Technology for small-scale farmers doubles crop yield - Stepping stones on the road to food security in Ghana

Andersen, Mathias Neumann; Arthur, Emmanuel; Bolwig, Simon

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

New Research - Policy Brief

Technology for small-scale farmers doubles crop yield - Stepping stones on the road to food security in Ghana

Mathias Neumann Andersen
Scientific Coordinator of the WEBSOC Project
Aarhus University

Emmanuel Arthur
Researcher
Aarhus University

Simon Bolwig
Senior researcher
Technical University of Denmark

Executive summary

Agricultural production in Ghana falls seriously short of its very high potential. This counteracts efforts to create employment in rural areas, to feed a growing population, and to protect natural habitats. New research on sustainable intensification shows that resources are available in smallholder agriculture that can at least double yield. Making and using biochar as soil amendment - from waste products such as straw - increased soil fertility and dwindled greenhouse gas emissions. The new research also finds that combined with irrigation, one or two additional crop seasons per year could be completed, and yield increases up to five times be achieved. Through joint research efforts between Ghanaian and Danish Universities, tools that are affordable for small-scale farmers for making biochar and for irrigation were developed and tested. The test showed that the systems are profitable. However, for small-scale farmers there are serious obstacles in terms of access to credit and service of the equipment that need to be better organized and overcome. This is crucial since small-scale farming will be dominating the food production in Ghana in the foreseeable future.

Land of bounty?

The humid tropics, in which southern Ghana is situated, have the highest primary productivity of any landscape found on Earth. Maize yields above 16 tonnes per hectare have been measured in CIMMYT experiments under similar climatic conditions in Uganda in a single season. This means that on a yearly basis, with three seasons, yields well above 40 tonnes grain per hectare is achievable. Compared to temperate regions, where yield seldom go beyond 12 tonnes per ha in a year, this is no less than astonishing.

The meagre average yield in Ghana of less than 2 tonnes per hectare per season is far below economic optimum and thus incurs a substantial loss of wealth to the Ghanaian economy in aggregate terms.

WEBSOC: "**W**ater, **E**nergy-from-**B**iomass, **S**oil, **O**rganics, and **C**rop agricultural management strategies in Ghana" has explored how to fill the gap between the actual and potential yield by use of readily available resources. The current low yield amplify deforestation and loss of biodiversity as well as it promotes poverty, malnutrition and migration to urban centres.

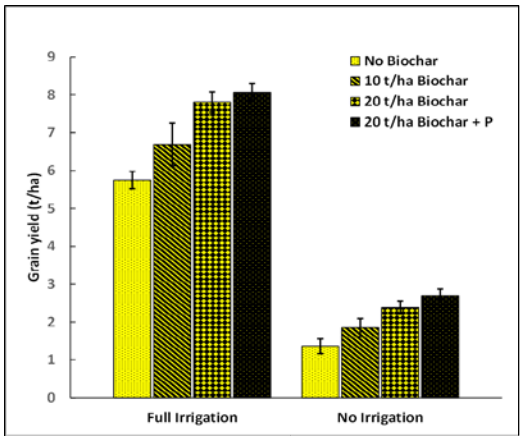
New Research - Policy Brief

The black gold: Biochar

The WEBSOC project investigated the use of crop residues to produce biochar and wood gas by pyrolysis for palm oil re-fining to lessen the pressure on forests for firewood and charcoal. Furthermore, the application of biochar to agricultural fields was demonstrated to increase soil fertility, carbon storage and crop yields. Thus, a triple-win situation was created in which farmers get sustained higher yields from improved soil fertility, greenhouse gas emissions are reduced by increased carbon sequestration, and palm-oil refineries and households get energy (from pyrolysis of empty fruit bunch and straw). In other words, WEBSOC developed as so-called "Bio-energy with carbon capture and storage" or BECCS-technology, which efficiently captures carbon dioxide from the atmosphere and sequester it as biochar in the soil for hundreds of years. The stove doing this job was developed by scientists at the engineering faculty of University of Ghana in cooperation with the Technical University of Denmark. It improved the combustion efficiency 10 times and solved the smoke pollution problems at the refinery where it was tested. Due to the high primary productivity in the tropics, the technology presents a huge potential for creating an upward spiral where higher yields produce more biomass, which can produce more biochar to boost yields.

Biochar is a pyrolysis product from organic material just like charcoal. Empty fruit bunch was pyrolysed in the WEBSOC stove and the heat used for artisanal palm-oil refining

The large positive effects of biochar on soil fertility and crop yield found in the WEBSOC experiments came as a surprise and were much higher than the scientists initially expected. However, it can be explained as follows. The main limiting factor to crop growth in the humid tropics is often the acidity of the soil (low pH) that makes nutrients in the soil inaccessible to plants. Biochar ameliorates the acidity by its content of lime that is formed during the pyrolysis process. The acid soils in particular binds phosphorus, so that the supply of this macronutrient to the plant roots severely limits crop yield. This effect of acidity is so strong that even supply of phosphorus fertilizer has little effect - apart from that it is very expensive. In addition, it was also found that biochar improved the soil structure and made soils less prone to erosion. Thereby another big problem in the humid tropics with respect to maintaining soil quality will become less.



Yield response of maize to irrigation and biochar at University of Cape Coast during the rainy season (Kwadwo Kusi Amoah)

The blue gold: Irrigation

The humid parts of West Africa including Ghana has plenty of water resources. Nevertheless, cultivation stops in the dry season in most places due to drought, which also occurs intermittently during the rainy seasons. Irrigation is increasingly recognized as a key technology, not only to improve food security, livelihoods and agricultural transition, but also for reducing vulnerability to climate change. However, facilities for irrigation are expensive and thus out of reach of most smallholders. To overcome this problem, the WEBSOC scientists developed an automatic

New Research - Policy Brief

drip-irrigation system driven by a solar panel at a cost of less than 2600 Ghana cedis. It is limited by only covering 500 square meter of land and by only being able to use surface water reservoirs, which however are plenty in many places. It is old wisdom that irrigation in combination with better supply of nutrients to crops produce a synergistic effect on yield. This was also found in this case, where the combination of biochar and irrigation increased yield of maize from 1.5 to 8.0 ton grain per ha i.e. more than 5 times. Considering this synergy effect and that, the small-scale solar drip irrigation systems can allow one or two extra growing seasons per year, it is no longer a dream to achieve yields 8-10 times higher than at present.

Economy

The research done by WEBSOC into these options was pursued within a framework that educated six PhD students and other young scientists at University of Ghana and University of Cape Coast. They also investigated the economic side of the new system and the possibility of creating new agricultural value chains, both on the supply and processing side. Vegetable growers around Cape Coast and Kade tested the irrigation system and were asked about the pros and cons. On the economic side, the irrigation systems were found very profitable with a net increase in earnings of about 1000 Ghana cedis in one (dry) season per system covering 500 square meters. While the access to water may not be a problem in Southern Ghana, it was found that access to credit for smallholders and lack of a service organization to maintain the irrigations systems, are important obstacles to widespread diffusion.

The economic analysis identified important environmental and socio-economic benefits for society as a whole in case of a large-scale adoption of the system. Drip irrigation using solar pumps reduces GHGs compared to grid and diesel powered pumps. Several socio-economic benefits were also identified: including improved nutrition and food security among adopting households, increased income and employment in rural communities, increased employment in the irrigation sector, improved access to better-quality vegetables for poor consumers, and reduced imports of high-quality vegetables.

Recommendations

Incorporate the automatic drip irrigation systems into the "Planting for Food and Jobs" programme so that farmers in applicable areas can get access to the credit from the local government.

Support and mainstream the NGOs and aid-organizations efforts on biochar and irrigation technology so that the information sent out to the farmers is coherent and applicable to the region/locality they find themselves in.