THE USE OF BIOCHAR AS A MEANS OF SOIL REGENERATION

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Abstract: *Intensive agriculture exploitations led to pronounced degradation of soil by altering soil structure, affecting natural circuits of water, carbon and nitrogen by presence of poisonous substances from pesticides family, of residues of harmful substances resulted by conducting crop treatments. One way to remedy these soils, used worldwide, is the use of activated carbon as the biochar. It copies the natural phenomenon of vegetation fires after which due to the resulting carbon is gets to soil regeneration. Aim of the study is to increase production by regenerating the soil as a result of using biochar and food fortification for targeted interventions, at poor households around the world.*

Keywords*: biochar, greenhouse gases, biomass, pyrolysis, TLUD module*

1. Introduction

In development perspective of sustainable agriculture is required efficient use of resources to increase their energy independence of technological processes, to reduce the use of mineral fertilizers in increasing the productive potential finality of agriculture. A relevant synthetic indicator is energy balance of crops that can show which the level of energy independence is and how it contributes to reducing the carbon concentration in the atmosphere.

Research in the use of biomass for energy production led to the conclusion that the plant coal, called biochar, resulting from pyrolysis and gasification processes is a valuable amendment for agriculture soils and an effective and very economical carbon sequestration.

Biochar is a product rich in carbon, created by thermochemical gasification of biomass with air in slow substoichiometric regime. Biochar is produced organically, it increases crop yield, improves the effectiveness of fertilizers, eliminates significantly the pesticides, reduces emissions of methane and nitrous oxide (two aggressive greenhouse gases) and stores carbon atmospheric in soil over a large period. It is widely highlighted as a method for reducing concentrations to carbon dioxide (CO_2) in the atmosphere, mitigating climate change dynamics. The exchange of carbon between plants, soil and the atmosphere exceeds the exchange between ocean and the atmosphere.

2. Methodology

Inorganic fertilizers used for growing crops produce on short-term intensive energy and carbon. The use of these fertilizers in soils emits nitrous oxide, a powerful greenhouse gas emission. Globally, fertilizer production is the largest source (38 %) of emissions from agriculture (EPA, 2010). Reduced doses of inorganic fertilizer by incorporating biochar into soil would therefore reduce CO_2 emissions related to agricultural production.

Biochar is a very important element that participated in time, by accidental burning of vegetation, at formation of productive layer of the present soil. A new biochar can be enriched with nitrogen and used as a valuable agricultural amendment, as a substitute for chemical fertilizers with nitrogen.

Internationally, there are known concerns in the use of production technologies of carbon by controlled burning of plant materials.

Pyrolysis involves trade-offs between the production of biochar, bio-oil and gas, and the process can be calibrated to maximize the output of different products, depending on economic factors. This is illustrated in Table 1.

Table 1: Typical product yields (dry wood basis) obtained by different modes of wood pyrolysis.

Mode	Conditions	Bio-oil	Biochar	Gas
Fast	Moderate temperatures (500°C) for 1 second	75%	12%	13%
Intermediate	Moderate temperatures (500°C) for 10–20 seconds	50%	20%	30%
Slow (carbonisation)	Low temperature, (400°C), very long solids residence time	30%	35%	35%
Gasification	High temperature, 800°C, long vapour residency time	5%	10%	85%

Source: International Energy Agency 2007

There are known methodologies for obtaining coal by burning wood in covered pits, or in stacks on the soil surface as shown below (Figure 1).

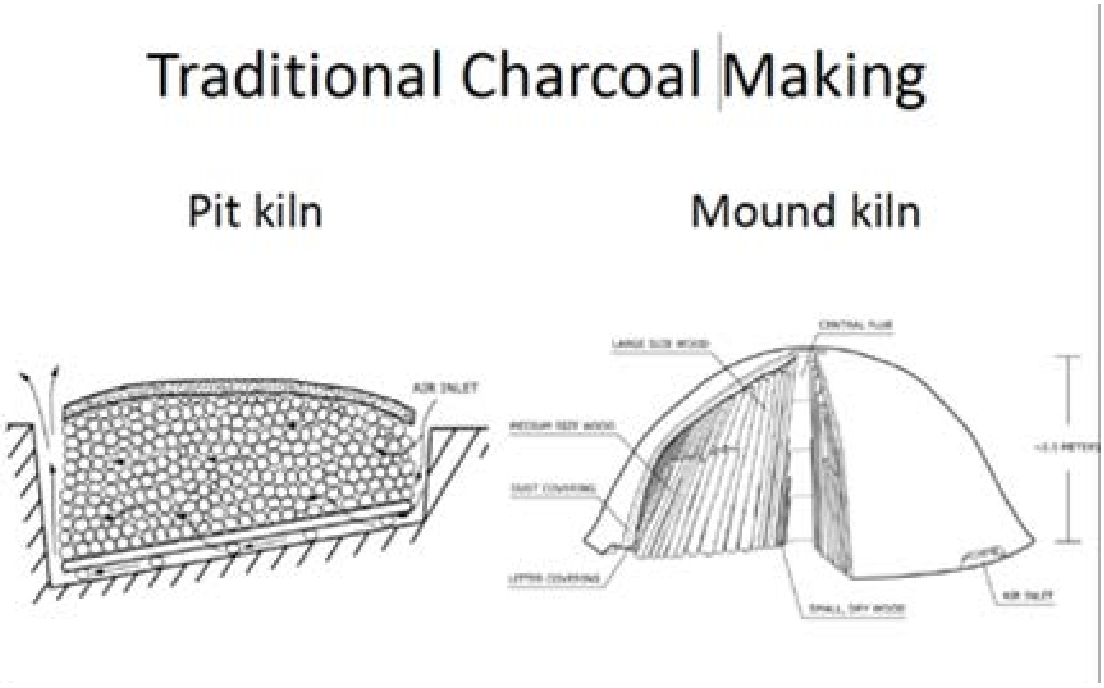

Fig.1 Methodologies for obtaining coal by burning wood in covered pits, or in stacks on the soil surface

Another example is the establishment of an open-plan kitchen stove TLUD. The focus is on the bottom of the stove where biomass burning occurs under the action of primary air that is adjustable. The results from pyrolysis are biochar, heat energy and biogas. By the middle part enters the secondary air, which burns the biogas at the top where one can cook.

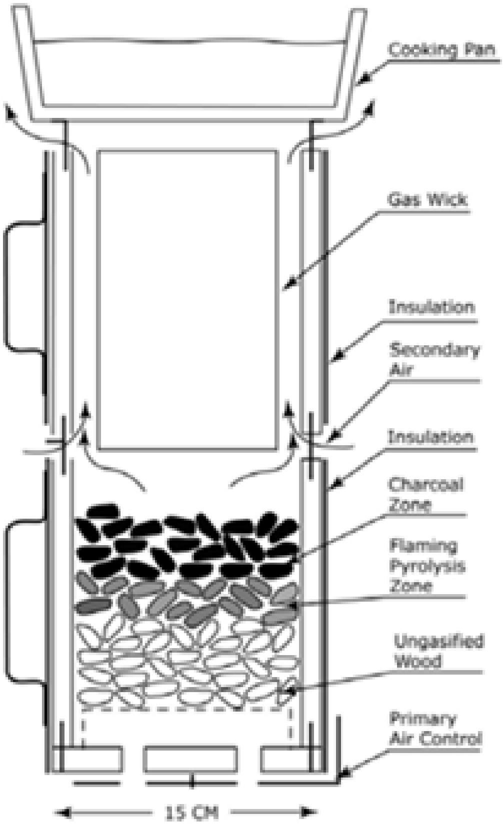

Fig. 2. Schematic of a top-lit updraft (TLUD) gasifier wood cook stove. (according to Brown RC (2009) Biochar Production Technologies in Lehmann, J., & Joseph, S. (Eds.) Biochar for Environmental Management: Science and Technology. London: Earthscan.)

Research has been conducted on effective use of biochar in soil obtained in controled field in shifting cultivation and in field in shifting cultivation with biochar embedded in soil.

Fig.3 The effect of using biochar after five years of application
(- is more stable that any soil amendment (MRT 1,000-2,000 yrs);
- increases nutrient availability beyond a fertilizer effect;
-is more efficient at enhancing soil quality than any other organic soil amendment)

Data on biochar technology (fig.4) and functional diagram (fig.5) of a module type TLUD is shown below.

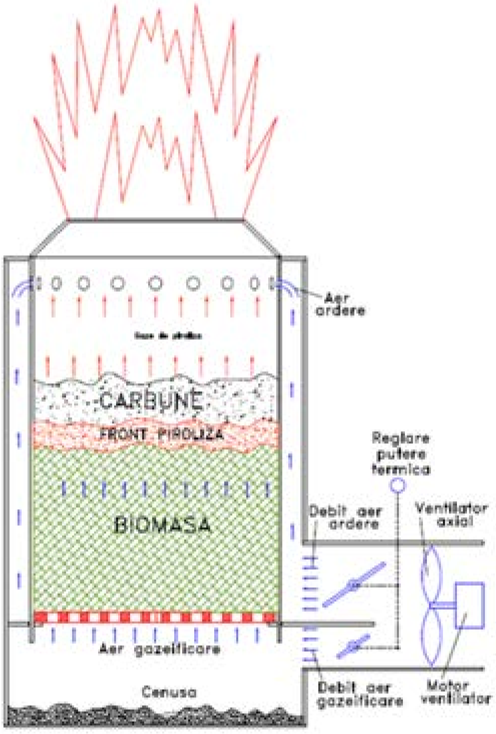

Fig.4 Biochar technology of a module type TLUD

Energy module type TLUD consists of a reactor which is filled with biomass and is introduced in a case that has two adjustable air circuits. Gasification air enters through the bottom and ensures the production of heat, oxidation and gasification of biomass, obtaining biochar and gas produced by gas generator (gengas). The second circuit provides preheating of combustion air which is mixed with the gas produced in the upper side and ensures burning of the gengas causing heat.

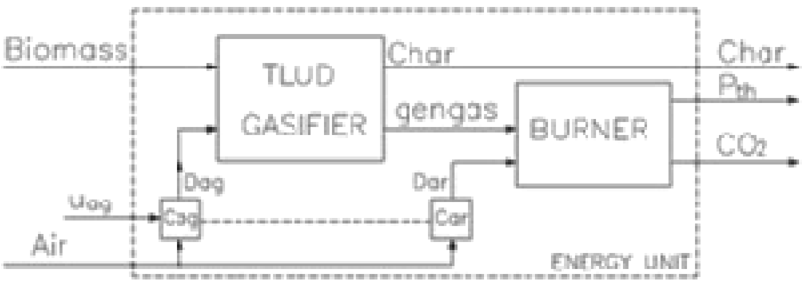

Fig.5 Functional diagram of a module type TLUD

Functional block diagram of an energetic module type TLUD - Input values are: biomass, air, task order, and output: biochar, heat, products of CO_2 combustion.

If a source of carbon is added to the soil without sufficient nitrogen, microorganisms must scavenge nitrogen from the soil environment, which can result in little nitrogen being available for plants which can greatly limit crop growth. In general, an amendment needs to have a C:N ratio that is no higher than about 30 to avoid nitrogen immobilization (the additional C is used for maintenance respiration).

Biochars, which are mostly carbon, usually have very high C:N ratios on an elemental composition basis; fortunately, nearly all of this carbon will not be available to microorganisms meaning that the effective C:N ratio is much lower. If a biochar is not pyrolyzed sufficiently, however, some of the carbon may still be bioavailable and may cause nitrogen immobilization, resulting in short-term negative effects on crop yield. Depending on magnitude of the carbon overloading, the nitrogen in the microbial biomass will eventually become plant-available again as microorganisms die off and the nitrogen is recycled, but by then (a few weeks to a few months later), the plants may not be able to recover. An example of nitrogen immobilization is shown in Figure 6. In this study, corn stover and carbonized corn stover (i.e. corn stover biochar) were used as soil amendments in pots growing corn.

The third case is nitrogen immobilization due to a high ratio of available carbon to available nitrogen in the biochar amendment. When they are actively growing (i.e. producing more biomass), microorganisms need about 1 mole of nitrogen for every 5 to 10 moles of carbon that they consume.

Both amendments had high C:N ratios but only the corn in the pots with the highest rates of uncarbonized amendment showed signs of nitrogen immobilization (the stunted plant growth in pots with 1.0 and 2.0% by weight of corn stover added).

Fig. 6. An example of nitrogen immobilization by microorganisms: the effect of soil amendment bio-available C: N ratio on corn growth in a greenhouse study

Soils used in the study were amended with either corn stover (CS), which had a high available C:N ratio, or carbonized corn stover (CCS), which had a much lower available C:N ratio due to the carbonization process, at applications rates of 0.5, 1.0 or 2.0 wt% of soil. The corn grown on soils amended with the higher amounts of corn stover (total C:N = 71) did worse than that grown on soils amended with the carbonized crop residue (total C:N = 49). (Source: Christoph Steiner, Biorefining and Carbon Cycling Center, University of Georgia, USA.)

Scientific innovation of the work results from biochar application in Romanian agriculture, process known worldwide but at us only at the beginning

In Romania we know works in the field conducted at:

> Metallurgical Research Institute ICEM SA, in partnership with the Municipality of Motru, SNLO Miami and IPROCHIM SA have under implementation, since July 2002, the project of obtaining activated carbon by exploitation of xylose using clean technologies.

> the ICDP Maracineni, the project PC 51-008/14.09.2007- concerns regarding the use of black coal in fruit growing.

Our institute has collaborated with partners such as Politehnica University of Bucharest, INMA Bucharest in research works for obtaining active carbon as a byproduct of gas-producing and TLUD modules, developing in works under the national programmes RELANSIN and PARTNERSHIPS.

> RELANSIN: motor pumps for irrigation, fueled by gas produced by gasification of plant debris.

> RELANSIN: storage and distribution facility for gas produced by a generator.

> PARTNERSHIPS: Research on the use of corn crop as a source of biomass for thermal energy production.

Food security, the challenge of ensuring the availability of safe, nutritional and accesible food, took a new dimension in the light of increased global demand, environmental restrictions on agricultural production and increased competition for soil quality and the means for obtaining it.

3. Conclusions

Modern experimental research demonstrates that biochar application can substantially raise productivity of crops such as soybeans, sorghum, potatoes, maize, wheat, peas, oats, rice and cowpeas.

Evidence suggests that significant productivity gains are possible at application rates as low as 0.4 to 8 tonnes of carbon per ha, but at extremely high applications crop productivity may actually drop due to nitrogen limitation.

Much synthetic fertilizer is currently produced by using natural gas to synthesis ammonia using nitrogen from the air, but this releases one molecule of carbon dioxide for each molecule of ammonia produced. Conventional urea-based fertilizers, made from this ammonia, also have other adverse environmental impacts when used inappropriately. Combining ammonia, carbon dioxide and water in the presence of biochar forms a solid, ammonium bicarbonate fertilizer, inside the pores of the char. This nitrogen-enriched char can be incorporated into the soil, where it serves three purposes: as a carbon store, as nitrogen fertilizer, and as a biologically active soil enhancer.

REFERENCES

[1] S. Anghel, C. Dumitrescu, Gh. Sovaiala, "Research study regarding the making of maize stalks briquettes", Wroclaw, 7-9 Oct. 2009, Conference Proceedings, pp. 349-353
[2] E. Murad, A. Culamet, G. Zamfiroiu, "Biochar- Economically and ecologically efficient technology for carbon fixing", International Symposium HERVEX-2011, Călimăneşti, 9-11 November 2011, Conference Proceedings, ISSN 1454-8003, pp. 37-43
[3] E. Murad, A. Ciubucă, A. Culamet, Radu Marian, "Biochar produced from vine prunings organic soil amendment for viticulture", Symposium ICDVV, Valea Călugărescă, 12 June, 2012
[4] E. Murad, F. Dragomir, "Heat generators with TLUD gasifier for generating energy from biomass with a negative balance of CO_2", International Conference HERVEX 2012, Călimăneşti, 7-9 November 2012, Conference Proceedings, ISSN 1454-8003, pp. 440-447
[5] D. Sumedrea, C. Marin, E. Chiţu, C. Nicola, M. Sumedrea, V. Chiţu, M. Călinescu, M. Butac, "Preliminary results regarding the influence of black charcoal application in apple orchards on chemical and microbiological properties of the soil", International Symposium, 2010, Annales of the University of Craiova, vol. XV (XLXI), Publishing House Universitaria, Craiova, ISSN 1453-1275, pp. 534-543, http://anucraiova.3x.ro, CNCSIS B+.
[6] P. Winsley, "Biochar and Bioenergy production for climate change mitigation", International Energy Agency, 2007, New Zealand Science Review, Vol.64. 1, 2007, pp. 5-10