NUFFIELD FARMING SCHOLARS

How to reduce inputs in no-till systems: Global approach of an agriculture inspired from Nature

Adressing the cause instead of treating the symptoms

Sarah Singla – Nuffield France 2011

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Adressing the cause instead of treating the symptoms

Sponsor

To my father,

« We must draw our standards from the natural world. We must honor with the humility of the wise the bounds of that natural world and the mystery which lied beyond them, admitting that there is something on the order of being which evidently exceeds all our competence »

(Vaclav Havel)

Contents

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« One day in your lifetime you will have the opportunity to change your life and your vision. Take it easy, do it" (Nuffield Contemporary Scholar Conference)

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Study

Farmer in Aveyron, on the farm which has been no-tilled since 1980 and without any animals since 1990, I wanted to step back to explore the ways which can make this system more reliable for the future.
Amongst the weakest links, I found out that there was an impact from the inputs as theire price is going up and down every year and they depend on a fossil energy, non renewable.

Considering the soil as the most important part of every farming system, my first researches were about the soil fertility (chemically, physically and biologically). Initially, my objectives were to know how to reduce inputs in no-till systems for arable farmers.

Going through that study, I quickly understood that it would be better to go beyond the only agronomy. That is why, a part of my study was to look at the farm more globally, integrating the economics, social and environnemental aspects in the short and long term.

When it is time to sum up more than one year of research, readings and courses, this report is more orientated towards an agriculture close to Nature, more human, where all the principles are applicables all around the world. Because by addressing causes instead of treating symptoms, it is easier to get results.

Introduction : A long term vision

« ***10 years for a man, it's a lot, for a soil, it's nothing*** »

The agriculture we know today was born in the second half of the 20th century, in a period where not everybody could find enough to eat.

Progressively, the mechanisation went on the farms, helped farmers to work more land in a shorter time, and helped to replace the workforce which has gone.

The new methods linked to an intensive work of the soil, to breeeding programs and to the artificial fertilizers and pesticides, allowed agriculture improving yields and productivity. Farms went bigger and slowly by slowly became specialized in one kind of production. For example, in France, the cereals are now produced in the Parisian basin while the pigs are mainly produced in Brittany.

Agriculture was considered as an industry because the resources were abundant and cheap. The consequences of farming practices on the environment weren't taken in consideration because it was to ensure the economic viability in a short term period and because the natural resources rarefaction wasn't considered as a problem.

The productivity araising was to be done by ignoring the natural constraints, by reducing the limititating factors (weeds, insects,…). That is to say, it was to treat identically different biological systems which came from various environments.

The problems identified today find their root in the hypothesis and results defined with a reductionnist approach. A method in which each component is studied independently and where all the components added to the other can explain the system and foresee what will happen. In other words, it means to study the hand, the head, the knee and other organs and by putting them all together, we pretend explaining the body functionment. But this thing don't help to fully understand the system as it only reflects some elements and don't take int considerations all the interactions.

This approach leads, for example, to breed plants only because of their nitrogen use efficiency, without knowing the impacts on the organic matter mineralization or the plants palatability, which are long terms effects.

Because of the complexicity of the system and because of all the interactions, it means we must go from a model where only one parameter differs to a model with multiples datas.Win other words, the system can be only understood with a multidisciplinary and global approach.

Today, while it is inconcevable to reduce the food production, our farming practices, defined earlier, show their weaknesses and give new objectives. Our farming processes, our consumption ways need to be rethought.

The equation is simple : produce more and better with less

We must reduce our impacts on the environment and renew the natural resources which means to look at ecology as a science and not as an ideology.

We must stop the rural exodus and dynamise all the rural areas by a garanted wage and by attracting young people towards agricultural jobs.

We must let to the agriculture her noble role, which is to provide food in sufficient quantities.

We must adopt a global vision, by integrating economics, social and environmental aspects in space and time. An agricultural approach on a world scale and in the long term. A thinking culture which is « think global and act local » to go beyond the only economic reliability which has produced some of the problems we see today.

We must change our look at agriculture and a tour production methods, getting an humble approach where the question is not to know « how to produce food in quantity and to insure the short term economics » but to see how :

« We can produce quality food in quantity by working WITH nature, by being economically sustainable and by restorating all the natural resources needed by the future generations ? »

The soil : base of a global approach

« To know where you go, look at where you come from » *(African saying)*

a) Soil : humus, humility, humanity

Looking at soil, we must also look at his etymology. To define the dust, the clay, the soil, the semites people used the word adâma. In Hebraic language, âdam, also means man and gave its roots to several words such as : homo, human, humanity, humus, humility.

Our conception of the Nature, if we want to integrate the soil, asks for a better understanding with wisdom and humility. Often, by looking at only one thing we think to know, we can create some mistakes because we have avoided to look at the big picture. « *It's not what we ignore which causes problems, it's only all what we know which is not true » (Mark Twain)*

Dwayne Beck, from the Dakota Lakes Research farm mentionned that we probably have a lack of knowledge but we have a bigger lack of wisdom. It means that maybe things work better if we do not try to master it. It's a shame we have used our knowledge to modify the Nature instead of using them to try to understand the Nature.

b) The soil : Basis of the civilisations

« ***A civilisation which destroys its soil, destroys itself »*** (Roosevelt)

The story of agriculture, put aside with the story of the civilisations, show that the most fertile plains in the past are the biggest deserts today (Egypt, Iran, Irak,…). This is because the soils were over worked and not respected. If we can apologize theses attitudes because by the past they didn't know what they were doing, today, we must do our best to save the land we have.

A long term vision implies that our main goal should be to regenerate the soil, basis of our humanity, in order to avoid that History repeats itself and that the area of arable land keeps on shrinking. It is a project where we can even imagine to green the desert.

The soil : Basis of the food trophic chain

*« **Food as a medicine and medicine as food** » (Hippocrate)*

« Why the numbers of pills I take is more than the number of food in my plate ? » (Anon)

a) At the basis of our food, at the basis of our health

Our health is strongly influenced by the quality of the food we eat.

As soil is at the basis of the food trophic chain, it is important to have an healthy soil so as to all the plants which grow in it can get all the nutrients they need.

As humans, we are more sensitive to diseases and bacterias which are in the air when we are weak and not in a good shape. This is also true for the plants and animals : the stronger our intern resistance, the better the defense against diseases. Having a fertile soil means we can grow healthy plants instead of curing unhealthy plants. More over, if the plants are correctly fed, they will supply us all the nutrients we need such as magnesium, calcium and so on. It means it will be useless to take pills and complementary products.

b) Because quality food shouldn't be a luxury product

Thinking global means considering that food access shouldn't be luxury because each human being has to have a healthy food (quantity and quality).

In order to do that, we need to find ways to reduce costs of production, for example by reducing our dependence to fossil fuel in the countries where agriculture is mechanised.

From a global approach, we need to ensure that each farmer can make a living from its production in order to be sure that farmers are not the first ones who are not able to have access to food…

The soil : An ecosystem in itself

*« **The soil comes first. It is the basis, the foundation of farming. Without it, nothing ; with poor soil, poor farming, poor living ; with good soil, good farming and living. An understanding of good farming begins with an understanding of the soil.** » (Ahlgren – Yearbook of agriculture 1948)*

a) Soil formation

The soil comes from 5 different factors : the climate, the parent rock, living organisms, the relief and the time.

b) The carbon cycle and the soil

According to a report from the European commission, agriculture is responsible of 10% of the european greenhouse gases. The fuel used by agricultural machinery is often considered as the main source of CO_2 coming from the primary sector. But this part does not take in consideration all the CO_2 coming from the burning of the organic matter when the soi lis mechanically destroyed. sol[1].

Some studies have shown that the organic matter content in soils has decreased a lot because of the methods used to produce food. A decreasing of 1% of the soil organic matter content in the 30 first centimetres would be responsible of a lost of more than 45 tons of carbon, which means 166 tons of carbon per ha. That shows the impact of agriculture in the emission of CO_2 in the atmosphere when the soil is cultivated with machinery.

On the other hand, that also points out the soil's potential to sequester carbon and that a change in agricultural practices could help to restore a part of the carbon that has been lost in the atmosphere during the last decades because of an intense use of mechanisation.

c) Soil's structure : full of emptiness for gaseous and aqueous exchanges

The structure, represents the physical part of a soil and is defined by the way the aggregates and soil particles are linked.

[1] Reicosky and Archer, 2007

This architecture depends on the texture, the water content, the organic matter content and in a larger part from the soil's organisms activity (plants, bacterias, mushrooms, earthworms, nematodes,…)

Comparing with a house's construction, the materials used (wood, iron,…) would be represented by the texture elements : clay, loess or sand. The ciment between the soil particles would be represented by chemical links, and molecules such as glomaline.

Soil's structure is important because it defines it capacity to hold water and plays a major role in the air and water circulation in the soil.

It is often said that a soil well structure dis reprensented by 50% of emptiness. The vaccum spaces arrangement correspond to the porosity which is used for the gazeous and aqueous exchanges between the plant an its environment

Another important parameter when we look at soil's architecture is to look for a vertical structure. It is essential to ensure the water infiltration in the soil and also helps in having a good capillarity in the soil.

Soil's structure can be quickly destroyed by farming operations. Either talking about compaction or creating a disruption in the vertical structure, a soil's physical properties degradation can lead to a problems when it comes to plant nutrition.

d) **Soil's chemistry : Presence and availability of minerals nutrients :**

If bringing calcium, magnesium or other macro-nutrients can have obvious visual effects, we one must also think about other nutrients.

When it comes to « good fertilisation » it doesn't necessary means that the fertilisation is at its optimum. There is no nutrient which can be considered as more important than another, no nutrient deficiency which can be corrected by bringing another nutrient to the plant or to the soil.

In plant physiology, a nutrient is said essential when it enters in the plant's functiuning : either because it enters in the plant's composition or because it plays a role in biochemical reactions.

In plant physiology, nutrients are classified by looking at their weight's in the plant. Hence, there are the macro-nutrients (nitrogen, phosphorus and potassium) which represent around 80% of the nutrients content in the plant. Then, there are the secondary nutrients (sulphur, magnesium and calcium) and the micro-nutrients (copper, boron, zinc, iron, molybden, manganese, sodium, chloride). To these nutrients, could be added the trace and ultra-trace

nutrients but their detection in laboratories is quite difficult because they only represent such a small part of the nutrients content in the plant's dry matter.

A soil chemically balanced means that it can provide all the necessary nutrients to the plant in quantity and availabilty. The presence of a nutrient in the soil doesn't mean it can be removed from the soil. Depending on water's moves in the soil, on soil's structure (for instance if the soil is too much compacted, the roots won't be able to reach the deep layers in the soil and since then will have difficulties in the nutrients removal) and also on soil's activity. Living organisms play a major role in all the chemical process, whatever it is about organic matter's transformation or nutrients removal.

In terme of chemical balance, as all the mineral nutrients are important, and not only N,P and K, it means that farmers can have a more precise system of fertilisation by using secondary and micro-nutrients in their fertilisation program.

e) Soil's biology, a living soil

"Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted." *(Albert Einstein)*

Biology plays the major role in soil's fertility.

The soil is living : in addition to living organisms which can be seen, such as earthworms, carabs ou slugs, the soi lis made of billions of micro-organisms which can be seen with microscopes. In one gram of soil, there would be more than 1 billion of bacterias, kms of fungi, 100 000 protozoas[2].

The rhizosphere represents the soil's volume formed and influenced by the plant's roots and all the associated micro-organisms. The rhizosphere has en effect on physical, chemical and biological soil's properties : acidification, nutrients removal, organic substances accumulation.

Plants don't only remove nutrients from the soil, they also produce energy. Thanks to the photosynthesis mechanism, when there is a light source, water and CO_2 are combined to form sugars. A part of this energy is transferred to the roots and then secreted into the soil in forms of roots exsudates (sugars, aminoacids, enzymes,...). All these exsudates will provide carbon energy to soil's organisms but also will contribute to increase the soil organic matter content.

[2] "Teaming with microbes" Jeff Lowenfels & Wayne Lewis

The different exsudates attract and stimulate specific soil's microorganisms. Some of them can be associated to plants throughout a symbiotic association : it's a collaboration between two species where both of them can find benefices. For example, the legumes are plants which present nodules. These nodules are like small balls on the root system where some bacterias are living. These bacterias, specialised in the nitrogen fixation will provide nitrogen to the plant and this one gives sugars to the bacterias. Introducing legumes into fields is also a way to reduce chemical fertilizers use.

f) Organic matter : a fertile sponge :

Organic matter is made of living organisms, dead organisms and products in decomposition. Its role is really important in soil's fertility since it influences the physical and chemical soil's properties.

Organic matter has en effect on soil's pH and holds the nutrients used in the plants development. Once used by the plants, these nutrients must come back to the soil to be recycled by micro-organisms and then re-used by other plants.

Jim Hoorman, from the Ohio State University, published a study about soil's compaction[3]. As a conclusion, the only way to limit soil's compaction is to increase the organic matter content in the soil. It acts like a sponge which can absorb deformations and will come back to its initial form after being compacted.

Concerning water, if the soil's organic matter content goes from 0,5% à 3%[4], the soil water capacity[5] is doubled. In other words, if you fullfill a glass of 20 cl of water, you will put only 20 cl, whereas if you put a sponge in this glass before pouring water, you may increase the water content in the glass because the sponge will hold more water thanks to its absorption ability. It means that in a same volume of soil, it is possible to hold more water only by increasing the organic matter content.

Here, were described some components of the soil's fertility. Recent discoveries such as the influence of the oxydo-reduction potential or electromagnetics fields show that there will still be many things to learn before a complete understanding of the soil…

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[3] James J. Hoorman, Biology of soil compaction, American Society of Agronomy

5 Soil organic matter and available water capacity, Hudson, BD, Journal of Soil and Water Conservation - Vol. 49, no. 2, pp. 189-193. 1994

[5] Réserve utile du sol : volume d'eau disponible pour les plantes.

A simple approach and humble approach should lead us to accept that doing nothing is still doing something. In other words, nature often works better when it is not disturbed by our farming practices.

Another thing is to know that with our discoveries, because they are linked to quantifiable and measured things, can lead us to misunderstandings or creation of imbalances because we don't take in consideration the interactions between things and because we don't look at the big picture.

Simplicity is the supreme sophistification, so whatever we can discover, the conclusion will still be that there is no better or efficient tool than living roots systems to regenerate and restore the soil's fertility.

Farmer : builder of living soils

To deal at first with soil is important because whatever the production system, its productivity and sustainlability depends on keeping a soil which can produce food. And soils will keep on existing only if it's formation speed is greater to its degradation speed.

« *The difficulty lies, not in the new ideas, but in escaping from the old ones»* *(John Maynard Keynes)*

a) Covering the soil all year long with living plants

The main cause of a soil destruction is due to erosion (wind or water erosion). If a process of degradation and transformation or the relief. It goes in 3 steps : at first, the particles are removed, then they are going to another place and finally finished to accumulate and sediment.

Each year, because of this phenomenon, there are several cubic meter of soil, nutrients minerals and soil particles which are removed.

To avoid erosion, some terraces were made and people were looking for new ways of farming such as contour farming or reducing the depth of the soil's tillage. But unfortunately, it doesn't solve the problem of erosion since these things address the symptoms and not the cause : erosion exists when the soil is bare.

Erosion can be only reduced if the soil is covered in permanence.

Living plants, thanks to their root system can agregate the soil particles. Crops and residues will protect the soil from wind, raindrops, reduce evaporation, and provide food to the organisms.

A permanent soil cover with diverse living plants is the only way to regenerate and rebuild soil

b) The only thing to do : a surgery without scar

« What is a paradox for us today, will be a truth for the posterity » *(Diderot)*

- **"Ironing" the soil is destroying it**

In most of the ecosystems, the soil's formation is not possible if it is mechanically disturbed[6]. Not to work the soil is the necessary condition to avoid soil degradation and to keep the ecosystems functions.

It's been centuries we were taught that man should plow, aerate, decompact, level, crumble the soil so as to get a good seed bed and a clean field. In the opposite, all these things don't solve the cleanlinless of the field, neither they give the ideal conditions for a crop establishment and development. If tilling the soil was so efficient, it would have been decades since we would have seen weeds…
Also, how can you explain that near our roads, it is always green, we don't have any infiltration problems whereas it wasn't touched, wasn't plowed…

- **Soil doesn't compact itself**

Compaction is the consequence of a reorganisation of soil's particles under an external pressure. It leads to an increase in its density and a reduction of the porosity needed for gaseous and aqueous exchanges.

The main conditions which bring this compaction are low organic matter content and high moisture content when it comes to going to the field with machinery. It also because with the development or machinery, we went to bid equipment, often to heavy to be in the fields. Another point which leads to compaction it when the animals don't graze properly : the animals are not in the field when they should be.

It means that it's to the farmer to manage correctly his farming activities if we wants to avoid soil's compaction.

- **The only and unique job to do in the soil : sowing**

Seeding should look like a surgery without a scar : a well-done sowing is not visible…

[6] Montgomery, 2007

One has to check out not to destroy the work he does to build his soil thanks to the soil's biology.

c) **Introduce diversity : complementarity, harmony and synergy**

By complaining about diseases or pests in our culture, maybe should we have another vision of what we are doing : there is often the same specie cultivated in the same field from one year to another. Consequently, yield's decreasing may appear, but also resistance to chemical products or repeated pests attacks. This lead to a bigger use of inputs (fertilizers, herbicides, fungicides) which make the system weaker.
All these problems can be solve by introducing more diversity in terms of cultivated crops and also by looking at rotation.

- **There is no weed….**

A weed is considered as a weed because it competes with the crop we try to grow or because we haven't found a way to use it.

In one cubic meter, there are plenty of seeds which are able to germinate and grow. The dormancy is defined by external conditions (moisture, temperature, compaction,…). Hence, weeds could be used as indicators of the physical and chemical properties of the soil.

Before killing the weeds, maybe should we understand why they grow and then we will know what to do to increase the soil fertility…There is no weed, there are only useful plants.

- **There are no destructive animals…**

« The problem is not an excess of slugs, it comes because of a lack of carabs…»

Some insects, when they are over-represented, take the name of destructive animals.

By adopting another point of view, if there is only one kind of plant, one specie on thousand hectares, the fauna which live in this field doesn't have another way to be fed than eating the crop we are trying to grow. This is because these organisms are so small that they cannot walk on a long distance to find food. It's like if we were in Siberia, that our unique way of transportation were our feet and that the only food to have would be wheat. When you are hungry, what would you have to eat ?

On the other hand, if several species are present, the damages would be minimized because diluted amongst the several plants. Also, when it comes to diversity, wood, trees

can help to attract natural predators and can bring to rebuild an ecological and biological balance. Another vision : going from the destructive animal to the crop auxiliary…

- **Synergy : the whole is greater than the sum of its parts**

Adding diversity means to introduce new species in the fields but also growing our main crops differently in the rotation sequence.

Each specie has its own physical, chemical and biological characteristics. Thanks to different roots systems, every soil layer can be explored which lead to a valorisation and a nutrients recycling. Looking at the aerial development, it is all the atmosphere layers which are going to be used : from the subterranean clover to the tall sunflower.

To choose a specie, a cultivar, it is to have the possibility to correct unbalances thanks to plants. For example, if the phosphorus is locked into the soil, using buckwheat will help to unlock it and then to make it available for the next crops.

Associating plants, means to restore and to increase the soil's fertility by looking at their complementarity and by combining their effects. Recent studies showed that plants are also able to transfer nutrients thanks to their root system. It means that a legume which is able to fix nitrogen can provide some nitrogen to cereals. There is a synergetic effect between the plants, that is to say that the whole is always greater than the sum of its parts.

Associating plants, covering the soil, changing the rotation, increasing the biodiversity, it is disrupting the pathogens cycles, reducing the diseases pressure and the use of chemicals in our fields. Introducing new species it is also, economically, not to put all the eggs in the same basket and can bring to a production diversification.

d) No leaks : Reuse, recycle and enhance the fertility

A system works on a long term period if the inputs are greater than the outputs. These conditions are indispensable not to have an impoverishment of the system and can also help to capitalize when it comes to an elements accumulation. Developping a fertile system is to enrich it, to recycle the nutrients, to ensure their circulation and before all by avoiding the leaks.

The inputs we use in our fields are to replace the elements which were removed and not recycled in our systems. Because one must address the cause instead of treating the

symptoms, our first objective has to be : avoiding the leaks. It doesn't worth putting water into a bottle with holes…

That can be done by using plants which are going to bring back nutrients from the deep layers to the top layers in the soil. They are acting like pumps which avoid nutrients to be leached and finish in the rivers and oceans.

Animals represent another tool in the soil's fertility restoration : they participate to the residues restitution in terms of « animal » organic matter. An organic matter often enriched in micro-nutrients because some farmers provide mineral salts to their animals in order to give them a good food. Hence, a slurry or compost will help in correcting nutrients deficiencies in the soil and will stimulate a part of the biological activity.

To be a farmer is looking at taking care and improving our main production factor (the soil) thanks to plants. It is a new definition which consists in grabbing a maximum of light and $C0_2$…

Global approach : Renew the generations, sociologic aspect

a) Renew the resources : back to the land, urban exodus

Several times, was mentioned the natural resources restoration as a long term objective. And this big agricultural project can be reached only if people are interested in it and committed to go towards this direction..

On the other hand, the farmers age has been increasing since the last decades and in some countries, the generations renewal seems to be a problem on most of the continents.

Unfortunately, agriculture is often short-handed maybe because of a lack of knowledge about what is to be a farmer or also because it is not profitable anymore.

If we are so proud of our job and if we like what we are doing, we should communicate our passion to the other ones if we want to attract young generations to come back to the land. We are the best ambassadors of our job, it's up to us to provide a new and good image of our job. "We must (re)discover excitement and joy to be a farmer and above all to enjoy our job" (Joel Salatin).

b) Job's thriving

« Find a job you love and you will never work a day in your life» Confucius

By choosing our job, our production, may guarantee that we will thrive in our life because we will be doing something we like doing.

It is important to step back before taking over a farm or another firm. It is a critical phase but essential because it helps to have a different point of view on the situation, on the way to produce, on the way to think. It has to lead to a position where one will keep on doing the same things or to modify them.

A global approach is also and above all to define our quality of life's expectations. It is because whatever the job, the human aspect, the psychologic and social aspects play a major role in the system definition.

Another way to look at the system is to define our skills (weakness, strengths) so as to delegate the different tasks to competent people.

Here is a sample of questions we can have to step back :

- Why have I chose this job ?

- What are my objective for my farm in 30 years time ?
- Do my personal aspirations match with my professional objectives ?
- What are my strengths, my weaknesses ?
- How are my skills in accounting, management, marketing ?
- What are my financial needs ?
- How my family, my friends are integrated in my production system (professionnal life) ?
- ….

c) Farmers education : an education all life long

« The more we learn, the more we see there are things to learn »

Being a farmer has been often seen as the job we were doing if we couldn't do anything alse, whereas today it can be a chosen job and not something which has been put up with someone or something.
To be a farmer is a job which requires a vast knowledge : agronomy, zootechny, mechanics, marketing, management,…Hence, a farmer should study as long as a lawyer or a doctor. Education is important because gives the possibility to understand and take decisions.

About the knowledge farmers need, there is no point by saying that it is urgent to teach about the soil. If so many damages are made to the soil it is because most of us consider the soil only as a support of production and don't know that the soil is living.

Being educated all life long is to have the opportunity to learn, to find new ways of production, to be open-minded, and to create added value on the farm thanks to the "grey matter" (the brain).

Nowadays, we are fortunate to be able to communicate on a global scale and access to knowledge has been facilitated thanks to Internet. Maybe should we take advantage of this wonderful opportunity to learn but also to exchange, share ideas, solutions so as to build projects which could contribute to enhance people life's conditions all aroung the world.

d) (Re)create the link between producer and consumer

« When you plant a seed once, you get one harvest. When you educate people, you get 100 harvests » *(Confucius)*

(Re)create the link between producers and consumers is important because it is necessary for the consumer to know where its food comes from and how it was grown. Communication about food is often done by people who are not producers but good marketers. Hence, it doesn't always represent the reality. As the "absents are always wrong", who better than a farmer can explain what he does and how he produces food ?

Communicate with consumers is to make him aware that it needs time to produce all the raw materials used for the food we eat : for example, the wheat for making bread needs around 9 months to be grown…
It is also to explain that the scenery seen from the plane or the train, were made by farmers and that going into nature is first of all to respect the farmers work because they produce food.
Explain, inform, it is to create a trust between farmers and consumers.

e) Be inspired by success

« What would you do if you knew you would succeed ? » (*R. Schuller)*

Each new activity, each new technical way we want to develop means to learn. When people don't want to do something, they will take examples of failures, if they want to do it, they will look at success stories. That's why, if we want to try and experiment new ways of farming, it is important to take for example the people who have found solutions to problems.

The farmers renewal will be done through a new image of the job : a chosen job because of its future perspectives, its liberty for entrepreneurship, its quality of life.

Global approach : economic considerations

a) The size doesn't matter, what is important is what you are doing with it

Getting more land doesn't necessary mean to produce more. Sometimes, getting more land is seen as a solution which can solve most of the problems. Shouldn't we also look at the compatibility with the labor it requires, the machinery, and the feasibility of the project ?

Maybe, one solution would be to look for autonomy and optimisation of the production system. An ecological intensification and a valorisation of the aerial and subterranean space is a tool to produce more with less : double culture, agroforestry, sylvopastoralism or aquaponics, and all that we can imagine.

b) Economy and ecology can team

Integrating man in the ecosystems is not to have an arrogant approach where man is upon Nature, neither it is to idolize Nature where man is out of it.

This ecological approach hasn't to look for a production decrease because it is socially irresponsible and humanly inacceptable. We need to keep on producing with more awareness of the environment and also by ensuring the profitability.

c) Economic profitability to avoid rural exodus : making money from farming instead of farming with money

Too much farmers have to stop their activity because their system is not profitable anymore. The profitability is the main condition to keep on having sustainable systems. It can mean to change the production system or to adapt the offer to the demand, and competitiveness will be found throughout a reduction of costs of production.

d) « The first money you earn is the one you don't spend »

« Why don't I plow ? Because I'm not wealthy enough… » *(American farmer)*

Direct seeding in permanent living cover is a way to make profit by limiting the costs of production. By avoiding plowing, most of the machinery hasn't any reason to be on the farm. It leads, amongst other things, to a diminution of the fossil fuel use and a diminution of the mechanisation expenses.

It was calculated that in a tillage system, fuel consumption is 10 liter/ha compared to 3,5 liter/ha for a no-till system. If we consider that the use of 1 liter of fossil fuel costs around 5€ for all the farming operations from the seed to the harvest, it means that for a farm of 100 ha, it would have been possible to save 32 500 € only by changing farming practices and without seeing a decrease in the yields.

Other savings can be realized thanks to an increase of the soil's fertility throughout more organic matter content which will help in holding nutrients and water.

e) Price maker instead of Price taker :

If we want a profitable system, the best way is to become price maker et non price taker. That means to be able to fix the selling costs so as not to be entirely dependant of the market changes.

To go until the finished product is a way to add value to the raw material produced on the farm. As a comparison, a "viticulteur" is a person who sells grapes to the cooperative whereas the "vigneron" is the person who sells the bottle of wine. Maybe the work more difficult because it means having marketing and management knowledge but it provides a very good added value to the initial product. If doing everything from A to Z may worry some producers, let's think about creating jobs for competent people who would love to help and work for you…

f) Don't put all your eggs in the same basket

To develop a new activity on the farm is way to diversify the production and not to be totally dependant of the hazards linked to one and unique production. If a diversification can bring more money to the farm, it is also a way to enhance the social life and contribute to the rural area dynamism.

To define profitable system, throughout a reduction of costs of production, a definition of prices and diversification allows farmers to make earn money and contribute to maintain alive rural areas, even in the most underprivileged ones

Inspiration for the future

« Imagination is more important than knowledge » *(Albert Einstein)*

The Polyface farms system, in Virginia, can represent a model for many farmers in their production system's conception.

On a technical aspect, he ensures the soil fertility thanks to adapted grazing methods such as « mob grazing » or « high density grazing » which consists, in summary, to put 365 animals on 1 ha during 1 day, instead of having 1 animal on 1 ha during 365 jours. In other words, it is not the area grazed which is important but the time of grazing

Once the grass was grazed by cows, he puts chicken in the field in a little house called "chicken tractor". These mobile henhouses are moved everyday or several times a week. By doing that, the chicken can be considered as free-range chicken and as they eat the worms which are in the cow's slurry, these chicken play a role in the reduction of parasitism.

Other tool : to aerate the compost by using pigs. As they love digging, he throws corn in the compost and the pigs dig so as to find corn and by the same time aerate the compost…

On an economical aspect, his costs of production are very low because it uses less and less inputs. He mainly focuses his work on marketing and by looking for a direct relation between his farm and the consumers. As he adds more value to his products, his gross margin is greater compared to system where the are many intermediates between producers and consumers. He also proposes farms visit and other products (t-shirts, books, etc).

On a social aspect, he contributes to maintaining the rural area as has created many jobs on the farm and accept people on the farm to come and see how we farm in the 21st century.

This is a simple and efficient system, which make us think and proves that agriculture, beyond providing food, can be a solution to social, environmental problems.

The Nuffield experience

This year was very rich in emotions, sharings, discoveries, learnings. A magic year from where we come back transformed and changed. It is a magnificent experience I can recommend to all those who would like to step back from the farm, to see the agriculture from a global point of view and to live beautiful human experiences.

Of course, this report and these lines can't totally explain by themselves the entire road which was done during this year.

As a conclusion, may these few sentences help and inspire all who would like to do new projects and to look forward :

- « Never let someone say : you can't » (Mark Inglis)
- There are only win-win strategies if you want to succeed
- You have 1 chance on 2 to fail…you have 1 chance on 2 to succeed !!
- Enjoy your job, you won't work anymore
- The right time to do something doesn't exist, don't wait for it, create it
- Be inspired by others, inspire others
- Imagine and dare : innovation and creativity for new solutions
- Help people to go forward, you will always be greater with someone on your shoulders
- If you want to progress, be prepared to change
- Don't worry about change : a butterfly is always more beautiful than a caterpillar

The Nuffield adventure doesn't stop to one year's study. With all the contacts established all around the world, with the Nuffield network, and the enthusiasm, it is easy to imagine another world and try to build a beautiful agricultural project which could lead to green the desert…...***« They didn't know it was impossible, so they did it ! »***

Agriculture is changing, it is at one of the major crossroads of its history, let's be a part of it with our imagination, ours innovations, our new ways of farming…

Conclusion

« The raindrop's brave is that it dares to fall in the desert » (*Lao Tseu)*

We have to stop treating symptoms instead of addressing the causes if we really want ot solve problems.
If we adopt new ways of farming, if we look at the big picture, agriculture provides plenty of solutions because it addresses directly the causes.

It's time for agriculture to play a double role : renew the natural resources without giving up its production's act.

Teaming with Nature, it's to restore existing resources, starting from the soil, which is the basis of our food, the basis of our civilisations, the basis of our humanity.

Teaming with Nature is to adopt an humble approach where man is in the system and not above it.

Teaming with Nature is to produce more with less. It means to apply principles which contribute to increase the production, to preserve the environment, to regenerate natural resources on a long term perspective and to ensure the profitability and the farmer's quality of life. Beyond, it is to maintain and give more dynamism to all the rural area, even the most unprivileged ones. It is to enable every human to have enough food to eat…

A global approach goes beyond the cultivated field, beyong the profitability, beyond agronomy or sociology. It includes all the parameters and promote an understanding of the system as a unique big part because the whole is always greater than the sum of its parts…

Think global, it's to understand that natural principles are universal, it means simple and easy to implement everywhere at any time. There are only billions of possibilities, solutions to imagine, to adapt to the climate, to the soil, to the kind of production, to the farmer's expectations.

Act local, it is to consider that there is no miracle solution, no ideal answer to a problem. Each farm is unique, each system of production has its own characteristics. Act local, it is to let to each person the choice of his professionnal project and to let him defining a system where he can thrive, because agriculture is above all a human adventure.

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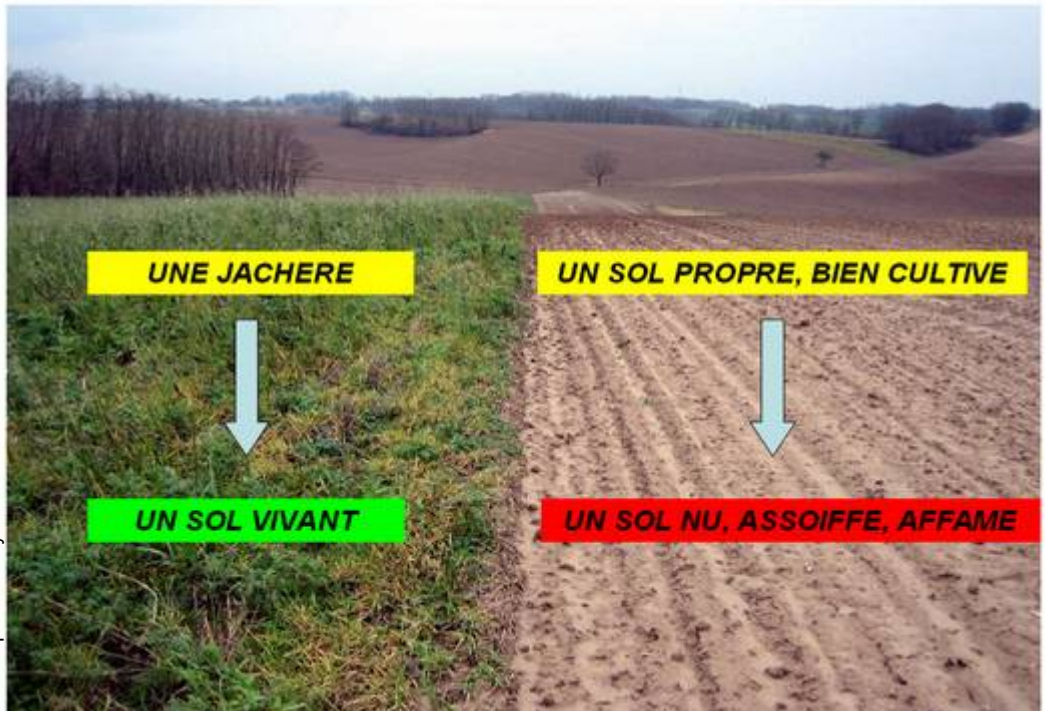
« Doing nothing, it is still to do something » **:**

Against old ideas **:**



Crédit photo : Ray Archuleta

Teaming with Nature by replacing… :

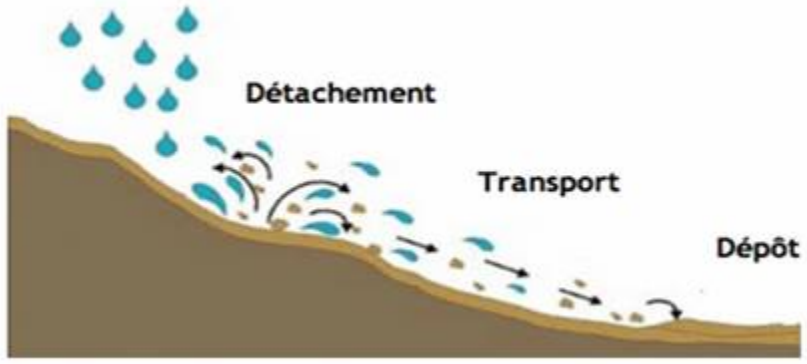
Iron with roots

Chemical fertilizers with nodules

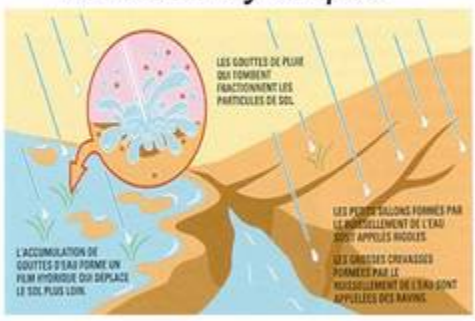
Insecticides with natural predators

Herbicides by a covered soil

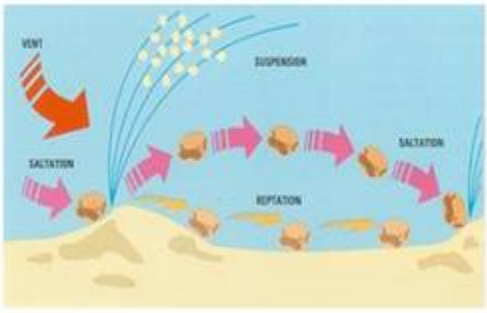
Erosion phenomenon



Erosion hydrique

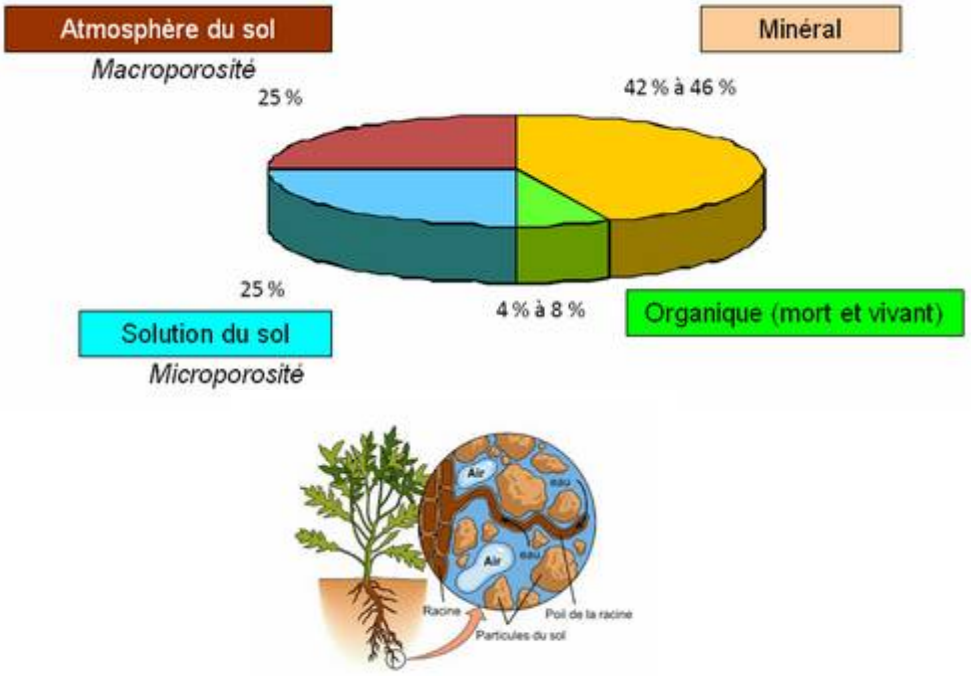


Erosion éolienne

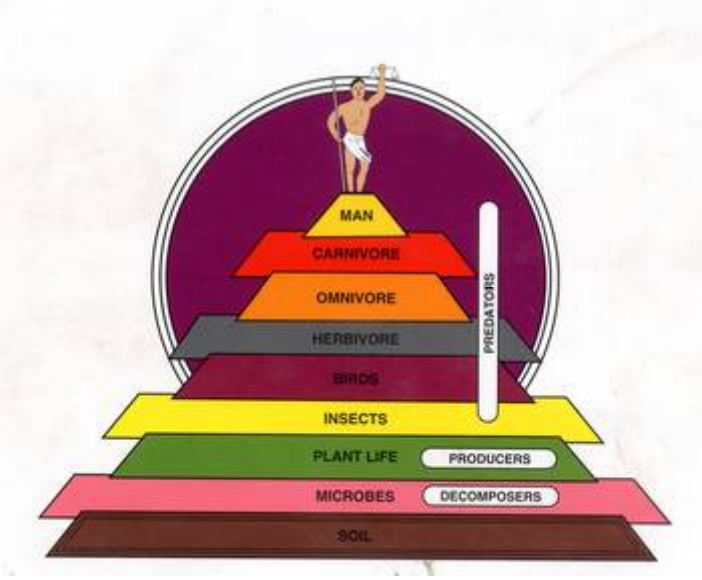


Soil's structure : 50 % of emptiness to ensure aqueous and gazeous exchanges

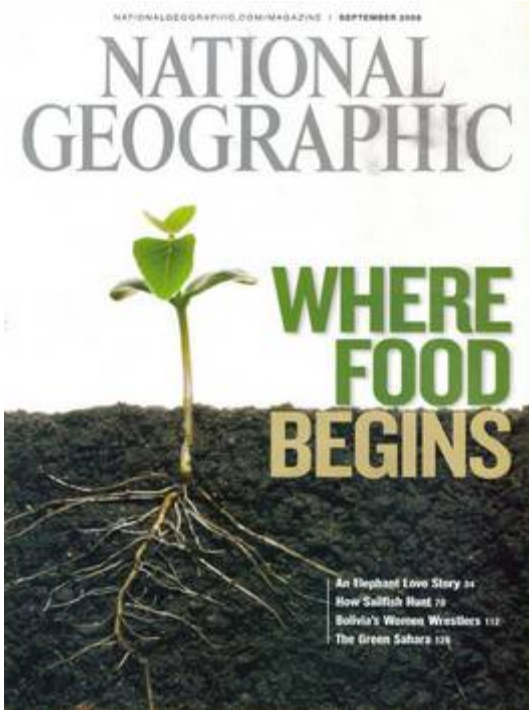
Crédit photo : M. Archambeaud



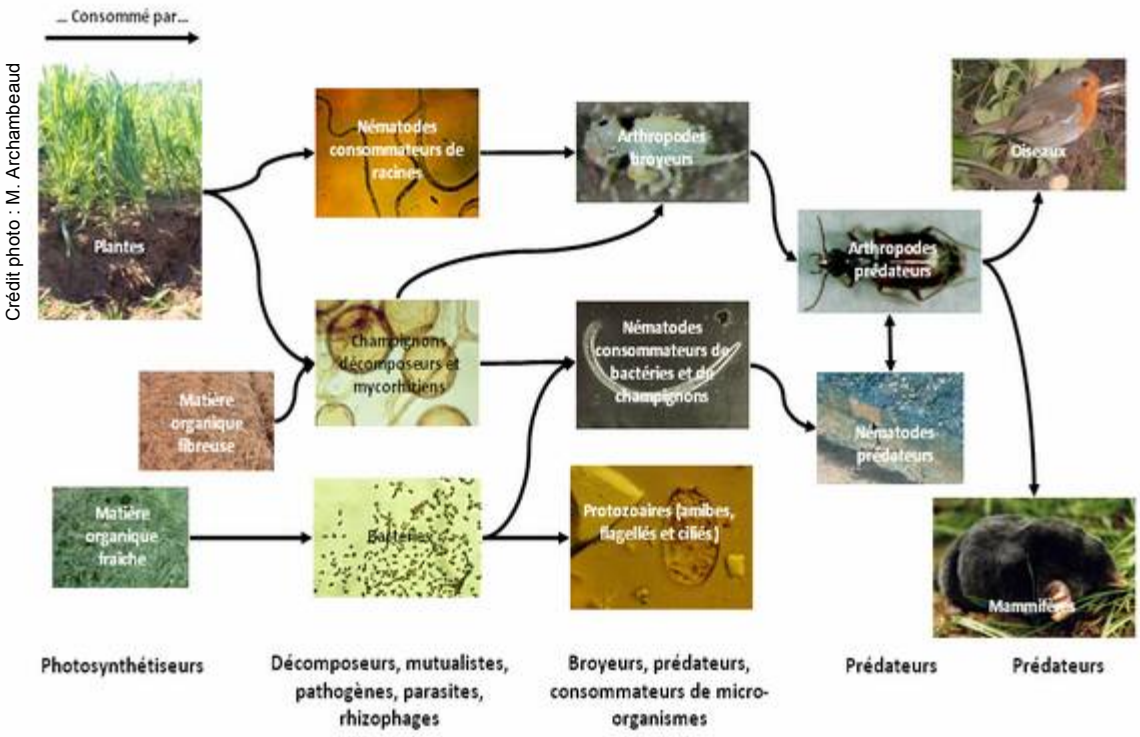
Soil : Basis of the trophic food chain



(Source : Albrecht : Soil Fertility and animal health)



Soil : a living place, an ecosystem in itself



Crédit photo : M. Archambeaud

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