

Biochar Effects on Fertilizer N and P Availability in Soil

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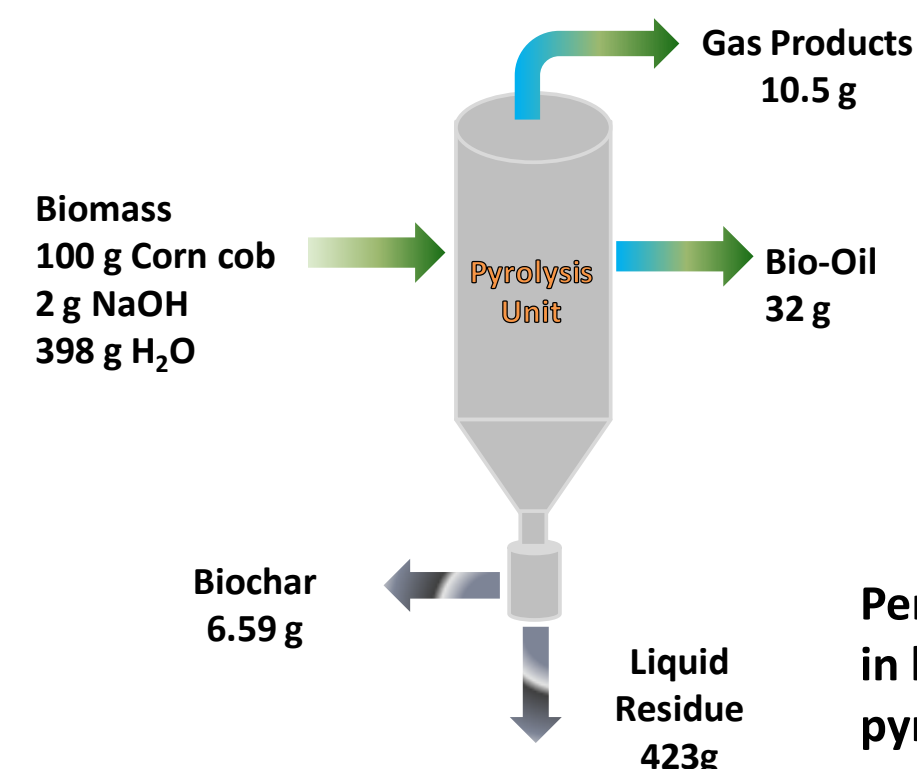
Justification

Biochar, a solid by-product rich in carbon generated during the pyrolysis of biomass, appears to have remarkable agronomic values. There is a growing interest in the use of biochar as a soil amendment, with potential to increase nutrient availability. Thus, the objectives of this project were to:

- Quantify **nutrient recovery** in the biochar relative to the nutrients removed in the biomass harvested.
- Study **availability of the nutrients** present in the biochar, and
- Study the **biochar effect** on availability of fertilizer nutrients.

Nutrient Conservation Study

- K presented poor recovery in the biochar. However, it was over 100% in the liquid residue.
- Recoveries over 100% were also obtained for Fe, Mn, Zn and Cu. This could be explained due to some contamination in the DI water used or some detection problems in the analytical method.
- Biochar and liquid residue from a liquefaction pyrolysis unit may be a good nutrient source.



Percentage of nutrient recovery in biochar in a liquefaction pyrolysis unit

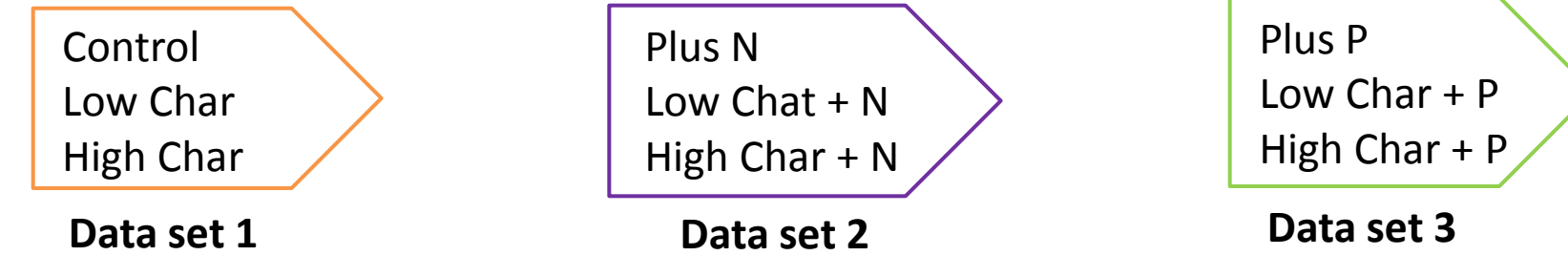
Nutrient Source	Nutrients								
	Primary		Secondary			Micro-Nutrients			
	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu
Feed Stock	355	6905	140	124	252	16	5	12	2
Biochar	1008	1117	799	1115	570	12208	73	220	28
Liquid Residue	33	2081	30	31	43	85	1	4	0
	mg kg ⁻¹								
Feed Stock	36	690	14	12	25	2	1	1	0
Biochar	7	8	6	8	4	85	1	2	0
Liquid Residue	14	880	13	13	18	36	0	2	0
	% Recovery								
Biochar	20	1	40	63	16	5501	101	126	119
Liquid Residue	39	127	92	105	71	2331	79	135	2

Nutrient Availability Study

- Two contrasting Kansas agricultural soils, Eva-Optima and Morrill Loam
- Randomized block design with 4 replications.
- Three biochar rates 0, 0.2, 2 mg/kg (0, 0.4, 4 Mg/ha)
- Two N rates 0, 100 mg N/kg (0, 0.2 Mg/ha)
- Two P rates 0, 20 mg P/kg (0, 0.04 Mg/ha)
- Mehlich III extraction for Phosphorus (P) and
- KCl extraction for NO₃-N and NH₄-N were carried out during six times (0, 3, 10, 17, 28, and 56 days).

Nutrient Availability Study Results

Differences among treatments and soil type were evaluated using Analysis of variance (i.e., SAS Proc GLM). Additionally, means and standard errors were performed with SAS v9.1. Three subsets of data were used to perform the ANOVA (Table 1).



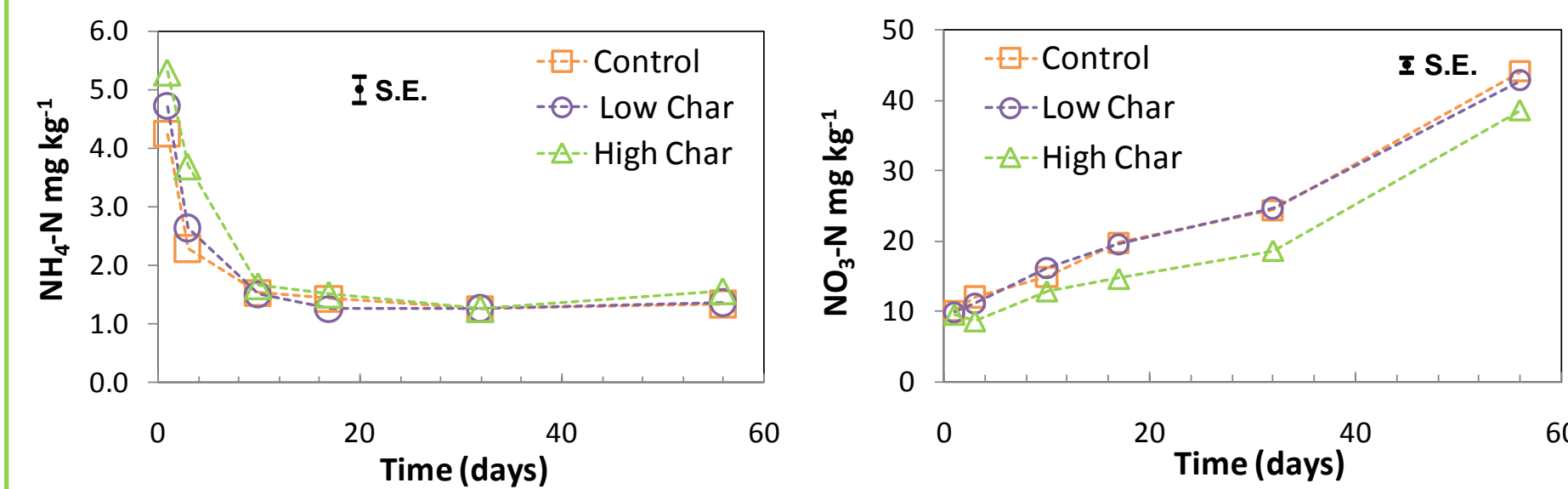
Biochar and biochar interactions effects on P and N availability in soil when biochar, biochar + P and biochar + N has been added, respectively.

Effect	Biochar added			Biochar + N			Biochar + P		
	M ₃ -P	NH ₄ -N	NO ₃ -N	M ₃ -P	NH ₄ -N	NO ₃ -N	M ₃ -P	NH ₄ -N	NO ₃ -N
Biochar	ns	***	***	***	*	*	ns	ns	***
Biochar*time	ns	***	ns	ns	ns	ns	ns	ns	ns
Biochar*soil	ns	ns	ns	***	ns	ns	ns	ns	ns
Biochar*soil*time	ns	ns	ns	ns	ns	ns	ns	ns	ns

*, **, and *** refer to p < 0.05, 0.01 and 0.001 levels respectively, and ns = not significant.

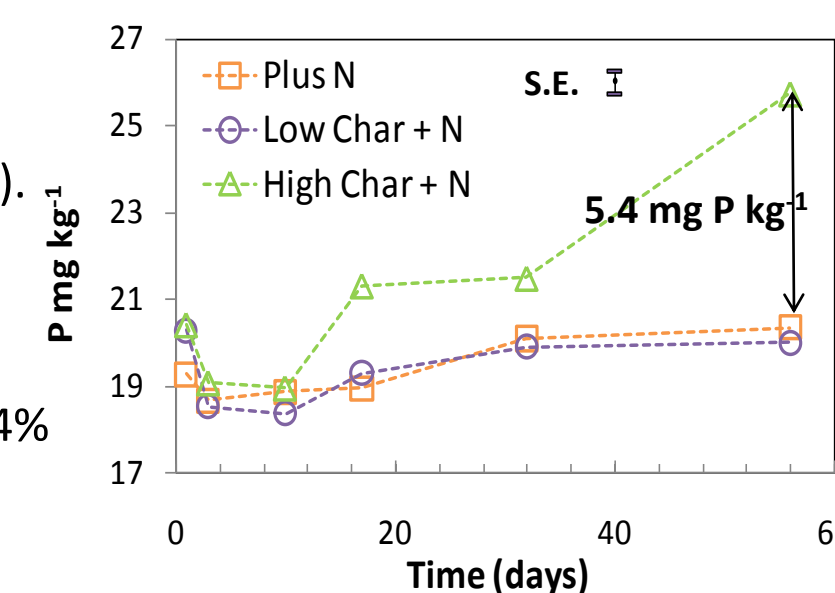
Biochar effects on N and P availability in soil samples (Data set 1)

- Ammonium concentrations were found higher during initial extractions when the high rate of biochar was added to the soil. Conversely, NO₃-N was lower with high biochar rate.
- This may be due to immobilization or fixation of ammonia on the CEC of the biochar. Therefore, high char addition may inhibit the nitrification process.
- P availability was not significantly affected when biochar was added (Data not shown).



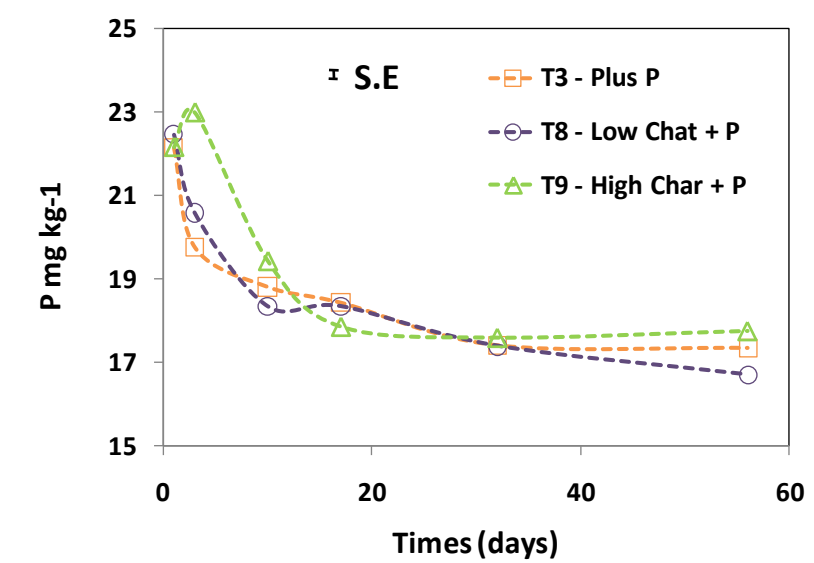
Biochar effects on N and P availability in soil samples when N has been added (Data set 2)

- Biochar reduced availability of N fertilizer.
- Similar trends to those plotted above were observed when N was added (Data not shown).
- P availability increases when N fertilizer was added. Around 5.4 mg kg⁻¹ of P became available when high char plus nitrogen was added. This represents a P recovery of about 24% of the P initially added in the biochar.



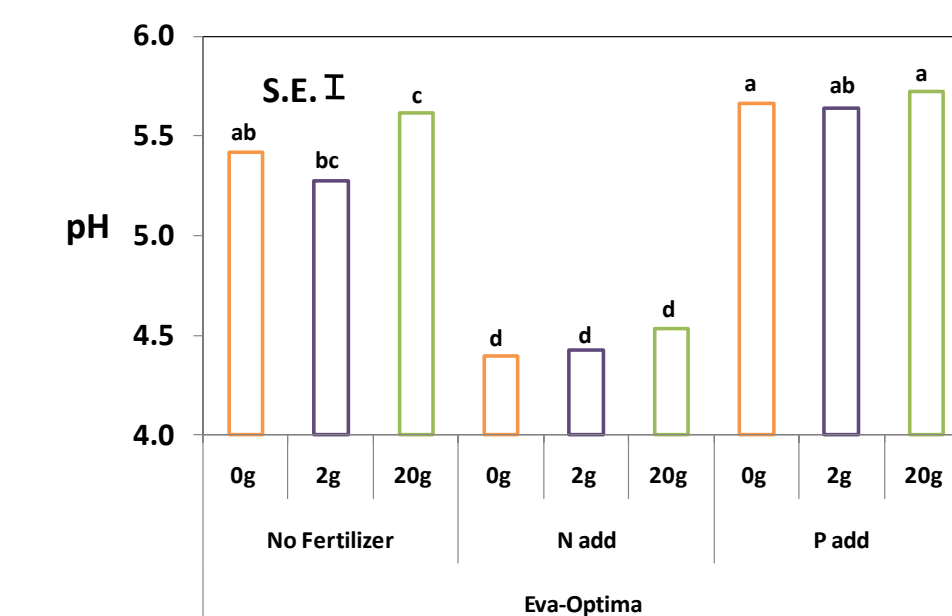
Biochar effects on N and P availability in soil samples when P has been added (Data set 3)

- Biochar did not affect P availability when P was added.
- Nitrate was consistently lower when high char plus P was added. This may be due to high biochar rates may inhibit the nitrification process.



Biochar effects on soil pH

- The addition of biochar did not have a significant effect on soil pH.
- The addition of N caused a drop in the soil pH which was mainly caused by the addition of N instead of for the biochar itself.



Biochar effects on CEC, macronutrients and micronutrients availability

- The CEC of the soils was not affected by the addition of the biochar.
- An increase in Fe availability was observed in the T2, T6 and T7 treatments. However, the increment was caused by the N addition not by the biochar itself.
- The biochar addition did not increase micronutrients (Cu, Mn, Zn, and Fe) availability.
- Base cations (Ca, K, and Mg) were not affected either by the biochar additions.

Conclusions

- Based on these results biochar itself does not have potential to increase P availability. However, once nitrogen fertilizer was added, P availability increased significantly.
- Biochar addition reduced N availability even when N fertilizer was added; therefore, producers may need to increase N fertilizer rates by approximately 10 kg/ha to compensate for the effects of biochar.
- Biochar did not increase the CEC of the soils.
- Biochar did not have any effect in macronutrients and micronutrients availability.
- Higher application rates of biochar may be needed in order to improve CEC, and nutrients availability.

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