UPS 2: Pyrolysis for energy and biochar production in rural areas

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Key Objective **To process crop wastes and by-products into useful energy and other products as means of adding value to the crop production subsector.**

FVC component(s); key constraints and objectives addressed

The key constraints identified include inadequate management of waste processing and nutrient cycling, inadequate utilization of crop waste products (e.g. maize cobs) as a household energy source, low value accorded to some wastes and by-products, as well as haphazard disposal of such by-products leading to potential environmental pollution. Therefore, the main objective of this UPS is to process crop wastes and by-products into useful energy and other products as means of adding value to the crop production subsector.

Description

On-farm crop residues are not efficiently used: typically it is left to decompose or, sometimes, used by livestock in-situ. Crops residues are available in parallel with animal manure where crops and livestock production are integrated. The main crops grown in the project area include maize and sesame in the Kilosa district and millet, sorghum and sunflower in the Chamwino district. These crops, primarily processed at both household and peri-urban centres, generate by-products that could be utilized in various ways, including use for cooking. The same applies to secondary processing, where the resulting by-products have some limited use, but are often left unutilized, resulting in pollution through decomposition into uncontrolled emission of marsh gases and proliferation of disease causing agents, such as mosquitos and flies. Although such products could be just burned, there are other alternative decomposition methods useful to the society. Promoting use of these products will add value to the FVC,

reduce use of fuelwood, and save the environment from being polluted by such waste. Residues from primary processing, especially from threshing and shelling, are usually high in highly lignified structural components and therefore suitable for thermo-chemical conversion. Among the decomposition methods a pyrolysis-treatment of these (already dry) residues will provide thermal energy for cooking applications as well as biochar production, which can be used as an energy carrier or for soil amendment. Simple pyrolysis for charcoal making can be done, but for low density materials like maize cobs it may not be feasible. Therefore an improved pyrolysis method can produce cooking fuel and biochar.

Proven success in TZ and beyond

The concept of bioenergy production in Tanzania is not new, but it is not well researched. It is common to find rice husks being used to cure bricks and fueling the cook stoves of peri-urban food vendors. Maize cobs are sometimes used for cooking, although they burn very quickly. Many remain unused. However, rice husks and maize cobs are recommended for curing clay bricks in Morogoro-Tanzania (Magembe et al, 2015). Wood shavings, although not directly linked to crop production, also serve as a potential source of energy for cooking (Lohri et al, 2015). Crop by-products, like maize cobs, may result in energy useful for both heating and biochar. Some useful work has also been successfully conducted at the University of Hohenheim, Germany, which may warrant adaptation to maize growing areas of Tanzania. Although use of maize cobs is not new, research on thermal conversion of this by-product may lead to its increasing use as an energy source.

Technical specifics, dimensions

The device has a top-lid-up-draft (TLUD) barrel-reactor, which can be built from scrap material (oil drums) available locally, that is capable of sustaining high temperatures up to 400°C. The drum diameter and height are 59 and 44.5 cm, respectively. The drum has a screw-top lid, and a central pipe with a diameter of 10 cm perforated with a dense array of 10mm holes made throughout its height. The same 10 cm diameter pipe is fitted offset from the top lid extending to a height of 1 m for venting flue gases. The offset extension is necessary in order to make a depression for cooking pots to sit on. The chimney pipe is also equipped with flaps for controlling the speed and composition of stack gasses. A provision for controlling the entry of oxygen is made at the bottom. The assembly is as shown, but before use the top lid and the chimney are lifted off, then the base is filled with maize cobs and grass on top that is lit. After about 5 minutes the cobs catch fire, the top lid is replaced and the process continues.

Other drum sizes can be used depending on availability. Use of smaller size drums can be more beneficial as they are lighter and less costly. The cost of the drum used in this case, along with other materials and manufacturing costs, are estimated at TSH 70,000.00. The current TLUD-reactor was based on University of Hohenheim design, then modified by SUA, with later adaptions requested by farmers in Ilakala.

Type of food crops applicable

Is not limited to specific crops. The current work is based on maize but later on the research will extended it to other crops and plant products, such as simsim straws.

Proven successful by Trans SEC

Test results from the UPS farmers group in Ilakala showed that pyrolysis for about two hours on 15 kg of maize cobs yielded about 4.4 kg of biochar (29%). Water boiled 35 minutes after starting pyrolysis process (Yustas et al., 2016). However, during testing farmers observed some challenges including its relatively tall height, high reactor wall temperatures, and messy production of smoke affecting the operators. This led to the suggestion of reducing its height, insulating the surface and redirect the smoke away. They also suggested making a second depression on the top lid to accommodate a second cooking pot. Therefor, the overall height of the reactor was reduced, the exit pipe end bent to redirect the combustion products away, and the reactor wall was insulated with 2 cm layer of rice ash encapsulated in the mild steel outer sheet.

UoH design

SUA made tested by Ilakala Farmers

The preliminary results of the improved reactor indicate biochar to maize cobs ratio of about 41% and side wall temperatures reduced by 56% from the previous values of 120 to 1300C. It took about 40 minutes for water to boil, but pyrolysis continued. Temperature on the top lid and the sides kept on rising the highest values until the 60-65th minute, when a drastic temperature drop was observed. It also produced no smoke except during the initial minutes of pyrolysis. To produce enough biochar for amending soils required running the reactor about four times a day, i.e., producing about 20 kg of biochar. This may not be enough for application over a big farming area, especially where applications at the rate of 5-10 tons per hectare are expected. Production of biochar from this size of reactor may be more suited to small gardens.

Implementation constraints

The constraints include manufacturing processes that require electricity for fabrication (welding, drilling, cutting etc.); the high cost of the central pipe, and the lack of reputable manufacturing workshops in rural areas. In addition to manufacturing constraints, the technology may suffer from competition with use of cheaper sources of cooking energy and a lack of awareness about the importance of increasing the C/N ratio in soils.

Linkage to other FVC components

Natural resources and crop production by use of biochar and consumption (cooking and water boiling).

Considerations & criteria for UPS outscaling

UPS outscaling can not be done right now for two reasons: 1) comprehensive testing with farmers is not yet complete; and 2) test results on use of biochar are not yet available.

Key lessons learned

Maize cobs are converted into more useful material (biochar) for soil structure amendment through use of TLUD-reactors in rural areas.

Low temperature cooking is achieved through use of TLUD-reactor.

References

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