RESTORING AFRICA'S *DRYLANDS*

ACCELERATING ACTION ON THE GROUND

BIOCHAR FOR CLIMATE-CHANGE MITIGATION AND RESTORATION OF DEGRADED LANDS

#GLFAfrica

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WHITE PAPER

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According to the United Nations Convention to Combat Desertification (UNCCD), 41 percent of global land area is drylands. In Africa, two-thirds of the continent's land area are classified as deserts or drylands, with 75 percent of those deserts and drylands being degraded. Furthermore, substantial areas of most sub-Saharan countries are part of Africa's drylands. In the same continent, the majority of the population is smallholder farmers and about one-quarter of these countries' GDP comes from agriculture, which largely is rain-fed. Therefore, rain-fed agriculture is vital for food security and is a major contributor to employment.

From a climatic and soil science perspective, rain-fed agriculture in many parts of sub-Saharan Africa is affected by prolonged dry seasons, irregular rainfall, and low soil fertility. The latter is mainly due to acidity, low nutrient status, and low carbon content. Restoration measures of such land must respond to these obstacles.

Biochar has significant potential to be part of the solution to overcome those obstacles, as it improves soil properties – in particular, for highly weathered, nutrient-poor, or acid soil under an arid or semi-arid climate; and for lowest income households or communities in rural parts of low and middle-income countries.

Biochar is a product of biomass that is subjected to pyrolysis, which is the process of charring biomass under absence of oxygen. This process can be performed at many levels – from small household stoves up to large communal or industrial devices. The pyrolysis process yields energy, so that the production of biochar can be combined with energy-consuming activities, such as cooking on small stoves or generating electricity through larger devices. As feedstock, a wide range of biomass can be used, including crop residues or municipal organic waste.

Photo 1. Biochar application along a seed row to reduce the biochar dose while preserving its effects on crop yields.

Photo © Mary Njenga, ICRAF

Therefore, applying pyrolysis to cook stoves in households has great potential to reduce the pressure on woodlands, because non-wood biomass can be used as fuel. Moreover, pyrolysis stoves are more efficient than the three-stone open fire; and at the same time, biochar is produced, which helps to improve soil and increase crop yields. Furthermore, indoor air pollution is reduced, improving the health situation of women and children in particular.

Huge amounts of brown wastes from crops – i.e., residues with a high carbon content – are currently burned as part of traditional agricultural practice. This is a very large source of CO_2 emissions that are warming local and global climates, and a source of particulate matter that harms public health. Augmenting the value of these resources through pyrolysis and biochar systems can reduce energy poverty, whilst also reducing dependency on wood fuel. At the same time, food insecurity is tackled, while strengthening climate resilience and storing carbon stocks in the soil of major agricultural systems. The availability of low-grade residues at field, farm, regional, and national scale can be forecast using simple allometric equations or more complex crop growth models.

Pyrolysis of biomass can appear similar to charcoal, which is the same as biochar in terms of its chemical and physical properties. However, the difference between the two is that charcoal is used as an energy source, while biochar is used as soil amendment. During the traditional production of charcoal, the energy-rich gases produced during pyrolysis are not used; in contrast, that energy is captured or used by the pyrolysis cooking stoves and larger devices to produce biochar.

Biochar has a very large surface area which enables it to both absorb large amounts of water as well as plant nutrients. That first property therefore improves the water-holding capacity in soils and increases the amount of plant-available water; particularly, in sandy soils. This enlarged amount of plant-available water is critical for rain-fed agriculture in climates with long dry seasons and irregular rainfalls, as the soil is able to deliver water more reliably and for longer time periods.

The second property also improves the ability of soils to absorb plant nutrients and retain these as plant-available nutrients. In particular, phosphorus is absorbed on the surfaces of biochar, instead of being fixed by iron and aluminum oxides and thus, made unavailable to plants. The ash fraction in the biochar is alkaline and therefore, acts as lime to reduce acidity in soil. Biochar takes over the role of soil organic matter with regard to nutrient and water storage and therefore increases soil fertility.

On-farm experiments carried out in Kenya and Uganda have emphasized the fact that biochar is not a fertilizer, but acts as a soil amendment, which improves the ability of soil to react more positively on nutrient inputs and rainfall. Therefore, biochar can be considered as an investment in soil to reverse degradation and improve soil properties to make soil more productive. Even small amounts of biochar (as little as one metric tonne per hectare) can show positive effects on soil properties and crop yields. If farmers do not have access to fertilizers, at least the water storage properties are improved, though farmers will not unlock the full potential of biochar application to soil.

No fertilizer (UC) | Biochar (UC+BC) | Fertilizer (FC) | Fertilizer+Biochar (FC+BC)

Photo 2. Maize growth under biochar and fertilizer application. UC: no biochar and no fertilizer application; UC+BC: application of biochar without fertilizer; FC: fertilizer application without biochar: FC+BC: biochar and fertilizer application.

Photo © IITA

Biochar is made up of inherently stable forms of carbon that are not decomposed by soil microbes, in contrast with most soil organic matter inputs from litter, compost, or farmyard manure. As a result, carbon in biochar is stored in soil for decades or centuries. Hence, biochar application into soil sequesters carbon in soil and therefore, contributes to climate change mitigation as a co-benefit to soil restoration.

Through the use of gasifier cooking stoves, which reduce fuel wood consumption, climate change mitigation is increased, as emissions from fuel wood burning are reduced. Furthermore, the pressure on woodlands is also reduced, which contributes to land restoration beyond improving soil properties. Sustainable sourcing of biomass for biochar and efficiency in pyrolysis technologies are key considerations in development of this novel innovation.

Pyrolysis energy systems and biochar farming practices involve complex processes that require multi-stakeholder transdisciplinary research and development activities, where natural and social scientists form a research community that works together with farmers in a co-learning process. It also requires collaboration of researchers, development practitioners and policymakers. Application of the lessons in development of bioenergy policy and strategies is key for scaling up and improving the technologies to respond to the needs and aspirations of people.

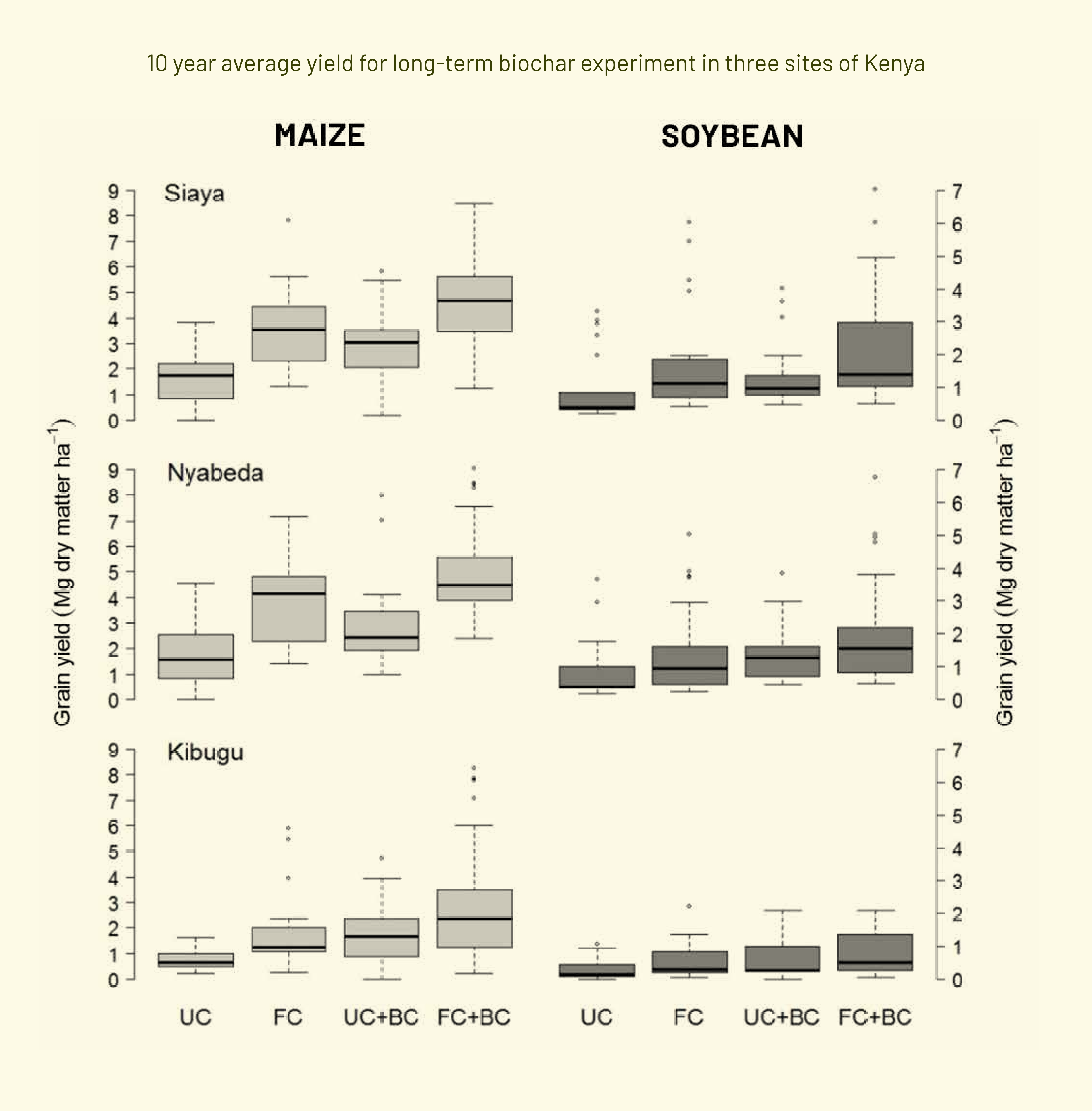

Figure 1. Maize and soybean yields under biochar and fertilizer application, averaged over 10 years after biochar application to the soil. UC: no biochar and no fertilizer application; UC+BC: application of biochar and no fertilizer; FC: fertilizer application without biochar; FC+BC: biochar and fertilizer application.

Source: https://doi.org/10.1016/j.fcr.2019.02.015.

Biochar collected from gasifier cooking stove.

Response of maize to biochar addition (left: without, right: with).

Application of biochar in the planting furrow. (left: without, right: with).

Photo 3. (top left photo): gasifier stove, for cooking at home and producing biochar; (top right photo): application of homemade biochar to farmer's field; (under photo): maize grown on biochar-amended soil.

Photo © ICRAF (left) and IITA (center and right).

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