Ramial Chipped Wood: the Clue to a Sustainable Fertile Soil

by

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Foreword

This paper has been written in order to fulfill a request from the Inter-American Development Bank, Washington DC, USA. Dr. Germain and I, in order to respond, have made some efforts for illustrating the RCW Technology and compare with both chemical fertilizers and composts over the results achieved.

This was also written in the framework of a new project we are seeking for Central America and where women stand in the center of our concerns. Those comments should bring some enlightenments on our worries and what we aim at.

Professor Gilles Lemieux
Université Laval
December 2000

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Project rationale and objectives

Close to forty percent of the world's agricultural land is seriously degraded, which could undermine the long-term productive capacity of those soils. Plus, the economic and social effects of agricultural land degradation have been much more significant in developing countries than in industrialized countries. However, they are the regions where the greatest growth in food production will be needed, and where such growth will be the most difficult.

According to Gardner and Halweil (2000), in rural areas of Africa, Latin America, and Asia, 80% of the food is in fact produced by women. Yet women have little or no access to land ownership, credit, agricultural training, education, and social privileges in general…

This project could partly solve those problems. The main objective is to implement a new technology, known as ramial chipped wood (RCW) for establishing a *sustainable* fertile soil. The implementation will be based on an agricultural training for women already interested in farming.

The second goal is in favor of farmers mastering the new technology where its implementation will be under the responsibility of agricultural advisers.

The third objective is to have regional scientists or scientific groups in charge to maintain a close cooperation between the development of RCW technology and the local agricultural advisers.

Degraded Agricultural Lands Threaten World's Food Production Capacity

(section taken from IFPRI, 2000)

Nearly forty percent of the world's agricultural land is seriously degraded, which could undermine the long-term productive capacity of those soils, according to scientists at the International Food Policy Research Institute (IFPRI), who carried out the most comprehensive mapping to date of global agriculture.

"The economic and social effects of agricultural land degradation have been much more significant in developing countries than in industrialized countries," says Dr. Serageldin, World Bank Vice President for Special Programs and Chairman of the Consultative Group on International Agricultural Research (CGIAR). "These are precisely the regions where the greatest growth in food production will be needed, but where all indications are that achieving such growth will be the most difficult."

"Halting the decline of the planet's life-support systems may be the most difficult challenge humanity has ever faced," said Jonathan Lash, World Resources Institute (WRI) President. According to Dr. Per Pinstrup-Andersen, IFPRI Director

General, these threats to the world's food production capacity are compounded by three disturbing trends:

- 1.5 billion additional people will be on the planet by 2020, almost all in poorer developing countries;
- the natural fertility of agricultural soils is generally declining; and
- it is increasingly difficult to find productive new land to expand the agricultural base.

Soil degradation, including erosion and nutrient depletion, is undermining the long-term capacity of many agricultural systems. One of the most common management techniques used to maintain the condition of agroecosystems is the application of inorganic fertilizers (nitrogen, phosphorus and potassium) or manure. Too little can lead to soil 'nutrient mining' (amount of nutrients extracted by harvested crops is greater than the amount of nutrients applied), and too much can lead to nutrient leaching (washing away of excess nutrients contaminating groundwater and surface water).

The findings of significant losses of soil fertility from IFPRI analysis of nutrient depletion in Latin America and the Caribbean are consistent with other sub-regional studies from Sub-Saharan Africa, China, South and Southeast Asia and Central America.

The unprecedented scale of agricultural expansion and intensification raises the growing concern over the vulnerability of the productive capacity of many agroecosystems to the stresses imposed on them by the intensification of agriculture. Can technological advances and increased inputs continue to offset the depletion of soil fertility and fresh water resources? As soil fertility reduces and water becomes scarcer, what will be the impact on food prices?

Competition for water

Competition for water will further magnify constraints to food production. According to Sandra Postel of the Global Water Policy Project, today some 40% of the world's food comes from the 17% of cropland that is irrigated. Of all the vulnerabilities characterizing irrigated agriculture, none threatens most than the depletion of groundwater resources. In fact, overpumping of aquifers in China, India, North Africa, Saudi Arabia, and the United States exceeds 160 billion tons of water per year. Since it takes roughly 1,000 tons of water to produce 1 ton of grain, this is the equivalent of 160 million tons of grain, or half the U.S. grain harvest.

The largest single groundwater resource deficits are in India (104 billion cubic meters per year) and China (30 bcm), and these deficits are growing. In India, where more than half of all children are malnourished and underweight, a shrinking harvest is likely to increase hunger-related deaths. David Seckler, Director General of the International Water Management Institute in Sri Lanka, estimates that a quarter of India's grain harvest could be in jeopardy from groundwater depletion. In China, under the north plain, which produces 40% of the country's grain harvest, the watertable is falling at a rate of 1.6 m a year. As aquifer depletion and the diversion of water to cities shrink irrigation water supplies, China may be forced to import grain on a scale that could destabilize world grain markets. (Brown, 2000).

In summary, we are facing two major problems: *soil degradation and water scarcity and quality*.

The soil: a fragile environment

The main soil characteristic is found by integrating life to the mineral world. One of fundamental processes, ignored until recently, is the biotransformation of organic matters in soils where the lignin Syringyl (type of polyphenols) plays an essential role, as well as other numerous polyphenolic compounds (Stevanovic-Janezic, 1998). The biotransformation is only the beginning of a long process in soil formation, which rules the life, the nutrients availability, the soil physical structure, the erosion resistance, and above all protecting and stimulating various steps of animal, bacterial and fungi life of the soil as major contributors to pedogenesis.

Therefore, the RCW soil, an exceptional resource, is able to remain stable and fertile as long as the basic elements stay active, which are lignins and diverse biochemical components stemming from biotransformation of organic tissues. They all maintain biodiversity and soil structure by dynamic processes of biological origin.

The chemical and biochemical characteristics of the soil are not properly valued and unfortunately too often exhausted. The soil limits are of biological order, and this lack of understanding may explain its degradation. In fact, the soil biological characteristics are playing an important role in particular in the nitrogen and phosphorous availability, as well as in water regulating and carbon sequestration. On this planet, the life of billions of people lies on this unique resource, which is the soil, but not on plant productivity.

The forest contribution to soils formation

The forest is playing a key role in the soils formation. The land used for growing crops under temperate climates are almost exclusively of forest origin. As the forest have produced soils of good agricultural value, why not refer to forest now? Numerous studies by the Coordination Group on Ramial Wood, under Prof. Lemieux, at Laval University, Québec, Canada, have shown that forest soil characters can be transferred to agricultural soils, and provide high yields and more important stable soil fertility (Lemieux and Lachance, 2000).

The main character of soils under forest lies in its structure, based on polyphenols, which aromatic rings are highly energetic. The byproducts of metabolic activity are stocked as energy and nutrients. Nevertheless, the most active elements are located in the ramial parts, which produce buds and leaves and, in numerous cases, fruits. *By returning into the soil these "ramial wood chips" rich in energy through biotransformation, they can renew, rehabilitate and, most important, reconstruct the degraded soils. In these soils, the fundamental mechanisms are found and can rebuild a fertile soil where no other modern technology has yet succeeded.*

What is ramial chipped wood?

The RCW have nothing in common with traditional organic matter such as compost. RCW have an impact on the short, medium and long terms global structure of the metabolism and of soil biology. The soils components (minerals, distribution of energy, biochemical, chemical, and biological components) are integrated with the microorganisms in such a way that nutrients are available to the plant request but firstly ruled by fungi instead of bacteria.

RCW are made from tree parts, branches, twigs and leaves rich in nutrients, sugar, protein, cellulose, and lignin, which all play a precise and specific role in the formation and maintenance of fertile soils. This is not the case for barks, trunk wood, sawdust, wood shavings, and all industrial waste material, *etc*.

RCW are the support for the soil stability and durability because they contribute to the soil structure and to the main biological characteristics. Thus, they contribute also to biodiversity by managing all the factors involved only if an energy source of low degradation rate is present such as polyphenols, whose the lignin syringyl and also the guayacyl are the most important under our climate. Fertility can be defined as an increase in soil efficiency of all soil parameters over a long period of time, rather then under the restrictive way of an immediate release of nutrients.

We don't yet fully understand the behavior of RCW and how to optimize its use. Nevertheless, as most research works are dealing with nutrients, particularly with nitrogen and phosphorous, the polyphenols and their implications remain essential to study. Despite limited studies, many enzymes are known to play an important role in the biotransformation into the decomposition processes. The lignin fractions of the wood, guaicyl and syringyl - two important polyphenols, and the condensed tannins (proanthocyanidin) are playing a vital role in soil formation. They are associated to Basidiomycetes fungi, which in turn are acting simultaneously as enzyme producers and food suppliers, in the form of fulvic and humic acids, and feeding important fungivore arthropods grazing mycelia as part of the dynamics of the soils system. There is, thus, a joint participation of biochemistry, of microbiological world, as well as animals (arthropods), where nutrients and energy are related in a dynamic and controlled process. We cannot ignore the secondary role that of the extracellular polysaccharides (ECP), in binding mineral and humic particles in order to form aggregates, the basis of a fertile soil structure. However, these aggregates can also be metabolized by bacterial flora, which uses polysaccharides as food and degrades again the soil. Thus, the soil structure is also linked simultaneously to sugars, celluloses, proteins, lignins, bacteria, and arthropods, where fungi are playing a key role.

The entire agriculture, including vegetable production, is based on soil fertility otherwise high yield and quality cannot be obtained. The yield was the mean used to measure the inputs in the industrial approach for the 20th century. The RCW imply an integrated approach of all factors (physical, chemical, biochemical and biological) in order to obtain an optimal production and good food quality, with limited inputs, including a significant water economy.

RCW studies

Observations

Since the 80's, many Canadian research studies have been conducted in agriculture and in forestry. Today, the research has expanded to Sénégal, Madagascar, Ukraine and The Dominican Republic. These studies have shown the following results:

- Substantial water economy plus biological and chemical water production and "water management" by the organisms present in soil; further studies on water economy are conducted in Sénégal, and financed by the Competitive Fund of the World Bank from a Canadian CIDA initiative.
- Yield increases up to 1000%-mass for tomatoes in Sénégal; 300%-mass for strawberries in Canada, 400%-mass in dry matter of corn in both Côte d'Ivoire and the Dominican Republic, and by 30%-mass in dry matter content for potatoes in Canada.
- Reduction of the negative impacts generated by some pathogens, for example, under tropical conditions, a complete control of root nematodes, the worst and most costly pest in vegetable garden.
- Noticeable resistance to drought.
- A remarkable enhancement of organoleptic properties in fruits and vegetables.
- An increase of 0.4 to 1.2 pH unit in acid soils, and a decrease in the range of 2.0 in alkaline soils. It seems that the pH is controlled by the enzyme systems.
- Reduction of conductivity in saline or brackish soils.
- Production of phosphatase (both alkaline and acid) is allowing the use of unavailable phosphorous otherwise.

Projects in progress

The most important project in progress is related to the implementation of RCW for vegetable production conducted in Sénégal at the cost of 2,5 M$cdn, financed by Canadian money at the World Bank under Competitive Fund. Besides this major project, numerous small-scale projects are going on mainly in Canada for market crops, flowers, *etc*., and also in Ukraine funded by IDRC on potato and rye since 1996. Some projects have been active for over 16 years, and they provide sound results; normally, every three years a small layer of RCW is added varying from 25 to 50 m^3/ha.

The RCW is currently used in Ukraine in order to correct and improve the degraded soils for cereal production. The results are so obvious that two RCW wood chippers have been ordered recently. A new Canadian international company is already building specific wood chippers for RCW production.

Mineral Fertilizers, Composts and RCW: Advantages and Disadvantages

Fertilizers are commonly used for improving crop yields. For example in 1996, in United States (AAPFCO, 1997) 54 million tons (110 billion pounds) were spread on agricultural land. Primary nutrients (N, P, K) accounted for 90% of this total, secondary nutrients (calcium, magnesium, sulfur) for 5%, liming materials for 4%, and organic fertilizers for 1%. All the advantages and disadvantages of mineral fertilizers, organic fertilizers and RCW must be under a close look.

Mineral fertilizers

This section is taken in part from EPA 1999a.

Advantages

- The intense use of mineral fertilizers worldwide reflects its high potential to release readily its nutrients and increase in the short-term crop yield. However, the drawback of this fast release lies in its potential to contaminate groundwaters.

Disadvantages

- Excess nitrogen pollutes ecosystems, and can alter both their ecological functioning and the living communities they support. Nitrogen is considered one of the five key factors responsible for driving most trends in biological diversity, according to a study co-authored by 19 scientists (Sala *et al*., 2000).

- The mineral fertilizers additions to soil, such as N, P, K, contaminate groundwaters and surface waters. In fact, dissolved nitrogen in the form of nitrate (NO_3^-) is the most common contaminant identified in groundwater. Human activities have doubled the amount of nitrogen cycling between the living world and the soil, water, and atmosphere, and that rate is continuing to climb.

- The persistence of nitrogen-based fertilizers on the land contributes to acidification and the increased loss of trace nutrients and release of heavy metals.

- Within the soil, bacteria generate nitrous oxide from fertilizers. Although the concentrations of this gas are low, they contribute to the serious problems of ozone destruction in the stratosphere and greenhouse warming in the troposphere. In 1997, the application of synthetic nitrogen and organic fertilizers accounted for about 36 percent of total U.S. nitrous oxide (N_2O) emissions. N_2O is a powerful greenhouse gas, about 310 times more effective at trapping heat than carbon dioxide on a molecule-for-molecule basis. Most N_2O is produced naturally by microbial processes in the soil. These processes may be augmented by the application of synthetic nitrogen and organic fertilizers, leading to an increase in emissions from agricultural lands where these fertilizers are used. According to the Intergovernmental Panel on Climate Change, if fertilizer applications are doubled, emissions of N_2O will double, all other factors being equal.

Therefore, limiting the use of mineral fertilizers will minimize nitrogen loss to the environment through leaching and atmospheric emissions.

Organic fertilizers

This section is taken in part from EPA 1997 and 1999b.

Advantages

- Compost technology is a valuable tool being used to increase yields by farmers interested in a more “sustainable” agriculture. Farmers are discovering that compost-enriched soil can also help suppress diseases and ward off pests. These beneficial uses of compost can help growers save money, reduce their use of pesticides, and conserve natural resources.

- Compost enhances water holding, soil aeration, structural stability, resistance to water and wind erosion, root penetration, and soil temperature stabilization.

- Compost increases macro- and micronutrient content, increases availability of mineral substances, and ensures pH stability.

- Compost promotes the activity of beneficial microorganisms, reduces attack by parasites, promotes root development, and high yields of agricultural crops.

- Since compost has the ability to improve soil water holding capacity and fix nitrogen into a form that can be used by plants, its use mitigates (at least partially) non-point sources of pollution in comparison to commercial fertilizers.

- Compost reduces reliance on pesticides, herbicides, and fungicides by providing an environment rich in organic matter. Beneficial microorganisms thrive in this environment and can out compete and suppress detrimental pathogens found in soils where organic matter is low.

- Consistent application of compost reduces soil erosion resulting from wind and water by improving soil stability.

Disadvantages

Section taken in part from EPA, 1998, 1999b.

- The delay for a mature compost. A 12-year study at the Connecticut Agricultural Experiment Station demonstrated that equivalent yields resulted on compost-amended plots when compared to those with only mineral fertilizer after 4 to 5 years when the steady state of nutrient release is reached.

- Large differences in the effectiveness of different composts.

- Very large differences between-year performance of some composts, but not others.

- Used as bio-control products, they cannot control diseases with the same consistency as synthetic chemicals. The lack of consistent performance is probably due to complex interactions between environmental conditions that modify plant susceptibility to a pathogen and/or change the relative infective potential of the pathogen (Burdon, 1992; Dickman, 1992; Couch, 1960).

- Need additional compost application every year.

As far as of annual productions are concerned, the "organic matter" was always seen as a nutrient and immediately assimilated by the growing plants. Numerous examples have shown that additions of fecal and waste substances to the soil, as nutrient source, have favored bacterial flora attack on wood and all other organic matters by the enzyme called laccase. Thus, this biotransformation reacts rapidly without increasing soil fertility in the *long term*, and releasing large quantities of carbon dioxide as a contribution to greenhouse effect.

RCW

Advantages

- The first and single most important advantage comes from the fact that soil is regenerated by a technology based on the way nature makes soil. As a result, this technology does not require any nitrate addition.

- The RCW approach is the only technology using the soil energy potential expressed in terms of polyphenols.

- RCW potential is found in the biotransformation process, which has nothing to do with "organic decomposition" but regulates the nutrient availability, the soil physical structure, the erosion resistance, and above all, protects and stimulates various phases of animal life, bacterial and fungus of the soil major contributors to soil formation.

- RCW, like compost, has the ability to improve soil water holding capacity, to fix and release nitrogen as needed by plants, and to mitigates sources of pollution.
- RCW can reduce reliance on pesticides, herbicides, and fungicides by providing a balance microbial and nutrient environments.
- No contamination by metals is provided by RCWs.
- Stable quality of soil favored by the lignin content.
- Maintenance of soil fertility at a minimal cost by growing trees or bushes in garden’s vicinity for subsequent applications of RCWs.

Disadvantages

- Colonization of RCWs by fungus is a process taking several months under temperate climate but much less under tropical.

In summary, the use of chemical or detriment products does not contribute to soil formation, neither to long term fertility. Therefore the soil, that feed the world, continues to degrade. RCW will keep on managing the energy source - the polyphenols - according to the plant need through the fungus activity. Consequently, a sustainable fertile soil can only be achieved through the Ramial Chipped Wood technology.

Agricultural training

Why oriented toward women?

"FAO estimates that more than half of the world's food is produced by women, and in rural areas of Africa, Latin America, and Asia, the figure soars to 80%. Yet women have little or no access to land ownership, credit, agricultural training, education, and social privileges in general… therefore, social sciences must be involved with the keen involvement of anthropology.

Moreover, women in developing countries reinvest nearly all of their earned income to meet household food and other needs, whereas men often set aside up to a quarter of their incomes… Women impoverished to the point of hunger bear hungry children, and are less able to care for their children and to breast-feed, conditions that perpetuate hunger across generations. In sum, societies that abandon women to poverty are weakening one of their key defenses against malnutrition." (Gardner and Halweil, 2000).

Consequently, it is obvious that agricultural training for using properly the RCW technology must be given to women in rural areas.

Implementation

The technicians, mainly women very well trained by the Coordination Group on Ramial Wood (CGRW), will be responsible for the local agricultural training.

The same technicians will also be in charge of marketing vegetables in each village or community involved in the project. A "model" garden will serve as reference for the farmers in order to be used as a check basis for yields.

The involvement of a regional scientist or a scientific group is needed to maintain good contact for developing the RCW technology with the help of local agricultural technicians.

How to use the RCW technology?

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 favor 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 amount of angiosperm species.

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, then favoring the biotransformation. Otherwise occurrence of non-hydrolysable polyphenols will take place, bringing the entire process of **pedogenesis** of a standstill.

In most cases, the tree species will not have been tested. Therefore, field experiments will be required to evaluate the quality of various RCW available tree species. In practice, however, one can estimate the more suitable species on the basis of ecology where trees are in association with higher plants (climax deciduous trees). By doing so, the RCWs will favor biodiversity and, then the most needed crops. By mixing tree species, soils will be improved by positive effects in the short, medium, and long terms.

As recommended standards by the Coordination Group on Ramial Wood branches must be used as the basic material and have a diameter less than 7 cm, (since larger diameter branches are often used as fuelwood), for a final product of wood chips ranging between 5 and 10 cm long. These RCW are generally without leaves under temperate climate. Under tropical climate, however, experiences have shown that leaves must necessarily be incorporated to RCWs, in order to avoid important zinc deficiencies.

The chipping

By chipping the ramial wood branches, the biotransformation take and give access to fungus Basidiomycetes within internal organic tissues normally protected by the bark. The invasion of these tissues by Basidiomycetes mycelium is essential. Otherwise, bacteria or Actinomycetes could invade and prevent the tissues to be colonized Basidiomycetes, the only fungus able to produce the enzymes involved in all other processes from lignin biochemical evolution.

Therefore, RCWs will regulate the whole system and improve the parameters dedicated to the release of nutrients for plants.

Numerous tools can be used for chipping ramial wood. A new Canadian company has developed an efficient and robust chipper especially design for this purpose, many times more efficient then regular large diesel motor ones. Purchase, operation and the maintenance costs are suited for the developing countries.

Spreading and soil incorporation

A manure spreader can be used. 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. Consequently, 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.

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.

Environmental and social impacts

Environmental impacts

The most important impact coming with this new technology is the fact that RCWs work the same way nature makes soils. Furthermore, the RCW technology approach is the only one using the soil energy expressed in terms of polyphenols to its full potential. <u>As a consequence, this new technology is the clue for sustainable fertile soils.</u>

RCW doesn't require nitrogen addition, nor or limited application of insecticides and herbicides. In fact, nitrogen addition would impair the soil durability by accelerating the polyphenols and cellulose decompositions. It will also modify aggregates structure, soil physico-chemical properties, and more important it will alter the natural barriers for nitrogen mineralization. Furthermore, nitrogen addition favors also the implantation of weeds, which are nitrophilous and are present only due to an excess of nitrates, nitrites, and/or ammonium salts. This proliferation of weeds could require some herbicide applications for limiting their expansion and growth. Similarly, the proliferation of insects can also be an expression of imbalance often resulting from insecticides additions, which can disturb soil protozoa critically (Neher, 1999). Therefore, with RCW technology, balance is obtained between fungal and bacterial components in order to reduce fertilizer additions. Within such a system, soil organisms will contribute to nutrient mineralization and biotransformation at sustainable levels, and the groundwater quality will not be impaired by *dissolved nitrate, the most common contaminant identified in groundwater.* There is more. Nitrogen is considered one of the five key factors responsible for driving most trends in biological diversity.

Secondly, this new technology works properly with less water than other ones, and shows noticeable resistance to drought. Therefore, its use seems particularly well suited for dry regions where the water resources are often scarce.

The apparent negative impact seems to be the removal of ramial wood rich in nutrients and could feed some animals, such as deers under temperate climate.

Nevertheless, a careful management of this resource should not impair the wildlife's habitat. This impact is rather limited for the implementation of the technology in a given region, since ramial wood source can be “harvested” from initial plots.

In summary, the fertile soil resulting from ramial chipped wood interaction can sustain and maintain food production, and also minimize soil degradation and groundwater contamination.

A new category for soil improvement: SOIL UPGRADERS

As described above, RCWs must be classified in a new category devoted to improve both agriculture and forestry. It cannot be assessed as a FERTILIZER even if its content is significant neither more to soil AMENDMENT well known as "organic matter". Using RCW technology, we enter in a new world of interventions where UPGRADERS will master our always depleting agricultural soils all over the world. Above all, UPGRADERS are bringing energy for the biological enhancement of the soil, while contributing to soil structure, plant productivity and groundwater quality. Most important, it contributes to a biochemical balance responsible for all biological and physical factors of soil fertility into a dynamic process.

Social impacts

The social contributions to this project on small farms, are concerned to women:

- Increasing their income
- Improving their status
- Acquiring better knowledge on food production by technology transfer
- Improving the health of their family by increasing the food quantity and quality.

The research team

Coordination Group on Ramial Wood (CGRW)

All the members are researchers from few Canadian universities, and from federal and provincial governments. The Canadian International Development Agency (CIDA) and the International Development Research Center (IDRC), Ottawa, Canada, are providing some funds. Expertise has been developed in Canada, the Caribbean, Europe and Africa. Over 120 publications have been produced in French, English, Spanish and German.

This Group was born in the early 80's at Laval University, Québec City, Canada, in order to put values over industrial wastes such as thousands of tons of crushed twigs from the production of essential oils. Chemical analyses of the material from evergreens have shown a high content in proteins, sugars, cellulose and polyphenolic compounds, where lignins are the most intriguing component.

From evergreens to hardwood, the crushed twigs and branches, mixed with poor soil gave even impressive results with crops such as wheat, oat, potatoes, strawberries... Those twigs had a very good effect on soil improvement, biodiversity and forest regeneration.

Since no mention was found in scientific literature, we gave the name of Ramial Chipped Wood or “RCW” in English, *Bois Raméal Fragmenté* “BRF” in French and *Madera Rameal Fragmentada* “MRF” in Spanish.

From 1990 with the close support of CIDA in Canada, trials were conducted in Africa (Sénégal and Côte d'Ivoire), with better results than under temperate climate conditions. Other trials were made in the Caribbean (Dominican Republic) with special reference to maize production increased by 400%-mass. Trials are underway for three years in Ukraine and financed by IDRC; all enhancing criteria are met just as in Canada and Africa.

After 20 years, we come to the conclusion that using RCW technology using trees branches not used even in the poorest countries, is a major contribution to pedogenetic mechanisms in soil rehabilitation and biodiversity enhancement. It is above all an upgrading technology with a significant influence on soil fertility, texture, nutrient control, availability and a major contribution to water and nutrient availability where agricultural soils are under a fast degrading mode as well as forest disappearing even faster all over the planet.

We are in the wrap up process for a large research and development project in Sénégal, which will be funded by both CIDA and IDRC. We are focussing on pedogenetic processes where polyphenolic compounds are ruling all walks of soil's life and, moreover, biological water production from plant and soil.

Hydrogéochem Environment

Hydrogéochem Environment, founded in 1996, operates in the domain of the environment. The firm is specialized in hydrogeology, geochemistry, and numerical simulations.

The main activities include:

- characterization of soils and waters potentially contaminated by inorganic/organic compounds
- design of processes for rehabilitation of contaminated soils and for water treatment
- water resources management
- numerical simulations of groundwater flow and contaminants migration

Technical support

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