Impact of Biochar on crop yield and nitrogen

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Aim

To determine the impacts of Biochar on crop yield
To determine how Biochar influences plant nitrogen uptake and soil nitrogen mineralization
To compare the effectiveness of different methods of applying Biochar to the soil

Background

Biochar is a carbon rich product created when organic matter is heated to temperatures greater than 250 °C in low oxygen conditions. During the conversion of organic matter to Biochar, volatile compounds are released. These compounds can be combusted to produce energy; hence it can be considered a carbon negative method of producing energy. Biochar is also very stable in soils. It can remain in soils for many hundreds or thousands of years, providing a method of carbon sequestration.

Our interest lies with its potential agronomic impact. It is suggested that application to soil may aid yield improvement. However, trial results have been varied. There are many potential explanations for varying results. One is the range of sources being used for Biochar. Biochar made from oil mallee will react differently in soil than Biochar made from a manure source. On top of this, the same Biochar may react differently in contrasting soil types.

There are many mechanisms by which Biochar can alter soil properties. The high cation exchange capacity of Biochar should improve nutrient retention, particularly in coarsely textured soils. As most Biochar is alkaline, it may also provide a liming effect. From a biological perspective, Biochar is also a potential habitat for microbes to avoid predation by nematodes and protozoa. Some Biochars can also supply nutrients.

With the proposed construction of a Biochar pyrolysis plant in Kalannie, the Liebe Group felt it was a timely opportunity to investigate the potential benefits and negative impacts of Biochar on crop production. The aim of this experiment is to examine the interaction between Biochar (made from wheat chaff) and nitrogen. From this we hope to determine whether Biochar changes nitrogen fertiliser use efficiency. Through funding from GRDC and Woolworths, the Liebe Group has been able to collaborate with the University of Western Australia in undertaking this trial.

Experimental methods

If Biochar does prove to be a beneficial soil ameliorant, growers will need to consider how to apply the product. In this trial, Biochar was either banded or applied on the soil surface at a rate of 4 t/ha using the Department of Agriculture and Food's trial seeder. The Biochar was applied in April 2010. The crop was then seeded on the 25th of May but due to a high ryegrass burden was sprayed out and re-seeded on the 17th of June. To investigate the claim that Biochar increases fertiliser efficiency the trial compares 3 nitrogen rates (0 units, 20 units or 40 units of N) applied as urea at seeding. No further nitrogen was applied.

Trial Details

Property	Liebe Long Term Research Site, West Buntine
Plot size & replication	20m x 2m x 4 replicates
Soil type	Deep Yellow Sand
Soil pH ($CaCl_2$)	topsoil 5.5, subsoil 4.6
EC	0.04 dS/m
Sowing date	17/7/10
Seeding rate	75 kg/ha Wyalkatchem
Fertiliser	17/7/10: 50 kg/ha Double phos. Urea as per treatments
Paddock rotation	07 Wheat, 08 Wheat, 09 Canola
Herbicides, Insecticides & Fungicides	17/7/2010: 2 L/ha Sprayseed, 1.5L Treflan
Growing Season Rainfall	166 mm

Results

Table 1: Average crop yield, grain protein and biomass production after Biochar was applied on surface and deep banded with 3 rates of nitrogen fertiliser (0, 20, 40 units of N). The L.S.D used is for comparing biochar treatments.

Nitrogen Treatment (kg N/ha)	Biochar Treatment (t/ha)	Yield (t/ha)	Protein %	Grain N (kg N/ha)	Post-tillering Biomass (t/ha)	Anthesis Biomass (t/ha)
40	Nil	1.5	10.7	35.3	0.8b	5.2
40	Banded	1.5	11.4	39.5	0.8b	5.5
40	Spread	1.4	11.4	35.3	0.9a	4.7
20	Nil	1.4	9.8	28.6	0.6d	4.5
20	Banded	1.4	10.0	29.5	0.7c	4.2
20	Spread	1.3	9.7	26.0	0.7c	4.9
0	Nil	1.4	9.2	27.7	0.4f	3.9
0	Banded	1.3	8.9	23.0	0.5e	3.8
0	Spread	1.6	8.7	28.7	0.5e	4.3
L.S.D (biochar)		**NS**	**NS**	**NS**	**0.08**	**NS**

Means followed by the same letter do not significantly differ (P=0.05)

Biochar and nitrogen had no effect on crop yield or protein in 2010 (Table 1). The total amount of nitrogen in the grain did not change with Biochar addition (Table 1), as such, the export of nitrogen from the soil did not change as a result of Biochar addition. There was no interaction between Biochar and nitrogen present in harvest results.

In the early stages of crop growth (post tillering) the addition of Biochar by topdressing increased plant biomass (0.7 t/ha compared to 0.6 t/ha where no Biochar was applied). By anthesis, however, Biochar had no significant effect on crop growth.

The increased crop biomass early in the season where Biochar was spread, could be attributed to Biochar's high water holding capacity, thereby aiding establishment and early plant growth in this below average rainfall season. In relative terms, 4 t/ha of Biochar contributes to only 0.5% of total soil mass of the topsoil (0-10cm). The effect this amount of Biochar has on water holding and cation exchange capacity in sandy soil, is largely unknown and required further analysis.

Comments

Biochar addition in this trial did not alter the grain yield, protein or total grain N harvested. This trial did not find any interaction between Biochar application and nitrogen fertiliser usage. The Liebe group will continue to monitor this trial in order to understand how Biochar affects crop production and the nitrogen cycle over time.

Using Biochar in broadacre agriculture, is a relatively new concept and is largely untested. Conditions for this experiment were not ideal, rainfall was below average, plots were cultivated 4 times in order to apply Biochar, and due to a high weed burden, the trial was seeded late. However, these are important considerations for farmers. Although not tested in this trial, laboratory plot trials have shown decreased pesticide efficacy with Biochar application (Yu et al., 2009). This, along with the potentially enhanced weed germination due to cultivation and the site's high ryegrass burden, are all potential contributors to the need for re-seeding.

Biochar is also considered a long term soil ameliorant. Once applied, it cannot be removed. Therefore, it is important to discover any potential negative ramifications prior to farmer application. Biochar also oxidises with time, and changes characteristics, for example, cation exchange capacity. Therefore it is necessary to monitor this trial over a longer period of time, as future results may vary from the first year.

Reference

Yu, X. Y., Ying, G. G., Kookana, R. S. (2009) Reduced plant uptake of pesticides with addition of biochar to soil. Chemosphere 76, 665 - 671.

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