Biochar and productivity of *Digitaria eriantha* cv. Premier on a degraded soil in northern NSW

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Abstract: *Biochar can benefit agriculture by sequestering stable soil carbon, improving soil quality, and increasing fertiliser use efficiency. However, long term data to support these claims are lacking for Australian farming systems. This paper outlines two experiments to assess whether biochar will enhance soil quality and water and fertiliser use efficiency under sown tropical grass (Digitaria eriantha cv. Premier) in the summer dominant rainfall of the North-West Slopes of northern NSW.*

Introduction

The availability of water and nutrients and their efficiency of use are major constraints to the productivity of most Australian farming systems. Increasing and maintaining soil carbon (C) content in these systems may improve water holding capacity and biological cycling of nutrients. However, soil C accumulated through standard practices (i.e. pasture rotation, residue retention, organic amendment, etc) is easily lost by cultivation or overgrazing. Practices that increase the stable forms of soil organic C may provide longer lasting effects on soil fertility in the hotter drier regions of Australia.

Biochar is a C-rich material produced by slow pyrolysis (heating at <700°C in the absence of oxygen) of biomass. Biochar can be used as a soil amendment and to mitigate climate change effect. As a soil amendment, biochar can increase water and nutrient availability, and microbial biomass (Van Zwieten *et al*. 2010; Chan *et al*. 2008, K. Sinclair *unpubl.*). Biochar is not a fertiliser, so it needs to be applied with fertiliser in order to increase production (Chan *et al*. 2008). The stable form of C in biochar means that it also serves as a long term C sink to offset atmospheric CO_2 emissions. Biochar also reduces nitrous oxide emissions from moist soil and can increase methane uptake by soil (Lehmann *et al*. 2006).

High herbage mass and water use index (kg DM/ha/mm) are desirable traits for pastures in order to sustain animal production and prevent excessive water loss. The perennial tropical grass Premier digit (*Digitaria eriantha* cv. Premier) has these characteristics (Murphy *et al*. 2008), and is suited to the North-West Slopes of NSW. Two experiments were established in early 2010 to evaluate the role of biochar on stable soil C and mineralisation of N at Tamworth, NSW. These experiments are part of an international project funded by the Australia Centre for International Agricultural Research (ACIAR) to build more profitable and resilient farming systems in Aceh, Indonesia and NSW, Australia. Similar experiments are being conducted in Aceh to allow soil and climatic comparisons. This paper presents an outline of studies conducted on the North-West Slopes, and describes results relating to pasture establishment and soil water in the initial growing season.

Methods

These experiments are being conducted on a red clay soil at Tamworth Agricultural Institute. The biochar used was made from poultry litter (PL), at 550°C by BEST Energies Australia.

Experiment 1: Effect of PL biochar and fertiliser on soil water and herbage mass of Premier digit. The experiment consists of 2 factors; fertiliser at 3 rates (0, 50 and 100% of the recommended rate of N, P and sulphur) and biochar at 2 rates (Nil and 10 t/ha), each with 4 replicates, randomly allocated across a total of 24 plots. Access tubes were installed in the centre of each plot (7 x 9 m) to a maximum depth of 2.0 m for a neutron moisture meter (NMM), and 1.6 m for an enviroscan sensor in August 2009. Biochar was spread by hand, raked, and rotary hoed to ensure a uniform incorporation to 0.1 m soil depth. Premier digit was sown on 6 January 2010 (2 kg/ha viable seed) using a cone seeder with press wheels. Establishment was assisted with 48 mm of irrigation over 3 weeks after sowing, and there was 157 mm of rain recorded from 6 January to 23 April 2010. Soil water content was measured using a NMM at 0.2 m depth intervals at sowing and on 4 occasions after irrigation ceased. Establishment plant counts (seedlings/m^2) were conducted on 1 February 2010. The fertiliser treatments will be applied in spring 2010, and measurements will commence, including herbage mass at 4-weekly intervals, soil water content at 2-weekly intervals and plant frequency twice a year using methods described by Boschma *et al.* (2008). Surface soil and plant samples will be collected seasonally for C and N analysis. Undisturbed soil surface samples will be analysed for soil water characteristics and hydraulic conductivity.

Experiment 2: Measurement of mineralisation of nitrogen from soil and organic materials mixed with PL biochar. The treatments consist of 3 types of organic material: Nil, cow manure (10 g) sieved to >0.1 mm and maize stubble (10 g) mulched to 10–30 mm; 2 levels of biochar (Nil and 10 g) with 10 replicates. Each treatment was thoroughly mixed with 100 g red clay soil sieved to >1 mm and placed in 0.1 mm mesh bags. A total of 240 bags were buried 100 mm below the soil surface in June 2010. Treatments are randomly allocated in 10 areas of 2 x 3 m. located along a 100 m transect. Sample bags will be collected each spring over a 4 year period and analysed for C and N.

Preliminary results and discussion

In Experiment 1, plots containing biochar had higher seedling densities (241 ± 14 plants/m^2) than those without (216 ± 8 plants/m^2). The high seedling densities established in all plots generated soil drying effects to a depth of 1.2 m; deeper than that reported by Murphy (*unpublished*) for a first growing season of Premier on a red chromosol at "Dunreath" south of Tamworth. At sowing, initial profile stored soil water was high (~670 mm) providing uniform conditions from which to record soil drying achieved by the grasses in their initial season. Applied biochar had no effect on stored soil water at the end of season, but treatments had reduced stored soil water to ~583 mm.

Conclusion

An experiment to investigate the effects of biochar on productivity and nutrient cycling of a Premier digit grass pasture was successfully established in summer 2010. With such high plant density and uniform soil water conditions, this study is well-placed to provide quantitative information on the effect of biochar on water and nutrient use efficiency, and the effect of biochar on nutrient mineralisation from soil and other organic amendments. The study will continue until 2013.

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