BIOCHAR IN POTATO AND KALE PRODUCTION

THE WAY TO INCREASED YIELDS

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ALL PHOTOS DAVID LELEI, EXCEPT WHERE INDICATED OTHERWISE.

INTRODUCTION

Agriculture is the most common form of human-environment interaction. Numerous studies show that increasing duration of cultivation with inadequate replenishment of soil nutrients results in nutrient mining, hence lowering the capacity of such soils to produce sustainably. Moreover, leaching and soil erosion experienced in high rainfall landscapes results in further nutrient loss. On the other hand, areas receiving low rainfall such as the drylands may experience crop failure due to insufficient water for crop growth. Furthermore, poor soils can be a barrier to attaining land productivity potential in Africa. Inputs are commonly used to improve productivity, however, it is challenging for farmers to purchase inorganic fertilizers because of their prohibitive costs. Additionally, there are some soils known as non-responsive soils that fail to improve with fertiliser addition. Therefore, the degraded and non-responsive soils exacerbate the soil fertility problems. A decline in soil fertility hampers crop production in Sub Saharan Africa. For example, kale and potatoes are among the crops which are valued by farmers for food and income generation in Kenya. Potatoes are the second important staple food crop in Kenya, after maize, while kale commonly known as "sukuma wiki" in Swahili is considered one of the most important vegetables consumed and used to generate income for the farmers in the country. However, these two crops face many challenges due to soil infertility as well as diseases such as black rot and bacterial wilt which commonly affect kales and potatoes respectively.

Sustainable land use, through agroecological practices helps in preventing soil degradation, erosion and the loss of valuable land by promoting practices that enhance soil structure formation and improved nutrient recycling. Biochar - a charcoal-like substance has been identified as an important soil amendment agent with multiple benefits which positively contribute to increased land productivity. Biochar is beneficial in many ways, namely: increased crop yield (Kätterer *et al.*, 2019); efficient nutrient recycling; pest and disease reduction; soil moisture and nutrient retention (Budai *et al.*, 2016, Biederman *et al.*, 2013); soil pH buffering as well as enhancement of cation exchange capacity (Hale *et al.*,

Kale production with biochar

Kale production without biochar

2020). Biochar addition has been used in maize production and has proved to increase yields (Kätterer *et al.*, 2019), but little has been done to use it as amendment for potato and kale production.

A study was conducted in Kapchorwa, south Nandi, Kenya to assess the effects of biochar on potato and kale yields.

BIOCHAR PRODUCTION

Biochar is produced through a controlled process called pyrolysis where organic matter from agricultural and forestry waste is burnt under limited oxygen. Biochar may be produced using simple to complex methods for example, use of Kon Tiki soil pits, barrel/drums as well as complex industrial processes. Every farm generates residue, which could be used for biochar production. This includes maize stovers, uprooted tea plants, leaves and branches from pruned trees, cow dung, animal bones, poultry waste, rice husks, sugarcane bagasse and many others. Biochar used in Kapchorwa on-farm demonstration plots was produced from bagasse collected from Kibos Sugar Factory and the charring process (pyrolysis) carried out using barrel drum stoves. Bagasse was air dried to <11% moisture content and about 16-17 kg were manually fed in each of the barrels and pyrolyzed for 45–50 minutes at about 500°C. When ready, biochar was allowed to cool by spraying it with water. After production, it was packed in bags for transportation to a central location within Kapchorwa catchment. It was bulked and thoroughly mixed for homogeneity to ensure that biochar had the same quality and properties before being used. After mixing, it was weighed to determine the wet weight before calculation of total dry weight. Biochar was applied at the rate of 1kg/m² or 10 tons/ha.

On the demonstration plots, the following treatments were suggested for kale and potato crops: biochar, biochar + DAP and DAP, with only one level of 10 tons/ha (1kg/m²) of biochar. All the trials were replicated three times. After land was prepared, biochar was evenly broadcasted on each plot at a rate of 1kg/m² and covered with topsoil using hand hoes.

Barrels/drum stoves

Industrial biochar production in China. Photo Solomon Kamau.

Certified varieties of potatoes (Sherekea variety) and kale (Collards variety EA) were planted. Potato planting was done on furrows with the spacing of 75cm between rows and 25cm between tubers while kale was planted in holes spaced at 60cm between rows and 40cm between seedlings.
Weeding was done once for potatoes and twice for kale to rogue out weeds. When potatoes were at flowering stage, they were sprayed using Dithane M45 every fortnight for prevention of late blight of potatoes which is common during wet season.

RESULTS

The results showed that plots treated with biochar + DAP had higher potato yields as compared to the other treatments. With Kale it was the same (Table 1). In both cases, biochar + DAP had 48% and 114% higher yields of potato and kales respectively above those from DAP alone treatments.

Table 1: Effects of biochar use on potatoes and kale production

Crop	Biochar	DAP	Increase in crop yield in biochar+DAP above DAP	p-value
Mean potato yield t/ha	15.2 (4.2)	22.9 (4.2)	48%	0.06
Mean kale yield t/ha	0.44 (1.6)	6.73 (1.6)	114%	0.002**

Numbers in parenthesis are standard errors (SE)
*p-values marked in bold are significant: ** p<0.01*

Biochar

where yield increase was persistent in maize-soybean rotations over 10 years after biochar application in sub-humid regions of Kenya (Kätterer *et al.*, 2019). This persistence in yield increase indicates that biochar performance and nutrient retention last long implying its application could reduce the amount of inorganic and or organic fertilizers to be used. During high rainfall seasons, nutrients are normally leached beyond the crop roots, however, where biochar is used, it captures nutrients making them available for use by the crops. The process by which biochar in combination with DAP increased potato and kale yields (Kätterer *et al.,* 2019) is mostly due to its physical and chemical properties which play a role in increasing cation exchange capacity (CEC) (Major *et al.,* 2010). Biochar surface properties allow it to capture cations from soil solutions as well as ammonium from

Kon Tiki soil pits

DISCUSSION

Biochar + DAP played an important role in increasing yields compared to the DAP alone (Martinsen *et al.*, 2014). This is attributed to the biochar properties of retaining nutrients over a longer period. This means that a single biochar application can improve yields in the next season. This has been proven

DAP fertilizer and avail them slowly overtime thus sustaining higher crop yields over a longer period. The pH was higher in the plots treated with biochar and these may have resulted to increased availability of the phosphorus in the soil. Addition of biochar into the soil changes physical properties such as water holding capacity and soil aggregation hence an increase in retained soil moisture which is availed to the crops during periods of water scarcity resulting in higher yields where biochar + DAP was used (Budai *et al.,* 2016). This is a good climate-smart agricultural practice as dry spells become frequent following climate change.

TAKE HOME LESSONS

• The synergies observed between biochar and diammonium phosphate (DAP) led to increased kale and potato yields which contributes to food security and income generation

• Use of biochar is important especially now that farmers are faced with the challenges of recurrent drought as it improves soil water and nutrient retention

•Methods used in biochar production are simple and can easily be adopted by farmers on their farms to process waste biomass such as tree prunings and crop residue.

•For environmental management purposes, biochar should only be produced from sustainably sourced biomass.

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