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African Boxthorn Biochar Project
For
Northern Agricultural Catchments Council

Background

African Boxthorn (*Lycium ferocissimum*) is a densely branched, perennial shrub growing typically 2 - 3m in height and with branches that end in sturdy thorns. African Boxthorn is a Weed of National Significance due to its invasiveness impacts, potential for spread and significant environmental and socioeconomic impacts. (Commonwealth of Australia and the Australian Weeds Committee, 2012)

Once introduced, it displaces native vegetation in both coastal and inland environments, reducing biodiversity values of the local environment. It readily invades agricultural land, reducing access and usability. Boxthorn provides prime habitat for invasive animals such as rabbits. It provides impenetrable barriers to livestock, reducing access to pasture and water.

The fruit provides a breeding place for undesirable insects such as fruit fly, and a food source for birds and foxes, which in turn disperse the fruit's seed. Being spread by animals including birds, African Boxthorn is very challenging to contain and can readily spread to new areas including relatively remote coastal islands.

Current best management practice is to remove the whole plant with an excavator or by hand, pile in heaps and burn it when conditions are favourable.

Figure one (above): African Boxthorn removed and piled in heaps for burning

Objectives

The Northern Agricultural Catchments Council (NACC) approached Energy Farmers Australia (EFA) to trial the pyrolysis of African Boxthorn as a means to finding an alternative use for this plant once removed from the local environment.

Pyrolysis is the thermal conversion of organic material at high temperatures in the absence of oxygen. There are two types of pyrolysis processes, fast pyrolysis which produces a liquid and slow pyrolysis which produces a gas. Both processes produce a high carbon, charcoal like substance called biochar. The EFA system uses slow pyrolysis.

The aim of the trial was to look at the ease in which African Boxthorn, once removed from infected areas could be pyrolised into biochar. This trial focused on materials handling and pyrolysis of the African Boxthorn plant.

Materials Handling

In order for the African Boxthorn to be pyrolised through the EFA system, the material had to be broken down from whole trees and shrubs into smaller particles. As part of the project, EFA engaged Aussie Tree Services to travel to Dongara where the African Boxthorn piles were located and chip approximately two cubic meters. Aussie Tree Services then transported the chipped material back to Geraldton by truck where EFA bagged it into bulka bags.

After the piles had been chipped, it became clear that the African Boxthorn was not going to be able to be processed through the EFA system due to the large size of the material (see Figure two below). A one pass operation with a wood chipper as used by most tree lopping companies leave whole sticks and stems that cannot be moved by conventional augers.

Figure Two (above): Chipped African Boxthorn

EFA proceeded to process the material through a tub grinder which significantly reduced the particle size of the African Boxthorn into a more manageable form. (See Figures Three, Four, Five and Six below)

Figures Three, Four, Five (Left to right, above): demonstrate the process used to grind the chipped African Boxthorn material into a finer material for pyrolysis. Figure Six(bottom right) is the before (right) and after (left) photo after material had passed through the tub grinder

Pyrolysis

Pyrolysis of the African Boxthorn was conducted on the 28/5/2014. Unprocesed mateial was put into 3 x 60 litre drums. Drums were weighed and an average taken. Drum weight was approx 15 kg. (See Figure Seven below)

The EFA process works by feeding material into an delievery auger which feeds it into a drying auger inside the kiln. As the material moves along the drying auger excess moisture is driven off. The material then drops into the pyrolysis chamber. Another auger then moves the material along the bottom of the pyrolysis zone where it carbonises and gases bound up in the material are released. These gases are then mixed with introduced air and combusted, creating heat. The remaining biochar is removed, quenched and collected.

Figure Seven – African Boxthorn in 60L drums

Figure Eight – EFA Pyrolysis Kiln working

There are 6 thermocouples throughout the kiln which monitor and display (see Figure Nine below) process temperatures. Char is measured using a hand held thermometer as it leaves the kiln. During the process a record is kept of the temperatures.

(Figure Nine – Digital display of process temperatures)

Figure Ten – Internal view of pyrolsys process

Figure Eleven – African Boxthorn biochar

Key Findings

The African Boxthorn charred very well however, there were some problems moving the material with conventional augers. After some difficulty the decision was made to feed the material into the kiln by hand. While this practice is not ideal it did allow EFA to test the process.

Process temperatures were high, signifying a highly combstable material and ideal process conditions. Maximum temperature achieved in the gasification chamber was 982°C with the average being 715°C. Flare Temperature averaged at 374°C. Ideally, flare temps shoud be > 400°C to burn off any volitiles however, considering the short run time of the process and the fact that flare temps were on the increase before shut down, EFA is confident that the gas released is of high quality and well within acceptable emission standards. *(See Table One below)*

Table One – Process Temperature Log (°C)

	Flare	Chamber Feedout	Chamber Feedin	Trough Feedout	Trough Centre	Trough Feedin	Char
11.37 - Burner on	19	17	27	22	24	27	
11.50 - Start Feeding	187	356	774	33	28	43	
12.00 - Air on	148	788	974	72	54	78	
12.10 - Starting to Char	174	798	891	94	68	103	184
12.15 - Burner off/on	272	825	723	163	92	136	191
12.20 - Burner off	330	843	982	195	121	171	189
12.25	351	776	720	274	169	244	258
12.30	540	751	740	429	252	298	302
12.40	617	672	757	495	315	306	415
12.45 - Stop Feeding	671	664	797	495	315	306	415
12.50	664	475	713	635	413	328	458
12.55 Shutdown	512	277	476	611	427	315	403

Biochar yield was in the region of 20 – 30% which meets the target yield for biochar production through the EFA process *(See Table Two below).* Biochar temperature averaged approx. 400°C which is optimal for good quality biochar. Temperatures of 400–500 °C produce more char and retain nutrients, while temperatures above 700 °C increase the yield of gases however, nutrients can be driven off.

Energy produced was approx. 480 MJ thermal or 133kW of heat. Being a mobile system it would be hard and expensive to convert the heat to electricity however, process heat could be used to dry the incoming African Boxthorn which would increase the throughput capacity of the machine. Going forward the machine could be designed to utilise any syngas produced to run a generator to drive the machine and be totally energy self-sufficient.

Table Two - Results

	By Weight	By Volume
Processed Material	105 kg	420 L
Char Yield	30 kg	100 L
Yield %	28%	23%
Average Process Temperature	715° C	
Average Char Temperature	399° C	
Avergae Flare Temperature	374° C	
Heat Produced	479 MJ	
Power Available (heat)	133kW	

Conclusions

Overall this project demonstrated that while there are challenges with materials handling, pyrolysis of African Boxthorn is possible and mobile pyrolysis could potentially provide an “on-site” solution for the treatment of boxthorn waste, as opposed to the current practice of burning Boxthorn piles.

The biochar market in Australia is a small and expanding market. Currently, the retail price of woody based biochars is in the region of $2-5/litre. Therfore, there is potential to process Afican Boxthorn onsite to to produce biochars to sell into this market.

Considering the fact that African Boxthorn is a weed of national significance and very widespread throughout Australia. EFA recommend a more in depth investigation to determine benefits and the potential to deliever a positive buisness case for adotping the process. EFA would be pleased to work with NACC on such an initiative.