Comparative study of carbonization techniques on the quantity of charcoal and quality as a biochar in the city province of Kinshasa (DRC)

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Introduction

- The soils of Kinshasa and its surroundings for the most part, are highly degraded and very acidic. This translates into low agricultural yield.
- Peasants practice itinerant agriculture on burns and are more interested in making charcoal to improve their income. It is a threat to the forest and climate change mitigation.
- Biochar offers the possibility of improving the physical properties of sandy and acidic soils. However, the production of charcoal that can be used to make biochar, is done by traditional carbonization and gives low yields with a high environmental cost.
- It is in this context that we conducted a study to compare the production and quality of biochar of three carbonization techniques including the Traditional Technique (T), the Traditional improved Technique (TA) and the Traditional Improved Technique with Metal Vents (TAM).

Objective

- Evaluate the amount of production of each technique in order to determine the necessary planting forest area to be cut to amend 1 ha of sandy soil with 30 tons of biochar.
- Evaluate the quality of biochar from each carbonization technique in terms of pH, carbon content and water retention capacity

Method and material

A. Charcoal production

- The charred species is Acacia auriculiformis cut from a 7-year plantation with an area of 0.5 ha.
- Steps: preparation of wood, construction of 12 stere wheels, weighing of 5 steres with dynamometer to find the average weight of a stere, carbonization, unloading, sacking, charcoal weighing

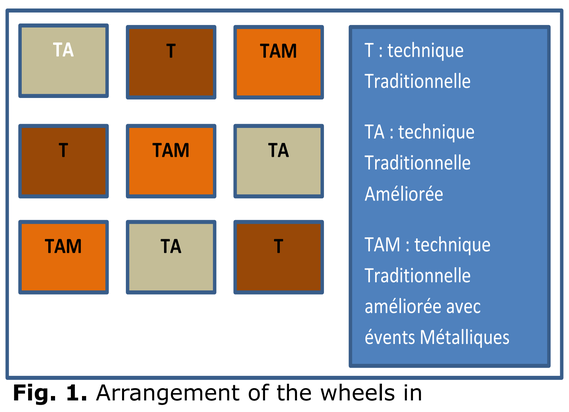

Fig. 1. Arrangement of the wheels in complete blocks randomized

- Processing of charcoal into biochar
- The difference between T, TA and TAM is in the grinding mwheel ventilation system
- Calculation of charcoal yield by technique:

Charcoal (kg)/grinding wheel weight (kg) x 100

Fig.2. Construction of a TAM Grinding Wheel

B. Soil sampling, Laboratory analyses

- Sampling of soil to be mixed with biochar: soil depth 0-30 cm, air drying, composite formation, measurement of soil pH (distilled water, pH meter) and analysis of soil texture according to the method of the Laboratory of the ORSTOM Center of Noumea in New Caledonia using hydrogen peroxide (H2O2) and hydrochloric acid (HCl).
- We mixed the soil and biochar in cups following the treatments. We then weighed them to have the dry weights. We moistened them (300 ml of water) until saturation and waited for the end of the infiltration and weighed the moistened weights. The follow-up was done by weighing every day.
- To determine the amount of biochar of the doses 15 T/ha and 30 T/ha corresponding to 816g and 813g of soil, we exploited the relationship between the weight of the soil on 1ha at the depth of 30 cm (depth exploitable by the roots of food crops) with the density of sand (d=1.5).
- Evaluated parameters: Water content **(Θ)= (Wet weight (Ww) – Dry weight (Dw)) /Dw *100*d** with d=sandy soil density = 1.5; Moisture at field capacity **(Mf)=(Ww-Dw)/Dw *100**; Humidity at the Wilting Point **(Hf)=Hc*1/3** for sandy soil with more than 10% clay,According to Perigaud (1963) cited by Kayembe (2016)

Fig. 3. arrangement of 18 permeable cups (dimension = 700 ml) associated with 16 jars to collect the percoding.

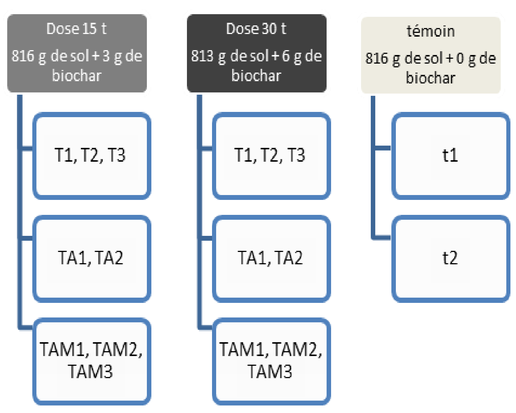

Fig. 4. Dose 15 and Dose 30 Treatments and sample control

Results

Area required by technique to produce 30T of biochar

Technique	Wood (kg)	area (m2)	Charcoal + waste (kg)	area/30T (ha)	area/30T (%)
T	6004.4	540.5	1304.467	1.243	100
TA	6004.4	540.5	1655.0	0.979	78.8
TAM	6004.4	540.5	1299.8	1.247	100,3

Tab.1. Area to be deforested to produce 30 tons of biochare to be amended 1 ha of crop

❖With the TA we can reduce the area of deforestation due to carbonization by 21.2% compared to the traditional technique (T)
❖Ibi village, where 100 ha of Acacia is made available in the carbonization market per year, the use of TA to produce 30 tons of charcoal biochar processing, represents a reduction of 21.2 ha on annual deforestation.

pH and carbon content of T, TA and TAM biochar soil pH and texture

Techniques	pH	%CO
T	6.80	43.45a
TA	6.63	78.43b
TAM	6.70	66.75ab

Tab. 2. pH et %CO of biochars

❖ pH (soil) = 5.59, texture = sandy (sand = 82.27% silt=3.39% clay=14.34%)
❖ pH of biochars of all techniques is acidic. Lehmann et al., 2009 showed that biochars can be produced at almost any pH (between 4 and 12).
❖ The carbon comparison test gave the following descending order: TAM > TA > T.

Water retention capacity

Evolution of water content

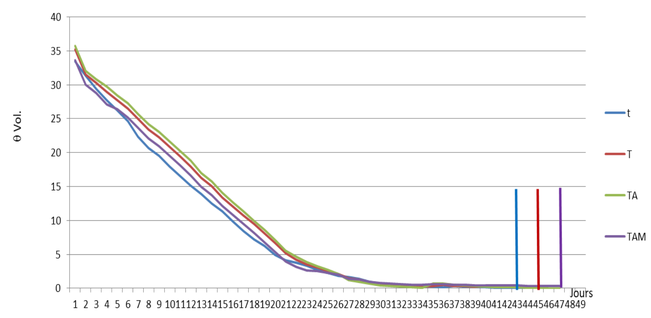

Fig.6. Evolution of the volumetric water content for dose 15

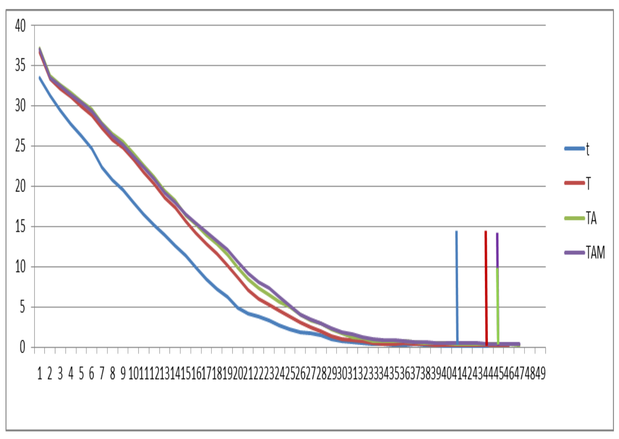

Fig. 7. Evolution of the volumetric water content for dose 30

❖ For the dose of 30T/ha the curves of the carbonization techniques have an almost confused appearance. But they are higher than the curve of the control sample. Towards the end of the observation the suction force had decreased, the temperature in the dry season at night dropped and this slowed down the trend of evaporation
❖On the one hand, biochar increases the water retention power of the soil and on the other hand, like any other organic matter, biochar prevents water from evaporating quickly
❖However, the performance of the control sample would be justified by the relatively high clay content (14%)

Observation of Moisture in the field, moisture at the point of wilting, water availability time for doses of 15T/ha and 30T/ha

The water availability time for the plant is the number of days that separate moisture at field capacity and moisture at the wilting point.

This is the time it takes for the water in the soil to no longer be available to plants.

Techniques	Hc (%)		Hf (%)		Temps (j)	
	D15	D30	D15	D30	D15	D30
t	21.9	21.9	7.5	7.5	15	15
T	24.0	24.5	8.0	8.2	16	17
TA	24.0	24.5	8.0	8.2	16	18
TAM	22.2	24.1	7.5	8.4	16	18

Tab.3. Summary of results on field moisture, wilting point moisture, water availability time for the plant

❖In the second part of the work the observation is not very different between the three carbonization techniques on almost all parameters observed. The difference is observed between biochar treatments of dose 30T/ha and the control.
❖The different aeration systems of the carbonization techniques have increased the yields and not the quality of the biochar because the majority of the factors influencing the quality have acted fairly in all the techniques, including the raw material used which is Acacia auriculiformis harvested on the same plantation of 7 years and the preparation of the wood before carbonization was done under the same conditions for all techniques
❖Also, the high clay content (14%) of our soil did not allow to observe the difference between soil amended with biochar and the control

Conclusion

Applying biochar is a sustainable technique. There are agricultural and environmental positives effects. In Kinshasa, producing biochar by the TA technique can improve the processing. However, other studies using other tree species, and monitoring parameters to see the long-term effect of biochars used on the evaporation process, the retention of mineral elements, the biological activity of soils, may be complementary to this study.