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«RAMIAL CHIPPED WOOD: A BASIC TOOL FOR REGENERATING SOILS»

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RAMIAL CHIPPED WOOD: A BASIC TOOL FOR REGENERATING SOILS

by: Céline Caron

Most of the world's agricultural land has been claimed from the forest, with the exception of the Asian steppes, the South American pampas and the North American central prairies. The most fertile agricultural regions were once hardwood forests, especially climax oak forests. The link between the forest and cultivated fields has been forgotten. The lack of ecological foresight and care for the soil and its fundamental biology has devastating consequences. It is a major cause of the actual agricultural crisis. It is leading directly to economic bankruptcy and human starvation.

The only difference between a forest and a farm is time, which allows the growth of the crops to become usable or marketable. The shorter growing time required for farm crops partly explains why soil research has been directed mostly to managed agricultural systems. The misunderstanding of the natural forest ecosystems, especially the forest soils, is so deep that all silvicultural practices use agriculture as a reference model. In agriculture, as well as forestry, the entire focus has been placed on mineralization, with little work done on, or interest shown for, humification which regulates mineralization and fertility. The lignin of Angiosperms is central to humification and biological controls of fertility. It has a profound impact on most mesic soils through the multilevel life they bear.

A close look at a forest ecosystem shows a fast transformation of plant tissues into nutrients by soil microorganisms. Nutrients are bound to the organo-mineral complex and are made available as needed for plant growth. In temperate forests, under a deciduous tree canopy ,this organo-mineral humic complex is stable within an internal biological cycle. It becomes fragile under tropical conditions. It has several roles and therefore must be closely examined.

The ramial chipped wood (RCW) story began in the mid-seventies when Mr. R. Edgar Guay, former Land and Forest deputy minister in Québec, began searching for new products that could be derived from the huge piles of residues remaining after logging operations: the branches. He linked two techniques: the sheet-composting method, developed in the USA, and the brush-composting method, developed by Jean Pain in France. The first field experiments with ramial wood from deciduous tree trimmings were made during the 1978 summer drought using the sheet composting method.

A first set of chemical analyses has shown a good balance of proteins, celluloses, lignin, sugars, starch, pectin, including most chemical nutrients. The C/N ratio ranges from 30/1 to 150/1 while stemwood C/N ratio ranges from 400/1 to 750/1. The research was pursued with enthusiasm and led to unexpected results. The soil-upgrading science was born, based on pedogenesis concepts.

A research team nucleus was formed, with Mr. Lionel Lachance and Mr. R. Alban Lapointe joining Mr. Guay. In 1982, Professor

Gilles Lemieux, from the Faculty of Forestry at Laval University, was asked to provide answers on the mechanisms involved. Scanning scientific literature for clues has shown no conclusive results. Koslwosky and Winget (1964) paid attention to the nutrient content of branches with no other concerns. Nothing was found in the literature on chipped branches and their contribution to agricultural-soil-upgrading mechanisms.

The name and description of «ramial wood» was given in 1986 (Lemieux) under the French name of «bois raméal». Since the method put forward by Guay, Lachance & Lapointe (1981) was based on chipping, this «new material» was then called *«Bois Raméal Fragmenté* or BRF» in French, *«Ramial Chipped Wood* or RCW» in English (1992), *«Fragmentiertes Zweigholz* or FZH» in German (1992), *«Madera Rameal Fragmentada* or MRF» in Spanish (1994), *«Aparas de Ramos Fragmentados* or ARF» (1993) in Portugese and *«Ramoscelli Frammentati* or RF» in Italian (1993). "Ramial wood" refers to twigs having less than 7 cm in diameter. They contain soluble or little-polymerized lignin, the base for soil aggregates and highly reactive humus. These small-size branches are not used as firewood, even in the poorest tropical countries.

Although fungi are most important for humus formation and cycling, the humic system performs best when fungi are associated with the fungivore soil mesofauna. This process, linked to virus, algae and protozoa, makes nutrients available when needed by plants.

The basic mechanisms lie in the role played by «white rots» which use enzymatic systems to produce both fulvic and humic acids from lignin, the base for aggregate formation (Leisola & Garcia 1989). The best results are achieved with deciduous trees due the chemical structure of their lignin. Evergreens perform poorly, due to the transformation of their lignin by «brown rots» which produce polyphenols and aliphatic compounds (Swift [1991], Larochelle [1993]).

Fifteen years of continuous experiments in both forestry and agriculture provide the following facts:

• Ramial wood has both non-polymerized and soluble lignin (Lemieux 1993);

• The total amount of lignin related to cellulose is much higher than in stemwood;

• Chipping or crushing ramial wood encourages fast entry of soil microorganisms, enabling both nutrients and energy to be transferred to the humus complex (Lemieux 1993);

• This upgrading process leads to three types of organic matter: inherited, soluble and organo-mineral aggregates (Toutain 1993).

The «Groupe de Coordination sur les Bois Raméaux» now has a membership of fifteen scientists from various fields of the scientific community. Data from various experiments has been collected over the years. Some results are being released. The most promising observations from a 350-plot experimental site are:

• Better soil water conservation

• A pH increase from 0.4 to 1.2 within two years
• A yield increase ranging from 30% to 300%
• A noticeable increase in frost and drought resistance
• More developed and highly-mycorrhized root systems
• Fewer and less diversified weeds
• A decrease or complete elimination of pests
• Enhanced flavor in fruit production
• Higher dry matter, phosphorus, potassium and magnesium content in potato tubers
• A soil turning from pale to deep brown in the same season
• Selective natural germination of tree seeds
• A thick moder turning into a soft mull under a sugar maple canopy.

AGRICULTURE

Experiments with RCWs on wheat, oats, potatoes and strawberries in the late seventies have shown spectacular results with regard to yield increase, water availability, pest and disease control, as well as frost and drought resistance. In addition, the soil has evolved towards an increase in organic matter, pH values and nitrogen availability. After a single application of $200m^3$/ha, the soil-upgrading beneficial effects can be clearly perceived ten years later.

Under tropical conditions, a set of experiments with the bitter tomato *(Solanum æthiopicum),* using RCWs obtained from *Casuarina equisetifolia,* gave even better results in Sénégal (Seck 1993). Fruit yield doubled within a period of 43 days . Fewer weeds were reported, as well as a decrease of more than 50% in water needs and, moreover, a complete control of root nematodes, the worst and most costly pest in garden vegetable growing.

Experiments are underway in the Dominican Republic with various crops such as bananas, strawberries, coffee, grapes and reforestation projects, using local species of trees for RCW production.

Another project, established recently on the high plateau of the Bouaké region in Ivory Coast with maize and dry rice, is giving astonishing results in a rather short span of time.

Similar effects on soil and crops occur in both tropical and temperate climates, the latter being more spectacular in the short run. The soil upgrading effect of RCWs arises from the microbiological process. It is a universal pedogenetic process which deals with humification first with emphasis on nutrient management and availability as well as storage for plant needs. Adding RCWs to agricultural soils allows the recovery of all typical biological, chemical and physical features of forest soils lost by the suppression of the forest canopy.

FORESTRY

Thirty experimental plots were established in the spring of 1983 on an open sterile soil known as such for half a century, surrounded by a mature balsam fir/white spruce forest. In 1985, another 30 plots were established under a sugar maple canopy (Lemieux & Toutain 1992). Some major points must be underlined:

Under forest canopy

RCWs from a high-quality sugar maple stand were used. In mid-summer, all litter from the previous fall was integrated into the soil ecosystem. Some minor changes in vegetation were noticed after four years. Humus status has completely changed from a thick moder to a mull after five years, reversing the podzolic process to a brown soil. Species from rich stands such as red oak, sugar maple, beech, yellow birch, linden and ash, gave much better results than those from poor-quality stands such as red maple or trembling aspen. A mixture of species is preferable.

On sterile degraded soil

- New seedlings of various local tree species appeared between the third and the fifth year.
- The seeds came from the surrounding forest ecosystem.
- RCWs from rich stands gave better results in terms of regeneration than those from poor stands.

• Depending on the species used, all from the same rich stand, some RCWs promoted deciduous tree seedlings while others gave conifers, mostly white spruce *(Picea glauca)*.

Ten years of observations and measurements is a short period of time in the life of a forest ecosystem, but they bring to light some fundamental questions and answers. The humic system is involved, an element never taken into account in any management plan.

METHODS AND TOOLS

The basic methods called «Sylvagraire» for agriculture and «Sylvasol» for forestry are better known. They give the best low-cost results. RCWs must not be composted nor ploughed under but spread in a layer not thicker than 2.5 cm, 1.5 cm being the optimum. The upgrading mechanisms best perform when RCWs are mixed with the first 5 cm of the topsoil.

The fundamental mechanism relies on massive entry of soil microorganisms into the twigs; therefore, chipping or crushing them is necessary. Effective for twigs less than 3 cm in diameter are pruning shears, machetes and brush axes. The material can first be cut into 15 cm lengths, then the pieces bruised, scarred, scraped, beaten or raked with a large, sharp hoe-type mattock to provide as many entry points as possible to speed the proliferation of microorganisms as soon as RCWs are spread. Softwood branches can also be pounded with a rock. A second-hand forage harvester does a good job on farms. Chipping or crushing can be custom-made or chipping devices collectively owned. Many types of chipping devices can be found on the market.

Mechanized chipping is costly in both labour and money. Fifteen hours are needed to produce enough RCWs for a surface application of 150 m^3/ha, the quantity needed to enhance the quality of soil and crops for the next five years under temperate climate conditions. A RCW soil amendment should be perceived as an investment, redeemed over a period of 10 to 15 years.

Two projects are now underway to improve machinery for forestry needs, reducing the chipping costs of slash from 2 000 Can$ to less than 800 Can$ per hectare. Chipping on site offers several advantages including reduction in forest fire hazards while enhancing soil quality and productivity. It is the most efficient and the least costly soil-conservation practice one can foresee so far.

RAMIAL CHIPPED WOOD SOURCES

Trimming trees along public roads produce between 200 000 and 300 000 tons of RCWs yearly in Québec and no access cost is involved. Two large public companies, Hydro-Québec and REXFOR, both in Québec, produce an abundance of RCWs. An effective collection and distribution system must be put in place to use these RCWs wisely for soil regeneration.

With modern forest operation techniques, the whole tree is removed from the site. This practice seems to be more economical at the moment, but it is not in the long run and is unsustainable. Ramial wood must be chipped and spread on site as part of every tree logging operation. Burning ramial wood, letting it rot in piles or burrying it in landfills is a tremendous waste of a highly valuable organic matter.

Using ramial wood does not mean the destruction of the remaining natural forests nor the reduction of the turnover process by clearing the understory brush. It means bringing slash residues to a new life as a source of energy and nutrients instead of burning them. It also means intercropping with deciduous shrubs and planting hedges around cultivated fields. Adding RCW production to the many benefits of hedges could become part of any farm operation, especially where farming is not associated with livestock. Importing animal manures or growing green manures is expensive and only deals with mineralization, while RCWs deal with humification and nutrient management and are more valuable over a long period of time. Local small-scale reforestation for RCW production can be envisaged for gardening and horticultural purposes. Coppicing trees might also be a source of RCWs in some countries.

CONCLUSIONS

Branches and brushes were always perceived as a sign of poverty for centuries and as trash in the modern forest economy that has developed during the last century. A first assessment of small branch production shows a mere 100 000 000 tons per annum for Québec alone and probably billions of tons throughout the world. Small-diameter branches can be transformed into a «soil food». Feeding soil microfauna and microflora is more likely to bring mid- and long-term benefits to both agricultural and forest ecosystems in redeeming costs and increasing benefits. RCWs represent the only large-scale upgrading technology. It involves a large number of shrub and tree species resulting in variable responses, all positive with regard to enhancement of the humic system. RCWs bring the benefits of the forest soil to the agricultural soil at the lowest possible cost [Lemieux, 1993].

Agricultural land was «extracted» from the forest. The forest can now help degraded soils by keeping them alive and microbiologically diversified. Ramial chipped wood is a good tool available to all societies, even the poorest, to reverse soil degradation and desertification. As we are now aware of the major role of RCWs upon the formation of a highly reactive humus system, our attitude toward the forest will have to change. Instead of depleting our natural forests as we now do to grow commodity trees, we must grow «forest ecosystems» and tend them like perennial gardens. From an enemy, the forest must become a friend. From a resource to be exploited for immediate profit, it must become the source of infinite wealth.

RCWs must be carefully looked at in both the southern and the northern hemispheres. More than 75% of nutrients are stored in twigs. Twigs are the center of life, stemwood being the result of the whole crown activity. Twigs, once chipped and brought in close contact with the soil, momentarily replace the rootlets that are constantly transformed into short-lived aggregates by the soil microorganisms. These aggregates are the managers of soil nutrients and energy for the ecosystem's own sake. They enable biological actors to play their vital role, from virus to mammals, using available energy and nutrients. It is of prime importance to understand and visualize the whole picture and the role played by each actor in this formidable evolution of nature's work from which we now benefit after so many millions of years.

Time has come for large-scale worldwide organizations to deal with planetary problems. RCWs are the key to understanding the biological basics of our terrestrial ecosystems. They allow for scientific experimental methods to develop. There is no doubt concerning the value of RCWs and their positive impact in pedogenesis, which is a universal process. This universal biological material will have a direct effect in the short term as well as in the long term on soil, crops, economy and on both human and animal societies. It will be seen as one of the most important biotechnological contributions of this century [Lemieux (1993)].

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