A Review: CSA Extension Services Promoting Biochar in Belize

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Abstract

The promotion of climate-smart agricultural practices through extension services is vital since the livelihood of many Belizeans depends on both agricultural and natural ecosystem services. Climate change is becoming a major threat to farmers. Extension services can introduce biochar as a climate smart agricultural strategy to combat climate change. Extension agents use several approaches to introduce new agricultural strategies, such as farmer field schools, science field shops, and agrometeorological services. These tools help with implementing climate-smart practices and capacity building for promoting resilience against climate change. Climate change requires changes in behavior, planned strategies, and novel information. To date, Belizean extension service is shifting from an extension agent approach, to a more farmer-centered, systematic approach, which leaves the opportunity for biochar systems to be introduced as a novel climate-smart agricultural practice. This review focuses on the recent trends of biochar application and methods used by Belizean extension services that can promote biochar systems as a Climate-Smart Agricultural practice in Belize.

Keywords: Extension services, climate-smart agriculture, biochar, climate change

Introduction

Belize is at a juncture where the demand for agricultural production and natural ecosystems protection is increasing. Two driving forces of Belize's economy consist of both agriculture and tourism, hence the increasing demand for production and protection as mentioned in the Growth and Sustainable Development Strategy for Belize in 2016. However, activities in agriculture and activities in natural ecosystems are closely intertwined - one system affects the other. In Belize, current environmental issues include high deforestation rates related to agricultural activities such as slash and burn, removal of buffer zones near rivers, pesticide and fertilizer leaching and runoff, and inefficient management of other solid and liquid wastes, directly relating to agricultural activities (Young, 2008). However, farmers understand that these environmental issues can contribute to climate change. Moreover, farmers understand that climate change is directly affecting their agricultural production systems. Therefore, it is essential for farmers to apply Climate Smart Agricultural (CSA) practices to adapt to a changing climate. Once farmers understand that climate change can affect their production systems and they are key influencers in mitigating climate change, the farmers will be motivated to implement climate-smart agricultural practices.

To counteract the negative environmental effects of agriculture, an innovative strategy is to implement biochar systems in Belize. The key in promoting the implementation of biochar is through extension service. Extension service is a key policy tool for promoting ecological and social sustainable farming practices. This method has assisted in disseminating information and knowledge to vulnerable people in a community. Thus, agricultural extension officers play a key role in the decision making and promotion of CSA practices for farmers. Several approaches for knowledge transfer exist; namely, Farmer Field schools (FFS), Science

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Field Shop (SFS), and agro-meteorological extension tools. These tools will assist in the implementation of climate smart practices and capacity building to mitigate climate change, and to build resilience against climate change. Being resilient to climate change requires change in behavior, strategy, agriculture practices, knowledge, and information. It is evident that extension services have now shifted their objectives to conducting research (CSA Research), developing technologies with farmers, and facilitating innovative processes with farmer collaborations, which leaves a great opportunity for the implementation of biochar. Site specific analyses will be needed for extension officers to know which CSA practices will be needed per farm.

The Implementation of biochar, as a CSA strategy, well-versed agricultural extension officers must be equipped with CSA knowledge. The biochar systems strategies must highlight amendment of infertile soils, filtration of wastewater, reduce the use of pesticides and fertilizers, to produce natural pesticides and fertilizers, to minimize deforestation, and to reduce greenhouse gasses, amongst other strategies. This review focuses on the recent trends and methods being implemented by extension services to promote biochar as a CSA strategy for Belizean farmers.

Overview of CSA Extension Services in Belize

Strengths of CSA extension service in Belize involve well trained extension officers, qualified officers with a strong background in agriculture, including practical and theoretical pedagogy in research with ability to deliver research information to the farmers. To date, extension officers in Belize have gained much training and capacity building in Climate Smart Agriculture (CSA) practices; through partnerships with local, regional and international organizations. The University of Belize presently offers a Bachelor of Science in Applied Agriculture, where courses such as Climate Smart Agriculture: Adaptations, and Extension Supporting Climate Smart Agriculture, are being offered. These courses can produce professional CSA extension officers that can contribute to development of a healthy agriculture sector in Belize. The development of Farmer Field School Curriculum, training manuals on CSA programs, projects and climate data has been provided by the Food and Agriculture Organization of the United Nations (FAO), Inter-American Institute for Cooperation on Agriculture (IICA), Organismo Internacional Regional de Sanidad Agroprecuaria (OIRSA) and the National Meteorological Service; which provide a strong foundation for CSA in Belize.

Development of key projects such as the Rural Resilient Belize (RRB) Project, falling under the International Fund for Agriculture Development (IFAD) has strengthened the extension service in CSA. Sugar Industry Research and Development Institute (SIRDI) offers services and training to farmers that intertwine with CSA. In addition, extension officers have been trained by The Tropical Agricultural Research and Higher Education Center (CATIE) on CSA with a focus on adaptation and mitigation (CATIE, 2022). Thus far, there are many activities related to CSA extension, however, minimum published activities have occurred, which highlights the need for publishing findings and activities related to CSA extension services. CSA extension services face many challenges that have been identified by in-depth institutional assessment carried out by IICA and FAO. One of the key bottlenecks identified is the ability for the Ministry of Agriculture to train officers internally. The institution tends to depend on external projects for funding to train extension agents. CSA training is meticulous, requires expertise, technology and most importantly, funding. The need to outsource funds is unsustainable. Other identified weaknesses in extension services include language barriers, especially with farmers in Maya communities, Mennonite communities and Foreign – born communities. There also exists reluctance by farmers to work with the extension officers due to trust, religious and cultural beliefs. Examples of these include hesitance of farmers to work with female extension officers. Extension agents also have limitations with using technology due to lack of equipment such as GPS, data collection devices, soil testing kit etc.

Advantages of Biochar as a CSA Practice

Agriculture, forestry, horticulture, and livestock farming have contributed a total of approximately BZE $494.1 million in Gross Domestic Product (GDP) by Activity in Constant Prices, 2014 (Statistical Institute of Belize, 2015). Due to the increasing demand for higher agricultural yields, an increase in agrochemical usage has been predominating in Belize (Kaiser, 2011). The increased use of agrochemicals in the agricultural industry has been caused by factors such as accustomed usage of chemical intensive agriculture, pesticide suppliers' marketing agenda, pest resistance, and soil fertility decrease (Avella et al., 2008). Currently in Belize, the top registered and most imported pesticides in Belize as of 2015 have been Glyphosate at 136.06 t per active ingredient, Mancozeb at 88.87 t per active ingredient, and 71.24 t of 2, 4-Dichlorophenoxyacetic per active ingredient, Atrazine at 47.12 t per active ingredient, Diuron at 39.82 t per active ingredient, and Ametryn at 24.56 t per active ingredient as reported by the Belize Pesticide Control Board (2016). The Belize Population and Housing Census Country Report (2010) reported that 40,330 households in rural areas and 39,162 households in urban areas were observed to engage in farming or agriculture.

The intense use of agrochemicals in agricultural fields typically located near water bodies can potentially have a leaching pollution effect on both terrestrial and coastal ecosystems (Gibson et al., 1998). Though there exists a high pesticide contamination risk in aquatic ecosystems located adjacent to farmland with practice of intensive agriculture, in developing countries there is a lack of monitoring programmes and management practices (Villamiraz et al., 2016). There may be instances in agricultural activities where the distribution, production, application, and disposal of pesticides are poorly governed, therefore posing an immediate and prolonged threat to adjacent pristine protected areas and sensitive ecosystems (Wu et al., 2000). According to Castillo et al. (2011), coral reef ecosystems are being threatened by eutrophication caused by anthropogenic activities that affect watersheds which drain into the coastal regions. Dzul-Caamal et al. (2016) and Wu et al. (2000) have observed that diving reptilian species such as the Morelet's crocodile (*Crocodylus moreletii*) are negatively affected by toxic pollutants caused by local or upland anthropogenic activities. A possible solution for the reduction of agrochemical pollution from diffuse sources, is the application of biochar buffer strips between pollutant source areas and receiving waters (Muscutt et al., 1993). Generally, buffer strips in agricultural land have been used as a filter mechanism to reduce adverse effects of pollutants and nutrient leaching, so as to maintain water quality in aquatic ecosystems found further downstream of active agricultural land (Barling & Moore, 1994).

Biochar is a carbonaceous material specifically produced from waste biomass through the process of pyrolysis (Antal & Grønli, 2003), and can be used to suit a myriad of applications advocating for agricultural and environmental sustainability (Hale et al., 2015). Due to its physicochemical structure, biochar can be used as ideal buffer zone because it can augment infertile soils, reduce nutrient leaching, combat negative anthropogenic climate activities, adsorb metallic pollutants and pesticides, amongst other beneficial characteristics (Pereira et al., 2011; Milla et al., 2013; Reid et al., 2013). The effectiveness of a biochar buffer strip is determined by biochemical and physical characteristics, inclusive of soil type, vegetation, rainfall intensity and duration, and location within the landscape. Buffer strips amended with biochar can therefore reduce agrochemical pollution.

Implementation of Biochar as a CSA Practice

Agricultural production generates large amounts of waste biomass. Instead of leaving the waste material to be decayed or relocated in open spaces such as landfills (Demirbas, 2004), the waste material can be converted to a more useful and applicable material such as biochar. The Toledo Cacao Grower's Association has been known to produce and utilize biochar for the increase in yield of cacao production in Belize. Therefore, the awareness of biochar application has been increasing since 2012. The use of biochar as a soil improvement in agricultural buffer strips has potential to realize multiple benefits: renewable energy generation, carbon storage in the terrestrial environment, and the better protection of vulnerable ecosystems such as surface waters from pesticide pollution (Werner et al., 2015). Over the past decades, extensive pesticide usage has posed toxic effects on soil quality and extensive ecosystems (Khorram et al., 2016).

According to Tang et al. (2013), biochar has the ability to increase sorption and reduce the dissipation of pesticides, thus creating a very cost effective and eco-friendly method of remediating a polluted environment. Cabrera et al. (2011) observed that the sorption of fluometuron and 4-chloro-2-methylphenoxyacetic acid (MCPA) was variable due to the biochar feedstock type, physiochemical structure, and organic matter in soil content. The application of ricehusk biochar to agricultural soils from

Cayo, Stann Creek and Corozal, has proven to reduce the environmental fate of agrochemicals such as atrazine and diuron in the soil (Aldana et al., 2020). Qiu et al. (2009) found that pH and dissolved organic matter significantly affected the adsorption of 2, 4-Dichlorophenoxyacetic acid using black carbon. Herath et al. (2016) observed that glyphosate was removed by rice husk biochar pyrolysed at 700°C at pH4, while Kumari et al. (2016) found that sorption of glyphosate increased after 7-18 months of soil birch wood biochar interaction. Other studies, such as Cabrera et al. (2014), found that wood pellet biochar completely sorbed herbicides; aminocyclopyrachlor and bentazone. Cederlund et al. (2016) modified the chemical properties of wood biochar by applying a heat and iron treatment, which caused a significant increase in sorption of diuron, chlorpyrifos, (4-chloro-2-methylphenoxy) acetic acid and glyphosate. Numerous studies have delved into the effect of biochar upon the fate of pesticide and agrochemical usage in agricultural activities (Mesa & Spokas, 2011). Limited field studies focus on the attenuation of pesticides through the application of biochar as a buffer strip. There is much needed research in regard to modeling of pesticide attenuation through biochar application in subtropical regions such as Belize.

CSA Extension Services to Promote Biochar

The strategic work of the Ministry of Agriculture in Belize is to strengthen institutional capacities to provide effective support in marketing and trade, research, and extension, as well as relevant education and training (CATIE UNDP Curriculum for Farmer Field School on Climate Smart Agriculture in Belize). Participation and collaboration with Inter- American Institute for Cooperation on Agriculture (IICA) and Ministry of Agriculture in the development of National Agriculture Research and Extension Strategy enabled the strengthening of the extension service. Along with training, such as, onion production, postharvest technology for root crops and fruits, rainwater harvesting, integrated farming system, rural investment methodologies, disaster risk reduction and sustainable land development (Ministry of Agriculture and Fisheries Belize, 2010). Ninety percent of extension officers have been exposed to training that focuses on CSA which includes organic production, irrigation technologies, value chain, covered structure, soil conservation and slope management. Therefore, the opportunity to implement biochar systems through CSA extension services can be realized if stakeholders understand the importance of biochar as a CSA strategy.

Conclusions

Efforts for the adaptation and mitigation of climate change have now demanded that Belize implements Climate Smart Agricultural practices such as the use of biochar systems. As Belize gears towards Climate-Smart Agricultural practices, extension services are moving towards a more student-focused form of extension service, whereby the farmer actively participates in learning new Climate-Smart Agriculture methods. The efforts to promote Climate-Smart Agriculture gives rise to opportunities regarding biochar systems research. As recent findings suggest, biochar as a Climate-Smart Agriculture practice can prove beneficial to the agricultural and environmental sectors of Belize.

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