but only a place to stay afoot, and a storeroom for nutrients from outside. The scientists who have shown that many important nutrients are available as minerals – true minerals – are ignored (Kahn, 2013; van Baren, 1934);
- Today the new focus is on the genes. The idea is that the genes are a pool of fairly constant characteristics. And today the way plant and animal breeders change the gene pools is by genetic modification. Most plant and animal breeders are not interested in epigenetic factors which influence the working of the genes. Plant and animal genes are in their view a kind of building bucket. The role of the scientists is to remove bad building blocks for good building blocks. The question why some building blocks become 'bad' is for these people not a research item. Their view on genetics is also a static view. Weak plants have to be made strong by an outside force – human beings who think their work is rocket science (Green breeding program, 2019).

In fact this paradigm is **a paradigm of chemistry and physics as the basis of plant nutrition**. **Not biology**. Plants have to grow on dead inorganic materials, and their natural enemies have to be killed with pesticides, also dead material, in order to protect the crops from being destroyed. The germ theory of Pasteur is at its basis (Pasteur, 1878). The germs come from outside, so a farmer has to prevent their arrival. Béchamp who focussed on the environment, was his opponent. See Douglas Hume (1932). Kate Raines gives in 2018 a very clear overview of the controverse (Raines, 2018).

The classic NPK paradigm is rooted in the mainstream of western science. In this view all natural phenomenons are mechanical phenomenons, as in the philosophy of de Lamettrie (Lamettrie, 2007). And if the machinery is malfunctioning, it is the superior intelligence of the scientist which is needed to correct the errors. Liebig was an exponent of this type of thinking.

4. The dominant organic fertilization paradigm

Although there are many differences between different organic farmers and their organisations, and between scientists who do research in the field of organic farming, here I focus myself on what I call **the dominant organic fertilization paradigm**. The differences between the dominant organic fertilization paradigm and the Bio-dynamic agriculture (Pfeiffer, 2011; Steiner 1924), or the "organisch biologischen Landwirtschap" of Rusch and Müller in Switserland and Austria (Rusch, 1968), the approach of Fukuoka in Japan (Fukuoka, 1978) or No Tillage in Germany (Zikeli, 2017), the work of Lutzenberger and Primavesi in Brasil (with today a strong focus on agro-ecology and agroforestry) (Lutzenberger, 1995; 1998), and the new developments in India (vermicomposts, Sinha, 2009; Chaudhuri, 2016) are **not** my focus in this paragraph. I focus on the dominant organic paradigm.

The dominant organic paradigm has some extra rules and new insights above those of the conventional agriculture:

- Soil life is indispensable for healthy plants. They create an open structure which is necessary for a good exchange of gases;
- Mycorrhiza's help the plants to get more phosphor;
- Enough organic matter is necessary for keeping enough water in the topsoil;
- In order to make a good fertilizer from farm yard manure and plant residuals you have to built piles which become warm enough, in order to kill the weed seeds and the pathogens; these heaps must be heated till 60–65 °C. Then you have to open them and mix them in order to cool down the heap and the proces starts again. Some schools repeat this opening and mixing more

often than others (for example: the CMC* method (Diver, 2004). Many organic farmers don't compost their farm yard manure at all.

- And the slurry from the basements is also spread without any treatment in many organic dairy farms in the Netherlands (but not in Biodynamic organic agriculture). In the Netherlands the injection of the slurry in the soils is legally required.

- Most 'organic' scientists still think that plants feed themselves with inorganic elements from the soil moisture, like their conventional colleagues. Complex nitrogen compounds must be broken down into nitrate or ammonia before the plants can take them up: mineralisation. The same for the other elements. Just like their conventional colleagues they think that plants can't take up more complex organic compounds. Most of these 'organic scientists' are still addicted to NPK, and the mineralisation theory.

- And today in the Netherlands 'organic' scientists also focus on genetic engineering to get stronger crops with better characteristics. Genetic engineering in the classic way, with modern means (Lammerts van Bueren, verbal communication).

Many organic and conventional farmers are experimenting with new methods:

- They add rock flour or lava flour;
- They spread seaminerals with or without NaCl;
- They ferment their farm yard manure and/or plant residuals;
- They use effective micro-organisms;
- They use (vermi)compost teas;
- They use worms in order to open solid soils;
- They use mixtures of 15–20 green manures for soil recovery;
- Some fertilize their crops with dead grasses, clover or other plant materials on top of the soil;
- Some don't plough their fields;
- Some keep their fields under a permanent green cover;
- Some farmers experiment with different sowing systems: e.g. 10 – 15 kg of wheat seeds pro hectare. All the wheat plants get ample room (Steendijk – verbal communication; Stoop, 2017);
- Some make composts between 15–35 °C;
- Some grow crops in hydrophonics on algae.

The dominant organic agriculture is still a mixture of the inorganic conventional building blocks and some organic elements. Many spokesman – sir Howard (Howard, 1943); lady Balfour (Balfour, 1977) and J.R. Rodale (Rodale, 1978) thought that this was enough for a new paradigm. And as a consequence they thought this approach was good enough to grow healthy plants, and with these healthy plants to get healthy animals and healthy men. Which is not always the case.

Although, it is a fantastic improvement that this organic agriculture doesn't use synthetic pesticides, and almost no artificial tertilizers (Patent kali is still permitted and used).

In the Netherlands we see that scientists in organic agriculture today think that it is impossible to get crops with a natural resistance which are strong enough to stay healthy. This primary presumption (Howard, 1943; Balfour, 1977; Rodale, 1978) is abandoned. And they use tricks to solve the problems of lack of natural resistance: e.g. genetic improvements. They use new genes from wild varieties in order to restore the natural resistance of the (weakened) plants. For instance: potatoes. Or they select lupine varieties which can grow on soils which are rich in calcium. Lupines can't grow on clay soils rich in lime, they think (Green breeding program, 2019).

5. A new emerging fertilization pardigm

In my view we are entering a third stage in agriculture. And in fact – a new stage in organic agriculture. We can say a true 'organic' organic agriculture. Let me explain this by means of some examples of the new building blocks which we need for this new paradigm. Building blocks which were developed sometimes more than 100 to 160 years ago. Sometimes by farmers, sometimes by scientist or by consultants and concerned citizens. And, very interesting, sometimes by medical doctors:

* CMC means controlled microbial composting and is delevoped in Austria by Luebke.

- Virtanen and Schreiner found out that plants can take up organic nitrogen e.g. amino acids. And according to Schreiner amino acids are possibly a better plant food than inorganic nitrogen (Virtanen, Linkola, 1946; Schreiner, 1912);
- Schreiner detected also many poisonous compounds from plant residuals if the topsoil didn't have enough oxygen during the breakdown of organic residuals (Schreiner, 1913). Many of these compounds retard the growth of young plants. Krasil'nikov came to the same conclusion but didn't analyse which growth inhibiting compounds were formed (Krasil'nikov, 1958);
- Krasil'nikov cited many scientists who found out that plants can take up organic metallic compounds;
- According to Khan and Mulvany most soils contain enough potassium for thousands of years (Khan, 2013). Potassium chloride is in their view a very risky fertilizer. Van Baren concluded already in 1934 that in the Netherlands many soils had enough potassium from true minerals for good yields. On these soils there was in his view no need to give extra potassium. Potassium salts weaken the cereals by blocking the uptake of silicium (Van Baren, 1934).
- Stoklasa and Schanderl and many others have proven that also non leguminous plants, like buckwheat, potatoes and wheat, can take nitrogen from the air, like George Ville and many others in the 19th century had found out already (Schanderl, 1947; Roschach, 1960; Ville, 1854). But these crops need more start nitrogen from the soil than the leguminous plants;
- Mycorrhiza brings the plants organic nitrogen compounds as wel as other nutrients (Hood, 1993);
- Many clayish soils contain enough phosphor (from apatite) for years for most crops, especially if all the residuals are brought back carefully. For sandy soils the return of the phosphor in the sewage sludge, the plant residuals, the bones and the farm yard manure is still unmissable. For most crops a closed cycle for most of the macro elements is sufficient for ever lasting harvests. Sodium and trace elements is another question. According to the findings of Bowen sodium is one of the first cations which rinses out from the soils (the Bowens reaction series, 2019). Okay, this is the physical approach. But when the earth worms can do their work the picture changes dramatically. Sir Howard (1947) calculated that earth worms deposit 25 tons of castings per acre, and the castings contain 5 times more nitrogen, and 7 times more phosphor than the 6 inch top layer (see annex 2). With vermicomposts (some?) soils can be converted from a loamy sand soil into a sandy clay soil within two years. The underlying process is unknown (Chaudhuri, 2016). But if the amounts of castings earth worms can bring up into the top layer are correct, then we can understand that sandy soils can change into more clayish soils.The worms can bring the clay from down under or they make the clay by grinding the sand and loam. And also that there is possibly enough nitrogen and phosphor from 'somewhere' if the earthworms can do their work. The best food for earth worms is provided by litter layer worms like eisenia fetida; eisenia andrei or eudrillus euginius (Chaudhuri, 2016);
- Hanspeter Rusch developed the theory that bacteria can fall apart in smaller living entities which play a crucial role in maintaining the vitality of plants and other higher organisms (Rusch, 1968). The observations of G. Enderlein (Enderlein, 1925; Krämer, 2012) and Naessens (Bird, 1991) support this theory.

Problaby Rusch founded these ideas on the work of Antoine Béchamp, the french opponent of Pasteur. But Rusch (1968) never mentions his work.

- And more recently Thomas Pradeu has proven the existence of small living entities in the cells of higher organisms which in his view are essential for the vitality of the higher organisms (Pradeu, 2016). Already between 1850–1908 A. Béchamp developed the theory that small microzymas live in the cells of higher organisms and produce enzymas (Béchamp, 1912). According to Béchamp these microzymas in the cells of higher organisms become first vibrions and then bacteria when the symbiosis between these microzymas and their host, the cells of the higher organisms, is disturbed. For instance by changing circumstances.
- Sinha has proven that vermicompost made from a good wormfeeding – for instance cow dung – gives a better compost than warm composts or untreated farm yard manure (Sinha, 2009). Farm yard manure and warm compost loose a lot of nitrogen, phosphor, potassium and carbon during heating. The same happens in slurry basements. When anaerobic rotting bacteria dominate the slurry there are big losses of ammonia; fosfine (PH_3) ; hydrogen sulfide; hydrogen chloride; methane and cyanide (Vanhoof P., verbal communication). Hans Peter Rusch came to

the same conclusion: warm composts and 'classic' farm yard manure are inferior compared to fertilizing the fields with fresh manures and plant residuals on the surface of the soils. Higher organisms in the topsoil, including worms, break down these materials with the help of bacteria and fungi. These bacteria and fungi themselves are eaten by other bacteria and fungi. In the end the bacteria and fungi fall apart and their residuals, including the microzymas, are the new organic plant foods (Rusch, 1968). In a living soil these foods are stored in/on humic and fulvic acids (and problably many other humic substances), combined with clay particles;

- In doing so Rusch and his farmers found out that all soils get a pH around 7 within a few years. Without adding calcium carbonate. This is opposing the ideas of Albrecht (1938) that farmers have to balance their soils with – mostly – huge amounts of calcium. Albrecht promoted the idea that a balance of potassium, sodium, calcium, magnesium and H^+ in the soil is necessary (Kopittke, 2007);
- Murray did a lot of trials with the fertilizing of crops with sea solids. In one trial is proven that oat and corn, fertilizied with sea minerals, are a superior food. When these cereals were given to C3H mice they didn't get cancer – 100% remained free of cancer. In the contol group all mice died of cancer (Voss, 2010);
- Reinau proved that the plants get also carbonic acid from the soil. They grow better on soil- and airy carbonic acid than on carbonic acid from the air alone (Reinau, 1927). This is in line with the findings of Lundegardh (Lundegardh, 1924);
- According to Callahan (Callahan, 1995) plants can take mineral elements from the air with their leaf hairs. He calls them leaf antennas;
- In the classic biodynamic agriculture composts were made by mixing farm yard manure, plant residuals and earth. One third each. Then compost preparations were added. Some farmers in the Netherlands did already for years the same (the socalled 'toemaken', adding soil on the manure heap).
- Bowditch found out that ammonium is bound to aluminium silicate (clay particles) and iron, and advised the farmers to use earth in order to keep the ammonium in their dung heaps, and to prevent rotting (Bowditch, 1856);
- Mineralists (geologists) have shown that the amount of true minerals in the soil is rapidly vanishing through modern agriculture, especially through nitrogen fertilizers (Bergsma, verbal communication), or potassium fertilizers (Pius Floris, Presentation, May the 25th 2018 Lunteren, the Netherlands, 2018). We call potassium a mineral, but it is an element. Feldspar, apatite and biotite e.g. are minerals;
- Sodium helps, at least in some crops, to bring down the high amounts of potassium. In a field trial in Wales, UK, the optimum dose was 173 kg salt (NaCl) per hectare. With this dose the grass was almost complete in balance for its macro elements potassium, sodium calcium and magnesium.The cows were fond of these grasses (Chiy et al., 1995). According to Voisin these salt fertilized grasses had also more vitamin A (Voisin, 1963). In fact we have to find out if sodium also can or should have a role in the non halophytic plants. And if, how to fertilize these crops with sodium without causing damage to these crops or the (clay)soils;
- High amounts of potassium and nitrate salts hinder the uptake of silicium. The stems of cereals become weaker as a consequence of lack of silicium. Cereals with long stems had to be substituted by short stem varieties (Van Baren, 1934);
- Farmers and their counsellors are experimenting in the Netherlands with special clays which bind the ammonium and other poisonous materials in the fodders. The health of the cows improves quickly (Vriezinga W, verbal communication). Giving foods with enough silicium would problably do the same.

Rhizosphere bacteria and fungi live in symbiosis with the plants. They offer each other many services on a basis of mutuality. Bacteriophages on the slimey surfaces of the roots prevent – probably – the entering of the bacteria into the plants*. And my hypothesis is that after the eating of rhizosphere microbes by the bacteriophages, the tiny microbial entities which are freed by this process, can enter the plant roots.They are problably the 'small entities' which according to Hans

* I suppose this is correct for plantroots, analog with the role of bacteriophages in the intestines of mammals (Barr, 2013).

Peter Rusch help to maintain the health and vitality of the higher organisms. According to Pradeu they live inside the cells of the higher organisms as adapted viruses (or viroids) (Pradeu, 2016). Béchamp named them microzymas.

- Silt and rock flour: fertilizing with silt or rock flour gives crops which are much more in balance than crops which are fertilized with artificial fertilizers or todays cow dung. (Herapath, 1850; Hensel, 1894). The same for seaweeds (Marchand, 1869).
- Magnesiumchloride is the most powerfull molecule for restoring our health. Magnesiumchloride is a better 'vaccin' than all the man made vaccins (Neveu, 2009). Magnesiumchloride helps to bind phosphor and ammonium in the slurry, and so prevents its evaporation (Huisman A., verbal communication);
- Magnesium prevents the forming of calciumphosphate in the weak parts of the body, like the heart, the liver, the muscles, the brain etc. Calciumphosphate is the shield of nanobacteria (Kajander et al., 1998). I suppose that magnesiumchloride prevents the formation of nanobacteria and through this the formation and precipitation of calcium phosphate (calcification). Nanobacteria can cause low-grade inflammations;
- In bones and teeth magnesium cements calcium phosphate and protects against attacks of bacteria in our mouths. The amount of magnesium in the bones and teeth is in most western countries only one fifth of the necessary amount (Barnett, 1954).

<u>Recapitulation</u>

In the nascent new paradigm plants can only be healthy if they live in perfect symbiosis with 'their' symbionts in the rhizosphere. But these symbionts live also in their cells and on their stems, leaves and fruits or seeds. These symbionts give protection and help to get the nutrients from the soil, the water and the air in the right amounts, the good forms, at the right time. They only act if the (young) plants sent them sugars and other compounds. If the growth of the plants slows down through cold, dryness, or lack of sunshine then the production of sugars also goes down, so the rhizosphere microbes get less sugar and through this send less nutrients to the plant roots (Vanhoof, verbal communication).

The nutrients from the soil are converted into organic compounds by the symbiontic microbes before being taken up by the plants. The bacteriophages play a special role in maintaining the equilibrium of the symbiosis. They are the first protection shield of the higher organisms (Barr et al., 2013).

The inorganic salts are an inferior food for the plants. If the ions of these elements and compounds dominate in the soil moisture the plants have difficulties in the selective uptake of these materials. In our agricultural systems the plants are overloaded with inorganic potassium, phosphor, nitrate and ammonium. And sometimes also with calcium and sulphate. Then the plants don't send their sugars to the soil. So the rhizosphere bacteria and fungi are no longer able to convert all the nitrogen and sulphur compounds into amino acids and/or proteins. For this conversion into amino acids and proteins these microbes need a lot of magnesium and trace elements. Magnesium and trace elements are lacking, or are availabe but can't be taken up, because high amount of potassium prevents this. A possible role of sodium in the formation of proteins has never been studied. Nor a possible role in protecting the lactic acid bacteria through sodium as in sour crout.

If plants have high levels of potassium, NPN and NPS, they become sick (Chaboussouh, 2005; Lutzenberger, 1995; Swerczek, 2002, 2007). The symbiosis is weakened. And some of the symbionts can become predators for the host. The bacteriophages no longer offer the host their protection.

In our stomach lives a bacterium, Helicobacter pylorum, an epsilon proteobacterium. Normally this bacterium doesn't harm us. People with too little vitamin B12 are at risk of getting stomach ulcers by Helicobacter pylorum. Magnesium deficiency also plays a role. Magnesium deficiency and too much potassium, ammonium and nitrate are two sides of the same coin.

Potassium salts[*] irritate the slimey surfaces of our body, if high (Bunge, 1894: 136):

[*] According to Bunge, the potassium salts are no risk if eaten as a food. The risk is there when potasasium salts are given as inorganic salts – KCL - as is done today. In the Nordic countries the health authorities are really reluctant to give KCL in order to compensate for too much sodium. In he Netherlands the KCL is sold in the supermarkets as a consequence of the advices of Dutch nutrition scientists. Vegetables, fruits and potatoes today are very high in potassium.

“Die Kalisalze haben eine locale, ätzende Wirkung. Man findet die Magenschleimhaut bei Thieren, denen Kalisalze injicirt worden, stets hyperämisch [enhanced blood supply], bisweilen auch mit Ekchymosen [bruises] bedeckt.

Werden die Kalisalze in sehr concentrierter Lösung eingeführt oder gar in Pulverform — wie es in allen Vergiftungsfällen geschehen war — so kann es zur Gastritis mit tödtlichem Ausgang kommen”.

Problably the same for nitrate. Nitrate in drinking water is the cause of gastric ulcers and of many cancers (Yang, 1997) unless the drinking water has enough calcium and magnesium. The same for sulphate (Kobayashi, 1957). Sulphate forms a risk for apoplexy in areas where the water has almost no calcium- and/or magnesiumcarbonate – in the North East of Japan.

Maybe here is a parallel in cancer cells: Warburg O. (1956) teached us that all cancer cells have one thing in common. These cells are no longer able to burn pyruvic acid with oxygen in the citric acid cycle. The oxydation stops.The cells survive now on fermentation and produce lots of lactic acids. Normally the citric acid cycle finds place in the mitochondrium. The mitochondria are also former proteobacteria. The mitochondria can’t work properly if the cells don’t get enough magnesium. Then calcium goes into the cells and this calcium goes also into the mitochondria. There it binds with phosphor and forms granules. The mitochondria calcify (Kapustin, 2011). From the studies with nanobacteria we know now that in these granules live nanobacteria which cause low grade inflammations (Kajander, 1998). Magnesium can stop these nanobacteria to grow. So if the level of magnesium in the cell is low the mitochondria become a cause of low grade inflammation ín the cell itself. And apoptosis is prohibited by the same calciumphosphate granules. The disrupted cells don’t die, but become cancer cells.

It is not clear if the disruption processes in plants follow the same Lines viz calcification …

But anyway, the sick crops make the animals and human beings also sick. The imbalance between the macro elements in these crops and the high levels of nitrate, ammonium, potassium and sulphate are indications or symptoms of their being sick. In 1933 the amount of potassium, sulphur and chloride had almost doubled since 1880 (Theel, 1933).

So now we have the instruments to measure the quality of the crops of the dominant organic practise and of conventional agriculture. And we can understand when and why things go wrong.

In the following part I will show that the crops of the dominant organic agriculture are not as healthy as should be. They are not in balance and they still have too much nitrate and ammonium (the amount of non protein sulphur wasn’t measured).

6. Quality assesment: is the quality of the contemporary organic crops really good?

First I recapitulate the data for the carrots – organic and conventional – from the study of Domagała-Świątkiewicz I. and Gąstoł M. (Domagała-Świątkiewicz, Gąstoł, 2012) (Table 2): (data on the trace elements – Cu, Fe, Zn, Mn, Sr, B are not displayed here They can be found in the study itself).

Table 2. Elemental composition of carrot

Mg/kg FM of the juice	Organic carrots	Conventional carrots
N NO_3	11.7	37.6
N NH_4	49.4	119
Ca	67.9	54.4
K	2369	2099
Mg	126	166
P	376	384
S	141	194
Na	346	423
Sum of Ca to Na*	3425.9	3320.4†
Sum of Ca to Na minus K	1056.9	1221.4

* This is a measure for nutrient density.

† The difference is for the biggest part through higher potassium in the organic carrots.

Now we can calculate the ratios (Tables 3–7).

Table 3. Calculated ratios in carrot

Ratios	Optimal ratios	Ratios in Organic carrots	Ratios in Conventional carrots
K/Na	2–5	6.8	4.9
K/Mg	2–5	18.8	12.6
Ca/Mg	1–2	0.53	0.32
Ca/P	1–2	0.18	0.14
Mg /(K+Na+P+Ca)	0,1–0,25 (min 0,10)	0.038	0.052
NPN	ALAP*	61.1 (39 %†)	156.6

Table 4. Elemental composition of red beets

Mg/kg FM of the juice	organic red beet	conventional red beet
N NO_3	229	846
N NH_4	110	199
Ca	76.9	58.1
K	2685	2641
Mg	179	231
P	381	207
S	126	119
Na	191	574
Sum of Ca to Na	3638.9	3830.1
Sum of Ca to Na minus K	953.9	1189.1

Table 5. Calculated ratios in red beet

Mg/kg FM of the juice	Optimal ratios	Ratios in Organic red beet	Ratios in Conventional red beet
K/Na	2–5	14	4.6
K/Mg	2–5	15	11.4
Ca/Mg	1–2	0.42	0.25
Ca/P	1–2	0.20	0.28
Mg /(K+Na+P+Ca)	0.15–0.25 (min 0.10)	0.052	0.064
NPN	ALAP	339 (32 %)	1045

Table 6. Elemental composition of celery

Mg/kg FM of the juice	Organic celery	Conventional celery
N NO_3	104	88.9
N NH_4	52.5	126
Ca	248.8	129.2
K	4156	3863
Mg	284.8	264.6
P	921	806
S	133	86

* Should be As low As Possible (ALAP).
† = 39 % of the conventional amount.

Na	154	242
Sum of Ca to Na	5897.6	5390.8
Sum of Ca to Na minus K	1741.6	1554.8

Table 7. Calculated ratios in celery

Mg/kg FM of the juice	Optimal ratios	Ratios in Organic celery	Ratios in Conventional celery
K/Na	2–5	26.9	15.9
K/Mg	2–5	14.6	14.6
Ca/Mg	1–2	0.87	0.49
Ca/P	1–2	0.27	0.16
Mg /(K+Na+P+Ca)	0.15–0.25 (min 0.10)	0.05	0.052
NPN	ALAP	156.5 (72 %)	214.9

Summarising of the data

<u>In general</u>:

1. All vegetables are out of balance;
2. All vegetables have too much NPN; in the red beets juice NPN is extremely high, especially nitrate*.
3. Potassium is in all three vegetables very high, especially in celery.
4. The sum of the nutrients (NPN excluded) is highest for celery (above all through potassium and phosphor).

<u>The differences between organic and conventional per product</u>:

a. **The carrot juice, organic and conventional**:

- In the conventional carrots NPN is much higher than in the organic carrots;
- In the organic carrots potassium is higher and magnesium, sodium and sulfur is much lower than in the conventional carrots.

b. **The red beet juice, organic and conventional**:

- In the conventional red beets NPN is much higher than in the organic red beets;
- In the organic red beets magnesium and sodium are much lower and phosphor much higher than in the conventional red beets.

c. **The celery juice organic and conventional**:

- NPN is again higher in the conventional celery than in the organic celery, but the difference is less extreme than in the carrots and the red beets;
- In the organic celery potassium, calcium, sulphur and phosphor are much higher than in the conventional celery and sodium is much lower; magnesium is somewhat higher in the organic celery.

<u>Final judgment</u>

For NPN all the conventional products have a worse score compared to organic. That is in line with the data form other studies: on average organic products have half the amount of nitrate of the conventional products (Heaton, 2019). But there is a lot of variation (Dangour, 2009). According to Dangour the differences in nitrate content between conventional and organic products is small. And most studies don't measure ammonia.

The figures of the study of Iwona Domagała-Świątkiewicz and Maciej Gąstoł show how important it is to measure not only N $-NO_3$ but also N-NH_4 (Table 8).

* In a Dutch study in 2003 the same was found for red beets. In general conventional red beets, lettuce, spinach and endive have high to very high levels of nitrate in the Netherlands, depending a.o. on the season. 21 % of all the Dutch vegetables are above the safety limit of 2.1 gram of nitrate/kg DM (Van der Schee, 2003)

Table 8. Forms of nitrogen in vegetables

Vegetables	N NO_3	N NH_4	NPN total
Carrots organic	11.7	49.4	61.1
Carrots conventional	37.6	119	156.6
Red beet organic	229	110	339
Red beet conventional	846	199	1045
Celery organic	104	52.5	156.5
Celery conventional	88.9	126	214.9
Sum	1317.2	655.9	1973.1

So N NH_4 is almost 50 % of N NO_3. And the crops contained on average 328.8 mg NPN/kg FM of the juices* (unluckily total N is not measured (or mentioned).

The organic products contained on average 344.7/3 = 114.9 N NO_3 and 211.9/3 = 70.6 N NH_4. So NH_4 is on average 38 % of total NPN

The conventional products contained on average 972.5/3 = 324.2 N NO_3 and 444/3 = 148 N NH_4. So NH_4 is on average 31 % of total NPN.

But the variation between the three crops is great.

In this study the authors measured at least N NO_3 and N NH_4, luckily. And remember, the other NPN compounds are not even measured.

So far about Nitrogen.

For all three organic products potassium is higher than in the conventional products and sodium is lower. Magnesium is lower in organic carrot juice and in organic red beet juice, but not in organic celery juice.

The greatest health risc is produced by products with a high potassium level and a high NPN level. Especially if sodium and magnesium are low. Then there is the risc of a potassium – nitrate syndrome (Swerczek, 2002, 2007).

So from these data, with the exception of NPN, we can't say that the organic products are better than the conventional products. And Ca/P is much too low for all the products, organically and conventionally. Ca/P is slightly better for organic carrots and for organic celery, but not for organic beets.

For all three products Mg /(K+Na+P+Ca) is lower for the organic ones. But the difference with conventional is almost zero for the celery juices. And I must say: some products from Dutch greenhouses have an even lower Mg /(K+Na+P+Ca) ratio. In cherry tomatoes, grown on rockwool mats, we found a Mg/(K+Na+P+Ca) ratio of 0,015 (Duijvesteijn , unpublished data).

Nevertheless, the organic products are free from pesticide residuals and low in cadmium. That's a real progress.

Both groups are far behind what are optimal ratios.

For a comparison I have given the ratios of carrots at different times and different places (Table 9). NPN wasn't measured in these carrots.

- Dutch carrots from 2017 (RIVM Nevo, 2017): raw carrots; carrots with leaves; winter carrots ;
- Carrots from three finnish farms with a lot of disease problems: (van Laarhoven, unpublished data);
- Carrots from the study of Wolff E. (1871): nr 4 is a Belgian white carrot, and nr 8 from England 'from a very well fertilized garden';
- Carrots from Normandy, analysed by Marchand, fertilized with guanodung, seaweed; herring waste and brine (Marchand, 1869);
- And finally: the carrots from Poland from above: organically and conventionally fertilized.

* (1317.2 + 655.9)/6 = 328.8.

Table 9. Ratios of carrots at diferent times and different places

Ratio	Optimal ratios	Nl raw carrot	Nl carrot with leaves	Nl winter carrot	Finnland 1	Finnland 4	Finnland 7
K/Na	2–5 (max 7)	9.8	12.7	8	14.47	22.5	25
K/Mg	2–5 (max 7)	38	34.4	41	19.6	28.2	23.2
Ca/Mg	1–2	3.8	3.3	4.4	1.93	2.16	1.57
Ca/P	1–2	0.93	0.79	1	0.93	1	0.78
Mg/ (K+Na+Ca+P)	0.15–0.25 min 0.10	0.02	0.022	0.018	0.04	0.03	0.036

Continued:

Ratio's	Optimal ratios	Wolff nr 4	Wolff nr 8	Marchand yellow	Marchand red.	Carrot Poland organic	carrot Poland conventional
K/Na	2–5 (max 7	1.4	0.54	1.16	1.14	6.8	4.9
K/Mg	2–5 (max 7)	5	12.8	6.2	7.4	18.8	12.6
Ca/Mg	1–2	2.4	10.6	2.4	2.6	0.53	0.32
Ca/P	1–2	2.13	1.8	1.35	1.47	0.18	0.14
Mg/ (K+Na+Ca+P)	0.15–0.25 min 0.10	0.083	0.018	0.063	0.054	0.038	0.052

Especially the carrots nr 4 (Wolff, 1871) and the yellow carrots (Marchand, 1869) are almost complete in balance.

7. Conclusion

Most products from Normandy in the period before 1880 are much more in balance than the products today in organic and conventional agriculture. The reason is the way the farmers in Normandy fertilized their crops and grassses. They ordinarily fertilized their crops with guanodung, seaweed, herring residuals and brine. These products contain lots of sodium, magnesium and trace elements.

The way in which the white Belgian carrot was fertilized (Wolff nr 4) was not mentioned by Wolff. But I found the original data of Way and Ogston in The journal of the Royal Agricultural Society of England. The white Belgian carrot was grown bij mr Huxtable. And fertilized with bones and sulphuric acid, guanodung and ash (probably wood ash). "Drilled end of april; very good crop. Collected middle of November". The soil: 'six inches of reddish mould, containing some clay; subsoil, chalk. Does not require draining. Three years in tillage" (Way, 1847: 163).

The authors of the Poland study don't give detailed information about how the three crops were fertilized. The selected crops were grown on organic and resp. conventional farms in the south and east of Poland. The organic farms were all certified. And the scientists have noted the fertilizing and other data:

" (..) crop rotation, fertilization routine, pest management and other cultural practices for each field were recorded. At harvest the total yield and an average weight of root was noted (data not presented)" (Domagała-Świątkiewicz and Gąstoł, 2012: 175).

For a definitve judgement I needed the data about the 'fertilizing routine'. But after contacting the authors I found out that these data are not available.

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Annex 1.

Mulder's chart

Mulder's chart of mineral interactions – Soil Analyst Cooperative
soilanalyst.org/mulders-chart/

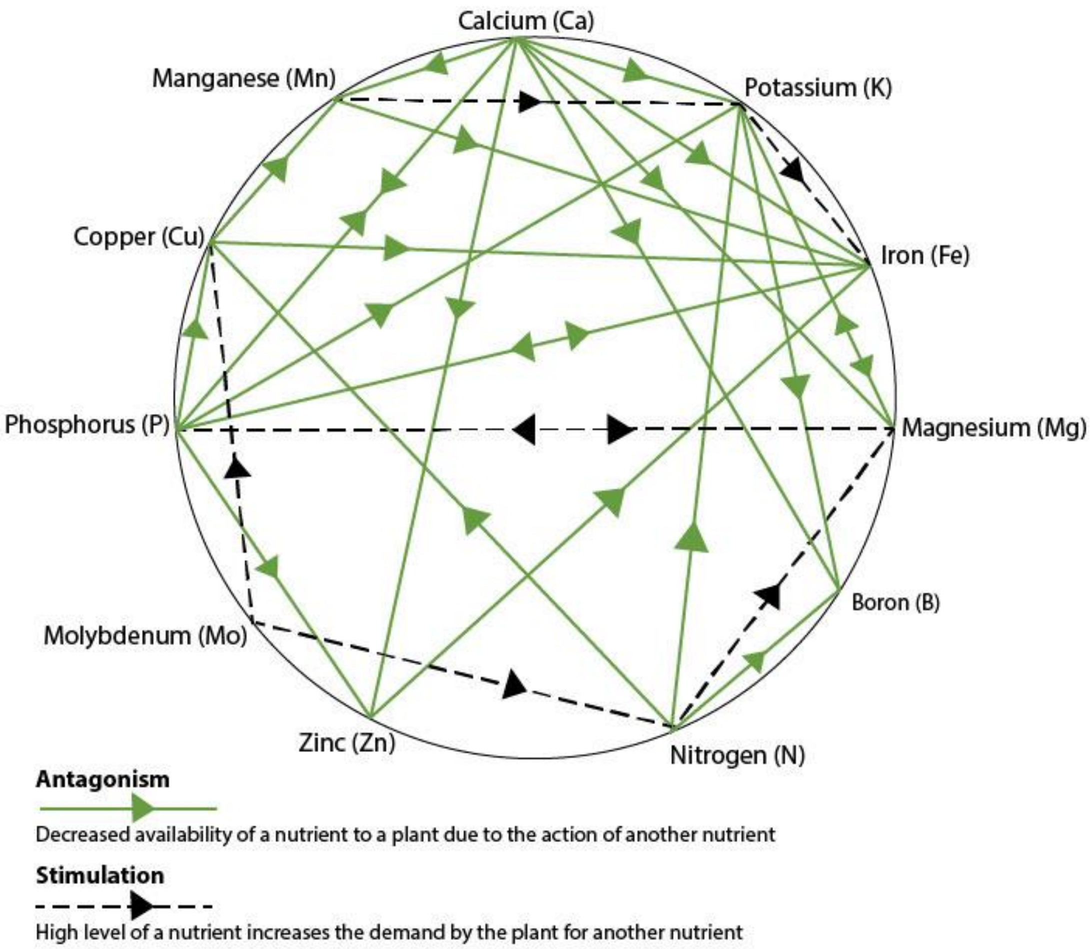
Mulder's chart of mineral interactions. Categories: **Mulder**, Soils and Growing, Soils General. **Chart** showing how the presence or absence of various elements influences the uptake of other elements by plants. **Mulder's chart** of nutrient interactions ...

"Antagonism

"Mulder's Chart shows some of the interactions between plant nutrients. High levels of a particular nutrient in the soil can interfere with the availability and uptake by the plant of other nutrients. Those nutrients which interfere with one another are said to be antagonistic. For example, high nitrogen levels can reduce the availability of boron, potash and copper; high phosphate levels can influence the uptake of iron, calcium potash, copper and zinc; high potash levels can reduce the availability of magnesium. Thus, unless care is taken to ensure an adequate balanced supply of all the nutrients – by the use of analysis – the application of ever higher levels of nitrogen, phosphorus and potassium in compound fertilisers can induce plant deficiencies of other essential nutrients.

Stimulation

Stimulation occurs when the high level of a particular nutrient increases the demand by the plant for another nutrient. Increased nitrogen levels create a demand for more magnesium. If more potassium is used – more manganese is required and so on. Although the cause of stimulation is different from that of antagonism, the result is the same – induced deficiencies of the crop if not supplied with a balanced diet. High levels of molybdenum in the soil and in the herbage reduce an animal's ability to absorb copper into the blood stream, and ruminant animals grazing these areas have to be fed or injected with copper to supplement their diet (see Mo/Cu dotted line)".



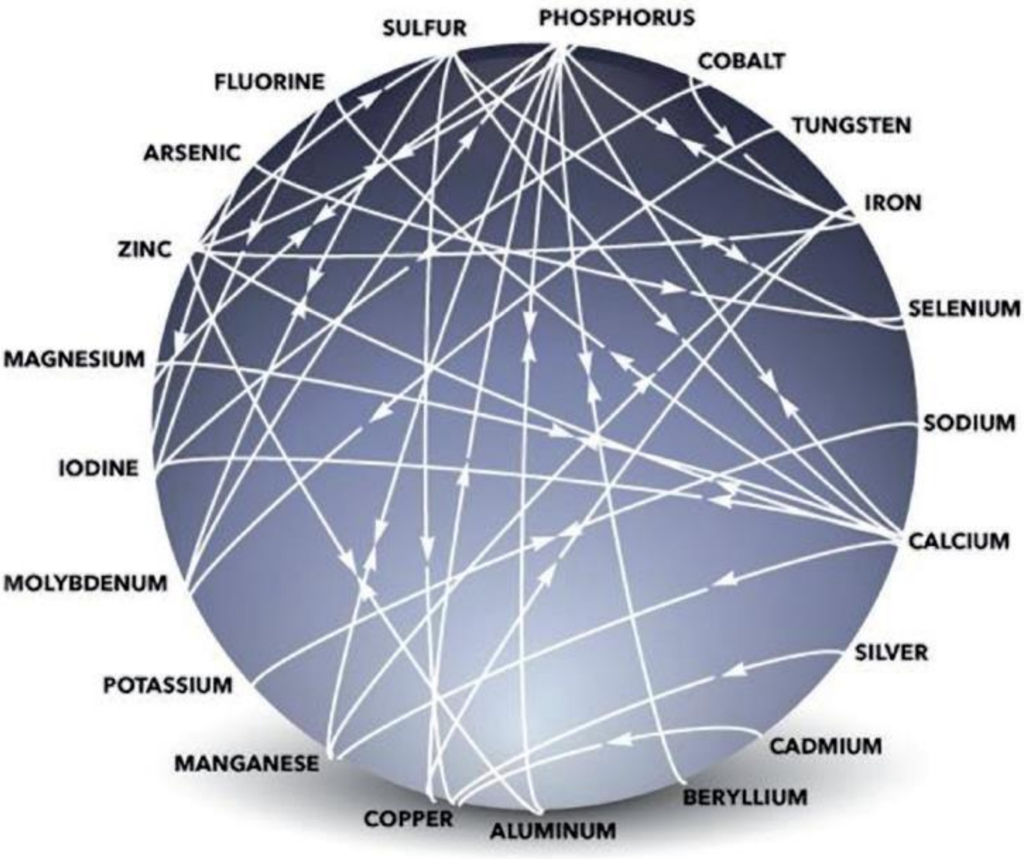
Mulder's Chart

ANTAGONISM A decrease in availability to the plant of a nutrient by the action of another nutrient (see direction of arrow).

STIMULATION – An increase in the need for a nutrient by the plant because of the increase in the level of another nutrient.

(Unluckily not all the charts of Mulder, avaible at the internet, are the same (Nigten).

Compare the next one:



At this chart there is no interaction at all between copper and molybdenum. And nitrogen is missing. And here there is no relation between potassium and iron, between potassium and magnesium, potassium and calcium, potassium and manganese, and between potassium and phosphor. Silicium is lacking on both charts. And we know that sodium promotes the uptake of calcium and magnesium (Chiy, 1995).

Annex 2

The role of earthworms

"(…) Here's what Sir Albert Howard, in ***Soil and Health*** (1947), had to say about the process and the make-up of [earthworm]castings:

"The casts are manufactured in the alimentary canal of the earthworm from dead vegetable matter, and particles of soil. In this passage the food of these creatures is neutralized by constant additions of carbonate of lime from the 3 pairs of calciferous glands near the gizzard, where it is finely ground prior to digestion. The casts which are left contain everything the crop needs – nitrates, phosphates, and potash [NPK] in abundance, and also in just the condition [soluble?] in which the plants can make use of them."

Further Explanation – Howard goes on to cite that often-mentioned analysis as follows: "Recent investigations in the United States show that the fresh casts of earthworms are 5 times richer in **available** nitrogen, 7 times richer in **available** phosphates and 11 times richer in **available** potash than in the upper 6 inches of soil." It's that word "available", in contrast with previously non-available, which explains the higher content of nutrient minerals in the castings coming out, versus the "soil" and organic matter going in. As near as I can tell, these numbers came from a single USDA study done in Connecticut in July, 1944.

Restoration Tool – Very large portions of the earth's soil have been eroded and exhausted over the past 5,000 years all around the world. In recent centuries the rate has been stepped-up many times the rate of natural soil formation. The earthworm potentially is a major tool (if properly fed) for restoring and rebuilding those soils. Here's further explanation from Dr. Thomas J. Barrett's 1947 and 1959 book ***Harnessing the Earthworm***:

"In the chemical and mechanical laboratory of the earthworm's intestines are combined all the processes of topsoil-building. The earthworm swallows great quantities of mineral earth with all that it contains of vegetable and animal remains, bacteria and microscopic life of soil. – – – Finally, it is ejected in and on the surface of the earth as castings – earthworm manure – humus, a crumbly, finely-conditioned topsoil, richly endowed with all the elements of plant nutrition in water-soluble form."

In Summation – I'm not sure that all (or most) topsoil is from worm castings which are, in turn, humus. Recall that this was the claim of Barrett and Darwin. Darwin calculated that worms deposit 10 tons of castings per acre each year. Sir Albert Howard figured it was 25 tons. In some parts of the world these deposits have been measured to far exceed those amounts. Whether or not topsoil is castings and castings are humus, or that humus requires soil and clay for its formation, the creation of 25 tons per acre or more of new topsoil per year is nothing to sneeze at. This represents a too-often overlooked means of restoring billions (yes, billions) of acres of ground lost to the plow, it's modern successors, and a century of reckless chemicalized agriculture that are soon going to be necessary to the survival of civilization. In ancient Egypt it was a crime to kill earthworms. Let's not forget the lowly earthworm. It's the least we can do". (Kline, 2013).

Annex 3

The loss of nitrogen in cereals (Lawes and Gilbert, 1856: 484, 485)

"As a final average it is seen that we have, including all these cases and extending over so many years, in the case of wheat, only 39.9 per cent, and in that of barley only 43.1 per cent, of the nitrogen of the manure recovered in the increase of crop! ...and certainly the near approximation in the averages of the two crops is not a little striking; especially when we remember, that in the case of the barley there were no instances of more than standard amount of nitrogen used, which would obviously have brought down its final average nearer to that of the wheat.

Now, the final average here obtained in the case of wheat, would represent exactly 51/4 lbs. of ammonia for each bushel of grain (with its equivalent of straw), obtained by its use, assuming average proportions of corn to straw, and of nitrogen in both: and, again, by the same method of calculation, tlie return of rather more than 40 per cent, of nitrogen, the result where the standard amount of ammonia with minerals was used, would be almost identically equivalent to 5 lbs. of ammonia in manure for every bushel of corn, and its equivalent of straw, obtained as increase of crop!

So much, then, for the indications of some hundreds of direct experiments on this subject. But we further unhesitatingly maintain, that the general result here arrived at, agrees very closely indeed with that of common experience in the use of guano and other nitrogenous manures for the increased growth of grain" (Gilbert and Lawes 1856: 484, 485).