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«A NEW FORESTED TECHNOLOGY FOR AGRICULTURAL PURPOSES; THE RCW TECHNOLOGY»

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A NEW FORESTED TECHNOLOGY FOR AGRICULTURAL PURPOSES; THE RCW TECHNOLOGY

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1• As time goes by, we better understand the world we live in. At the human level, the biology is our utmost concern. Nevertheless, our acquisition of new knowledge is so slow, over a millennium, to unfold our appetite for understanding what we are and the world into which we must comply with.

Basic forest historical approach

2• Looking at the importance of the forest on this planet, questions soon arose over its origin, constitution and basic mechanisms. These mechanisms are so important and mighty, that left alone nature will recover its equilibrium and building new ones all the time. Conifers were the first masters, but 60 000 000 years ago hardwood Dicotyledon trees became dominant.

A forgotten aspect: the soil biology

3• A literature review on agricultural land origins has shown that most agriculture developed from land covered by hardwood forest and found better to produce higher yields. There must have been good reasons to support this long lasting reality. Until recently all reasoning and findings were stemming from physical (climate, geology...) or chemical (basic nutrients assessed as such from their geological and physical origin), -standpoints, but biology was almost never taken into account.

The trail was blazed by a chemical perception

4• On the other hand, looking over the availability the two most important nutrients, nitrogen and phosphorus, it was clear that both were depending on biological processes to enter biological cycles for plant growing: nitrogen need biotrophic organisms for its fixation for protein building and phosphorus enzymes (also a protein) to be retrieved from strong chemical bonds with iron and calcium. For these purposes it was obvious that biology was blazing the trail of agriculture and forestry. At the end of the 19th century the chemical path was chosen because it was easier to control and could be, if necessary, by known chemical technologies.

From industrial residues to RCW technology

5• Back in the mid seventies, Edgar Guay, formerly deputy minister at the ministry of Land and Forest in Québec, Canada, began testing the possible value of conifer essential oil residues, as a sheet composting for potato growing. Results were outstanding.

6• A closer chemical and biochemical analysis of those residues rapidly showed high content of proteins, sugars, cellulose, hemicelluloses and lignins with many polyphenolic compounds.

7• Why this material has never been considered as a biological wealth for agriculture? No answer came neither from the scientists nor from this century scientific literature. We found no exhaustive biochemical analysis, but some common chemical ones. We also found no characterization nothing till on its production and availability throughout the world.

RCW first description

8• This new material was described in 1986 **(Lemieux, G. & Lapointe R.A.[1986])** and the name Ramial Chipped Wood **(RCW)** was then given. Only branches having less than 7cm in diameter, were concerned .In he past they were left on the ground to be burned or rot.

9• To be used properly, this material must be chipped and mixed with the top soil in order to initiate all the biological processes found in pedogenesis.

The predominance of hardwood RCWs over Conifers

10• After testing various tree species for their effect as RCW in the soil, hardwoods was found much better than conifer. Dominant climax hardwood forest species were found the best. These findings had to be included in various terms such as ecological, historical, geological, biological, evolutionary, biochemical so on and so forth...

The pedogenesis from forest origin

12• Actually, ecological and evolutionary term were taken into account and focused on a forgotten aspect; **the pedogenesis**, encompassing all level of concerns. Chemical and physical problems has been overcomed by a constant evolution of techniques in order to alleviate raising production and phytosanitary problems.

13• To understand the core of the question, we have published two basic studies on this **pedogenesis** question with regard to RCW technology **(Lemieux, G. [1996]** and **Lemieux, G. [1997]).** Forest is still managed by agricultural and productivity criteria while we are seeking a way to introduce for intensive sustainable productivity, and biologically wise forested criterion into agriculture.

Background of the RCW technology

Upgrading effects the second year

14• The first concerns dates back to 25 years ago when the first experiments on potatoes, wheat, oat and strawberries were conducted. It was then noted that evergreen RCWs were less effective in short term, than hardwood RCW. The upgrading effects were more important the second year and even over a longer period of time up to five years.

Agriculture developed from hardwood forest soils

15• It was obvious that RCW technology had a prime effect on soil structure and soil trophic chains responsible for the nutrient management and availability. Moreover, much more than chemical nutrients was expected and the difference between conifers and hardwoods RCW became a major concern. Under conifer forests soils are completely different from those under hardwood. How to explain that and what are the practical effects in economical and social terms? Why agriculture has developed primarily on the hardwood forest derived soils?

The guaiacyl and syringyl lignins

16• It was than noted that the lignin contents were different, with conifers guiacyl lignin has only one methoxyl ($0CH_3$) group on its benzenic ring while syringyl lignin dominant in hardwood, has two methoxyl groups. A major effect was perceived on pedogenesis for the carbon content of humic fractions.

Lignin depolymerization with enzymes

17• In 1989 **Leisola & Garcia [1989]** have proved interesting data on the role of some enzymes responsible for lignin depolymerization. From 1983 to 1989 several papers brought new light and knowledge on this respect in their attempt to bleach pulpwood for paper production through biological and enzymatic means instead of the regular chemical technic based on mercury later found in the sediments.

18• For lignin depolymerization the main enzyme is a lignoperoxidase dependent on manganese and responsible for the production of two different

molecules: the lower in weight is known as fulvic acid while the large one (300 000 daltons) is the humic acid. This enzyme is produced by Basidiomycetes mainly emerging from the tip of the mycelium. In such a processes the mycelium retains by adsorption the heavy weighted molecule, while the lighter one is released into the soil solution and degraded by the bacterial flora.

Humic acid, ECPs and the water stable soil aggregates

19• The humic molecule adsorbed cannot be repolymerized with the fulvic free one found in the transformation towards fat acids. This is most likely the basis for pH decrease, because iron precipitation is associated with a great affinity of iron and manganese, for polyphenols. In the meantime, high molecular weight humic adsorbed associated with extracellular polysaccharid from the fungus flora, is associated with the soil mineral fraction building water stable soil aggregates, being the core of brown soil productions.

Aggregates and the soil biology

20• Nevertheless, these aggregates are not permanent and become part of the food chain, namely for the microfauna. These water stable aggregates are also affording shelter to a great number of virus bacteria, fungi spores, etc. contributing to the biological stability. On the other hand these water stable aggregates provide a major contribution to the quality of the soil structure and mechanic resistance to soil compaction.

Polyphenols; a basic control over pedogenesis

21• It may look simple as possible but it is a complex world it also relates to polyphenol quality and what is basically the soil: **a polyhenolic matrix encompassing the mineral fractions, microflora and microfauna responsible for the plant mineral nutrition and soil life control**.

22• Whether dealing with light soil fraction such as sands, the polyphenols and polysaccharid are truly responsible for the aggregates formation, in which coarse soil fraction are integrated mechanically, without fertility effect, but with some physical ones. It is obvious that fungi, and mainly those from the Basidiomycetes family, are of prime importance into the soil mechanisms and pedogenesis.

Basidiomycetes, enzymes and soil structure

23• Basidiomycetes are good mychorhizae organisms, but *Glomus spp* fungi seem to be better. To be effective, mychorhizae must be phytotrophic. A good «organic matter» standard in the soil may also favor stability and interaction of

relevant fungus species. While producing ECP (Extracellular polysaccharids) according to **Tisdall & Oades,1982]** Basidiomycetes mycelium can develop at the tip a large number of enzymes and also act as a pipeline for carrying within the soil solution, many nutrients, namely phosphorus, the most precious one, water, ...etc.

Basidiomycetes: the base of biological soil fertility

24• With all these characteristics, the mycelium is the frame for microfauna enhancement, due to its sapidity as a niche for nutrient. is concerned, the Basidiomycetes are a food, a cement for aggregates and a basic soil enzymes producer. To do so, as all living organisms a source of energy is essential and is provided at two levels, first as food (from sugars, cellulose, poteins...) and second heat or light, or radiant energy. We suspect the radiant energy of being responsible for tropical soil degradation outside the forest canopy.

Challenging the no concept «organic matter»

25• Before going further, the term «organic matter» had to be reviewed to avoid some misunderstanding with RCW. Referring to basic pedogenetic mechanisms, RCW technology can bring light over the basic mechanisms involving nutrient control and physical structure of agricultural soil. The forest soil remains the absolute model developed by the nature itself over prehistoric times.

Back to some historical explanations of pedogenesis

26• In fact, conifer forest soil have different characteristics from the Dicotyledonous ones. The wood itself contains much more guayacil lignin, terpens and polyphenols and seems to play a key role. Pedogenetic mechanisms are different in their action: from podzolization if under dry or mesic conditions, or to peat if under humid or wet conditions.

Competition: elimination vs acceptance

27• Hardwood Dicoyledonous forest soils behave differently in regard to pedogenesis. From the historical and evolutionary standpoints, hardwood forests are younger with a mere 60 000 000 years when compared with the 300 000 000 years for the coniferous as underlined by **Godron and Lemieux G. [1998].** Instead of competioning by chemical means, as coniferous, hardwood forests use competition for a much stronger larger and diversified energy content into the soil and then use this improved environment to afford an incredible biodiversity whether for plants or animals.

An energy quality and availability problem

28• A major part of energy and biodiversity stands in the soil itself and is fed by energy going trough the trees metabolism. According to **Gosz, Holmes, Likens and Bormann, F.H. [1978]),** in clearcutting the hardwood forest in New Hampshire (USA) a loss from 15 000 Cal/m^2 to 3 000 Cal/m^2 was measured within a period of two years. This fast depletion of energy in the soil is taking place unless a constant energy flow from the tree canopy is available.

29• The brown rich and deep soils with high quality clay containing montmorillonite as an example are producing the best yields for agriculture and forestry. **But, let us recall that such a productivity is depending upon soil biology, nutrient and energy availability.** This system relies on constant renewal from the plants above the ground from a regulation of the energy flow as a food source for the microbial biomass and from the regulated radiant energy source within some seasonal fluctuations.

A biological contribution to nutrient and energy control

30• RCW used as a pedogenetic material tends to govern the most important dynamic mechanisms for regulating the energy requirements to favor microbial biodiversity and activity, and so replacing to some extent some phytotrophic ones essential to alleviate unavailability of important nutrients when required for high plant production.

The Boyarskaya project and its universal implications

31• The Boraskaya research project conducted with rye on a sandy poor soil have shown interesting results and most mechanisms have shown the potential and the economic response with RCW technology. As shown in trials, RCW from oak *(Quercus robur)* gave the best results as red oak *(Quercus rubra).* in Canada. Other species such as birch or aspen were less effective but nevertheless provided some remarkable contributions. The RCW effects on yields are improved when some forest floor litter at the rate of a few grams per square meter, is mixed with soil within the experimental plots.

The soil polyphenolic matrix

32• Two points must be underlined, one is the quality of branches and second, the cropping and chipping period. It was noted with rye that the tree leaves found into RCWs applied, have reduced the plant development. Then it is obvious that RCWs must be cropped during the winter time. More knowledge is needed to clarify clearly the role played by polyphenols found in the leaves over the microbial and enzymatic world in the soil. Once more the nutrient availability mechanisms are

involved. **This should ease the understanding of one of the most important base of RCW technology, the polyphenolic matrix of the soil and its dynamics.**

The tropical forest and the water cycles

33• The impact of RCW technology must be stressed in order to understand the evolution of tropical agriculture, where soil fertility relies on the forest only. The daily water cycles in the atmosphere are depending on the local forest microclimates. Water availability in the soil depends is closely related with the biology where fungi are the masters. Sapidity of fungi mycelium is of prime importance for feeding microfauna, regulating nutrient availability by their feces and decaying of their own bodies.

Trees «pumping» nutrients in their branches

34• Recent research into the canopy of the rain forest zone has shown that trees are behaving as «nutrient pumps» by storing more energy and nutrients in their branches and leaves rather the poor soil underneath, where a low quality clay, the kaolinite is found.

A reason for african desertification

35• During severe droughts in Africa the energy and nutrients flow are severely reduced close to nothing, This situation could be a reason to deforestation, where trees are becoming the most important competitors to crops, therefore to men.

36• My understanding of the tropical soils and their relative lack of productivity is mainly related to the biology able to renew fertility unless its quality and fertility is improved where telluric or geology phenomenon are taking place, such as volcanic activity. Under climatic regulated forest ecosystems in temperate climate, resources are made available for every level of life and consequently to productivity and stability.

A transfer from the forest fertility to agriculture

37• To conclude I must say that RCW technology is basically an efficient way to transfer the main forest features into agricultural soils with a sustaining impact on stability, nutrient availability through biological means over, namely nitrogen and phosphorus as far as a positive interference on insects in soils treated with RCW is concerned, for which there is more and more evidence.

38• Introducing into agriculture some forest soil characteristics should be coupled with genetic changes in a large number of plant species in order to benefit

from the better quality of soil. A shifting from low soil fertility taken for granted to a higher one should be of a major economical and sociological concern to all of us.

An academic need to improve knowledge

39• The first step should be undertaken at the university level and positive actions should be enhanced for harmony instead of a war where the philosophy is for fighting all «biological ennemies». Let us make Man and its biological environment good friends in a more convivial and harmonious world than ever.

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