Ramial Chipped Wood:
the Clue to a Sustainable Fertile Soil

by

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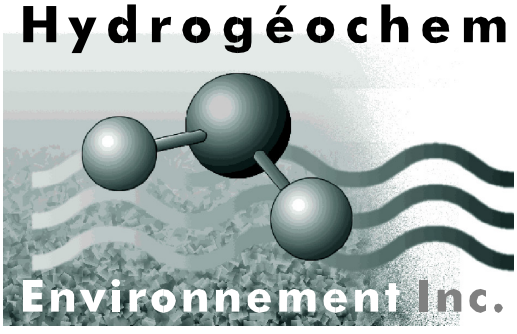

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1 Technique of Ramial Chipped Wood

1.1 Theory

The technique of Ramial Chipped Wood Technique (RCW) is in fact the "technique of the forest". This technique, developed by the team of Prof Lemieux, Laval University, is a 'copy' of the way the forest generates soils.

Why ramial wood? The theory of humus formation in the forest grounds starting from polyphenols is well-known. Therefore, given that ramial wood contains lignin (family of polyphenols), this material added to the ground is the raw material to generate humus. In fact, tests in Belgium by Noël (2006) show that for equivalent quantities of manure and RCW to increase the rate of humus by 1% would take 50 years with manure and only 10 years with the RCW.

Studies have shown that the branches of hardwood species increase more the soil fertility in comparison to those of conifers. This difference is likely due to the type of polyphenols present: lignin syringyle-guaïacyle for the hardwood species *versus* lignin guaïacyle for the coniferous trees (Stevanovic, 2006).

Moreover, the branches, which make the RCW, represent the richest part of the tree. They contain 75% of minerals, the amino acids, proteins and catalysts (Noël, 2006).

It is thanks to the fragmentation of the branches that the Basidiomycetes[1] can start the process of biotransformation because the fibers were hitherto protected by the barks. The invasion of the fibers by the mycelium of the fungus is essential, or else in fact the bacteria such as Actinomycetes[2] will colonize the "ground", prohibiting the access to the Basidiomycetes. The latter are the only able ones to produce the enzymes, which are at the base of the biochemical degradation of lignin in the process of biotransformation. The branches must be fragmented up to 5 to 10 cm length (Figure 1).

[1] **Basidiomycota** is one of two large phyla, that together with the Ascomycota, comprise the subkingdom Dikarya, which were in general what were called the **"Higher Fungi"** within the Kingdom Fungi. (Wikipedia)
[2] The **Actinobacteria** or Actinomycetes are a group of Gram-positive bacteria. Most are found in the soil, and they include some of the most common soil life, playing an important role in decomposition of organic materials, such as cellulose and chitin. (Wikipedia)

Figure 1. RCW obtained using a commercial wood chipper

RCW is a powerful bio-stimulator; during the first six months following its incorporation to the the soil, all categories of microorganisms, including fungi, are bio-stimulated (Figure 2). For the fungus, the bio-stimulation can be up to 10 times and this for a period of one to two years. The fungi, in particular the Basidiomycetes, are the main actors of wood decomposition. Come then the intervention of the pedofauna on the recycling of the nutrients and the decomposition of the organic matter (Noël, 2006).

The natural cycle of nutrients is stimulated by the input of RCW; this cycle allows food plants to meet the demand and avoids the losses and pollution from nitrates. The RCW stimulates the development of fungi, which capture dissolved inorganic nitrogen during their growth. The hyphae[3] of fungi are then grazed by microarthropodes of the pedofauna that feed bacteria by their feces. Finally, the bacteria in the rhizosphere release nitrogen and other nutrients to the plants (Noël, 2006). Among the microfauna, there are the ground worms, whose action is of primary importance. They multiply since the incorporation of RCW what increases the capacity of infiltration of water in the soil, thus limiting erosion. In short, this is how the trophic chain is created in a soil with RCW (Figure 3).

[3] A **hypha** (plural **hyphae**) is a long, branching filamentous cell of a fungus. In fungi, hyphae are the main mode of vegetative growth, and are collectively called a mycelium.

Ramial Chipped Wood, as organic amendment, can therefore restore microbial life in soil by providing direct energy, nutrients, as well as the habitat necessary for the development of the trophic chain in soil. In addition, this amendment promotes the formation of humus, which helps retain water and perhaps even to manage its fluxes.

This high microbial diversity (indigenous) in the soil is a guarantee for a perpetual healthy soil and crops (Shen, 1997).

Figure 2. Fungi decomposing wood chips and humification (Germain)

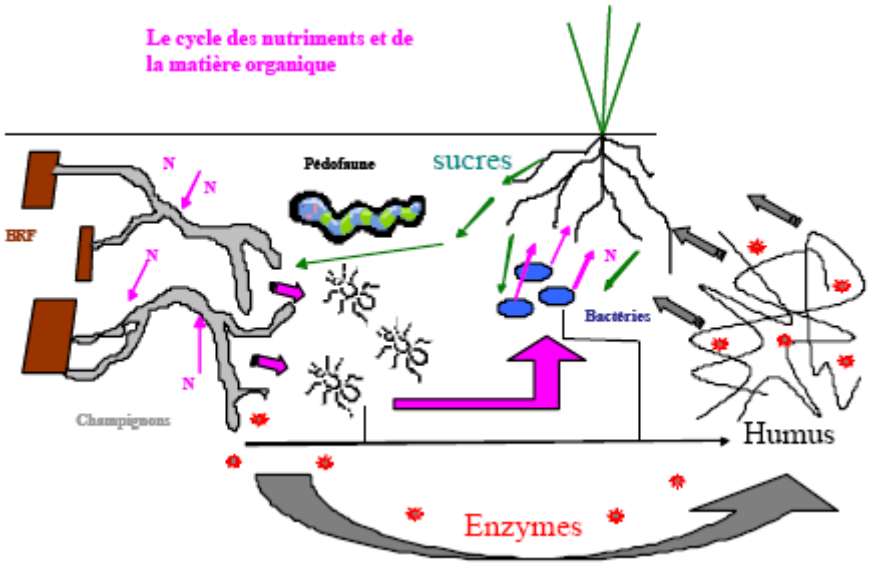

Figure 3. Nutrients and organic matter cycle

Note: Organic mater identified as BRF for (Bois Raméal Fragmenté; Noël, 2006)

1.2 Results with Culture on Ramial Chipped Wood

Since the beginning of the 80's, several studies made it possible to develop the technology of the RCW in agriculture and forestry (Lemieux, 1985; Beauchemin *et al*, 1990; Larochelle, 1994; Lemieux and Lachance, 2000; *etc*.). These researches have shown:

- An appreciable water economy - four times less water for RCW plots versus reference plots for forestry plants (seedbed) in Burkina Faso (Zongo, 2007);
- Twice less water for plots with RCW versus the reference plots - project in Senegal (Figure 4); plus a significant decrease of parasitic nematodes solanaceous observed in soil with RCW (Seck, 1994)
- A significant increase in the resistance of the cultures to dryness;
- A retention of mineral nitrogen in the soil;
- The production of corn increased by 400% in tests in Ivory Coast and Dominican Republic;
- An increase in the biomass of 300% in the case of the strawberries and about 30% the content of dried matter of potatoes in Canada.

Publications on this technique can be obtained in pdf format at the following URL:
http://www.hydrogeochem.qc.ca/pages/publications_gcbr.html

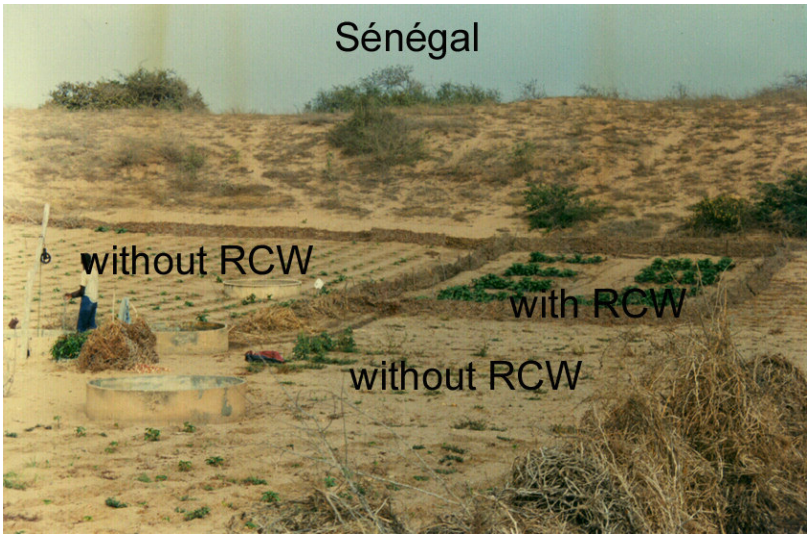

Figure 4. Tomato plots in Senegal: with and without RCW

2 Appendix II - Application

2.1 Tree Species, Harvesting, and Size

Various forestry species under studies have shown that the best results were obtained with climax tree species, namely maple, oak, beech… having a high lignin content. The tree species such as paper birch, poplar, aspen, have a lesser degree of efficiency. In the northern hemisphere, conifers did not favour the formation of suitable agricultural soils. As far as, pine, spruce, and fir are concerned, they cannot be used at a rate exceeding 20% of the total.

Under temperate conditions, the harvesting of RCWs is at best from October to March, when the access is easy. Deciduous high lignin content climax species have to be harvested during this period. During that time, the RCW is in good quality and can be protected from alteration by composting since temperature is low.

Under tropical conditions, the RCW harvest occurs when polyphenols with weak hydrolysis potential is at its peak, *i.e.* at the end of the raining season, favouring the biotransformation. Otherwise occurrence of non-hydrolysable polyphenols will take place, bringing the entire process of pedogenesis at a standstill.

In most cases, the tree species will not have been tested. Therefore, field and laboratory experiments will be required to evaluate the quality of various ramial woods from available tree species (including physicochemical properties). In practice, however, one can estimate the more suitable species on the basis of ecology where trees are in association with higher plants.

Under temperate climate, the RCW is generally without leaves. Under tropical climate, however, experiences have shown that leaves must necessarily be incorporated to RCWs, in order to avoid important zinc deficiencies.

The branches used for RCW must have a diameter less than 7 cm. The length of the RCW can reach between 5 and 10 cm.

Numerous chippers can be used for chipping ramial wood. A Canadian company has developed specific chippers for RCW (Ginove: http://www.ginove.ca/index_fichiers/page0026.htm).

2.2 Spreading and Soil Incorporation

To spread the RCW, one can use a manure spreader or by hand using a rake (Figure 5) for small garden. The recommendation rate is 150 m^3/ha, which means a layer of 15 mm. Once in place, RCWs are incorporated into the soil at a depth of about 10-cm, because the Basidiomycetes fungi

need aerobic conditions. The mixing with the soil done by harrowing, or preferably with a chisel device is of great importance for the phosphorus metabolism, which depends on two enzymes: alkaline and acid phosphatases found in the microbial biomass including RCWs. A significant influence was noted on the nitrogen availability on fixation as nitrate and ammonium, and on the role of mycorhyzea dealing with phosphorous biological retrieving into the fungus tissues and required by the plants. According to Neher (1999), good soil management will achieve relatively balanced fungal and bacterial components and reduce fertilizer requirements because the processes of nutrient mineralization and decomposition will be maintained by soil organisms at sustainable levels. The soil mixed with RCW need also to be well drained, otherwise the biotransformation mechanisms will be reduced as well as the expected advantages, associated to the process of soil formation.

The RCW technology is closely related to soil formation and reacts with all parameters including its action in time. Thus, additional inputs are required at regular intervals; similar to forest soils reclaiming annually twigs and leaves falling on the soil with small roots to be metabolized by grazing arthropods. In general, 75 m^3/ha of RCWs should be applied every three years.

Figure 5. Spreading RCW with a rake

2.3 The Forest Litter Addition

Research studies have proven that Basiomycetes are not found in cultivated soil and also the trophic chains are reduced to a minimum. Several organisms (fungi and symbiotic bacteria, microarthropods, insects, *etc*.), essential to the RCW transformation, are not found in cultivated land and they have to be reintroduced. An addition of 10-20 g of forest litter per square meter is sufficient to reintroduce the organisms. This matter can be removed from an old growth deciduous climax forest stand or something close to it, at a depth of 5 cm under the dead leaves just prior to the spreading of RCWs and so preventing drying.

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