Canola Yield and Nutrient Uptake as Affected by Biochar Addition to a Brown Chernozem

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The response of Canola (*Brassica napus* Invigor 5030) to biochar amendments was tested to investigate the effects of biochar on soil nutrients and crop growth. Series of pot experiments in controlled environmental conditions and a field experiment conducted with different biochars amended with brown chernozem soil (1 and 2 t ha^{-1}) in combination with N and P fertilizers. Parameters are tested include effects on germination and biomass yield, soil organic carbon, above ground nitrogen and phosphorus uptake and % recovery of applied N and P after harvesting. The crop yields were significantly increased in only a few cases with biochars, and only when in combination with fertilizer. Occasional negative effects were observed depending on biochar source. Soil amended with biochar showed increased nutrient uptake and fertilizer recovery in some cases. Liming and soil organic carbon effects were likely limited by low rates utilized.

Key Words: Biochar, Canola, Brown Chernozem, Yield Response, Nutrient Uptake.

1. Introduction

Biochar is fine grained, carbon enriched product mainly produced from biomass feedstocks (e.g. wood wastes, crop residues grasses, manures, etc.) burned at low temps (typically ~ 500°C) and anoxic or limited oxic conditions. Biochar predominantly used for sequestering C, and maintain or improve soil functions.

The physical features of biochar like, low biodegradability, high porosity and high surface area made biochar an important amendments which promote beneficial soil microorganisms, binding of nutrient cations and anions and may enhance the availability of N & P.

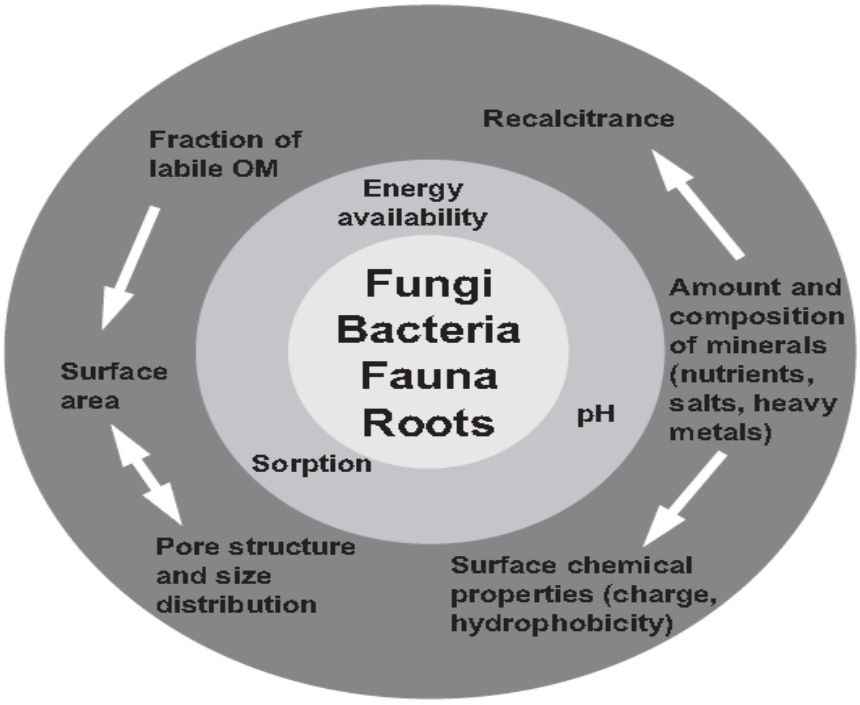

Figure 1: Diagram showing connection between biochar properties (outer circle), the soil (intermediate circle) and the soil biota (inner circle) *(From Lehman et al. 2011.)*

Biochar often impacts on soil properties by alteration of soil pH, iIncreases CEC, retain nutrients and moisture and affects soil biota, roots & nutrient uptake (Lehman et. al 2011) and thus Greatly affects crop Yield (Chan et. al 2007). Nutrient loss can be limitation to utilization efficiency of fertilizers and can be minimized using slow release nitrogen fertilizers (Gentile et al, 2009) or increasing adsorption sites. Biochar shown to play role in tropical soils but *what* about prairie soils?

2. Objectives of the study

To evaluate the effectiveness of different biochars as soil amendments to improve soil conditions for crop growth, with emphasis on soil fertility impacts in Saskatchewan soils.

2.1 Hypothesis

a. The biochars will improve N & P fertilizer uptake and recovery by crop and enhance yield, and

b. Effects of the biochars on soil conditions and plant growth will vary as a function of the different feedstocks and processes used in their manufacture.

3. Methodology

3.1 Study Site: Central Butte (Brown soil zone) Site

The site is gently rolling, dominated by Brown Chernozems, mixture of Kettlehut and Ardill soil associations, moderately calcareous, fine to loam soil texture with low OM content (2%).

3.2 Pot Trials in Growth Chambers

Soils: Central Butte (Brown Chernozem loam soil) 0-10cm

Biochars: Five sources from five different feedstocks (SRC, Prairie Biochar)

Crops: Canola (*Brassica napus* Invigor 5030) followed by Spring Wheat (Waskeda)

Growing Period: 4 weeks (each crop)

Experimental set up for Pot study: CRD with a control and two rates of biochar (1 and 2 T/ha) in combination or without two rates of N fertilizers (50 &100 kg N/ha) and 25 kg P_2O_5 ha^{-1}

3.3 Field Plot Trials

Experiment: Spring, 2012

Study Sites: Central Butte (Brown Chernozem loam Soil)

Biochars: Four sources from four different feedstocks

Crops: Canola (*Brassica napus* Invigor 5030)

Experimental set up for field study: Factorial Split split Plot design with a control and two rates of biochar (1 and 2 T/ha) in combination or without two rates of N fertilizers (50 &100 kg N/ha) and 25 kg P_2O_5 ha^{-1} broadcasted.

3. Results & Discussion

3.1 Biochar characteristics

Table 1: Characterization of different biochar types

Biochar Type	**Pyrolysis**	**Surface area (m^2 g^{-1})**	**pH**	**TOC (%)**	**CEC (meq /100g)**	**Ash (%)**	**N (%)**	**P (% In Ash)**
SRC Wheat straw	Fast (~400°C)	2.41	9.2	66	36	**14.6**	0.9	1.0
SRC Flax	Fast (~400°C)	1.03	8.6	71	32	7.6	1.38	**2.7**

straw								
SRC Willow-1	Fast (~400°C)	**3.02**	9.5	69	26	10.8	1.35	1.9
SRC Willow-2 (Chunky)	slow (300- 600°C)	-	9.7	**83**	11	-	-	-

3.2 Effects of biochar on biomass yield

The main findings from growth chamber on Yield were fertilizer addition significantly ($p<0.05$) increased canola yield. Biochar amendments did not significantly affect yield in majority of cases and this results agrees with results of Spokas et al. (2012).

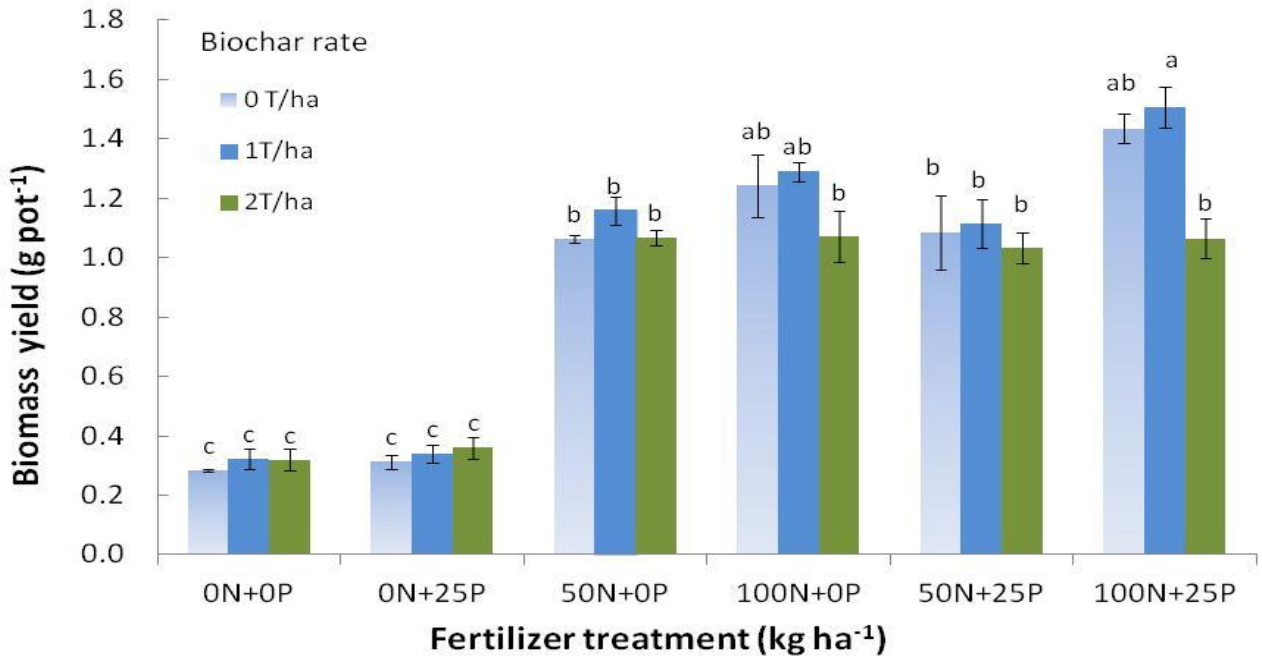

Figure 2: Biomass Yield (g pot^{-1}) of Canola grown in wheat straw (fast pyrolysis) biochar amended soil in growth chambers. Error bars are standard error of mean with the same letter are not significantly different ($P>0.05$).

The Main findings from Field Study on Yield were *Similar to growth chamber* in which fertilizer effect, but no significant effect ($p<0.05$) of biochar amendment alone or in combination with fertilizer on canola yield.

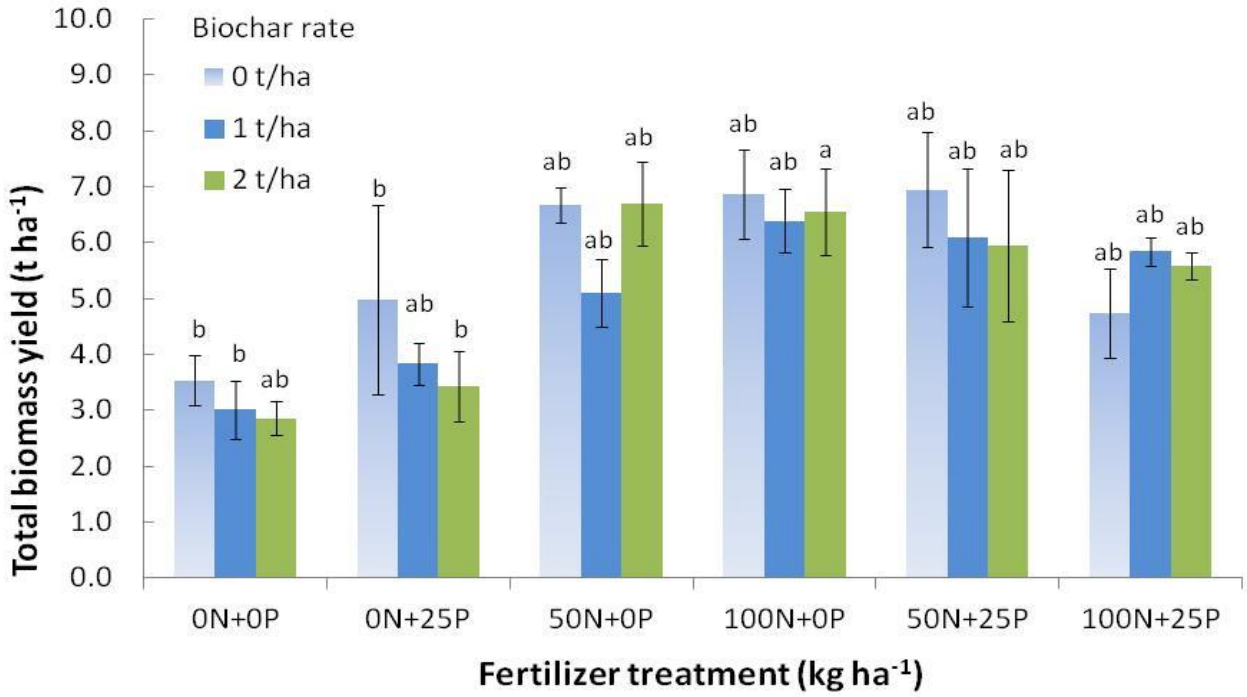

Figure 3: Total biomass yield (t ha^{-1}) of Canola grown in wheat straw (fast pyrolysis) biochar amended soil in field. Error bars are standard error of mean with the same letter are not significantly different (P>0.05).

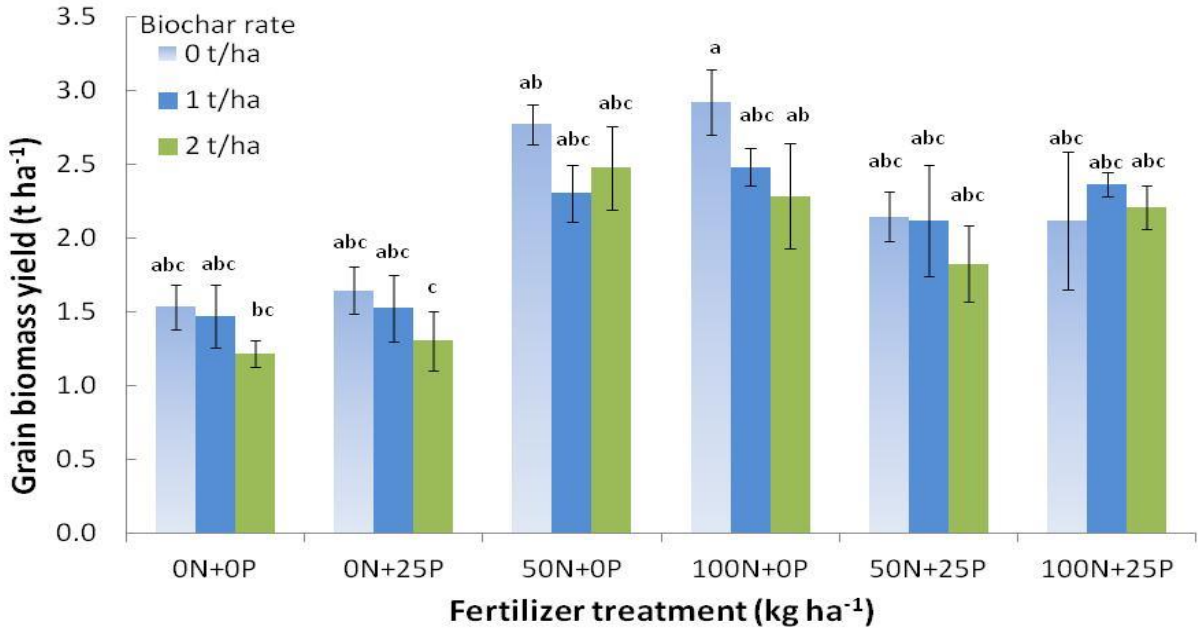

Figure 4: Grain yield (t ha^{-1}) of Canola grown in wheat straw (fast pyrolysis) biochar amended soil in field. Error bars are standard error of mean with the same letter are not significantly different (P>0.05).

3.3 Effects of Biochar on Nutrient Uptake in Growth Chamber

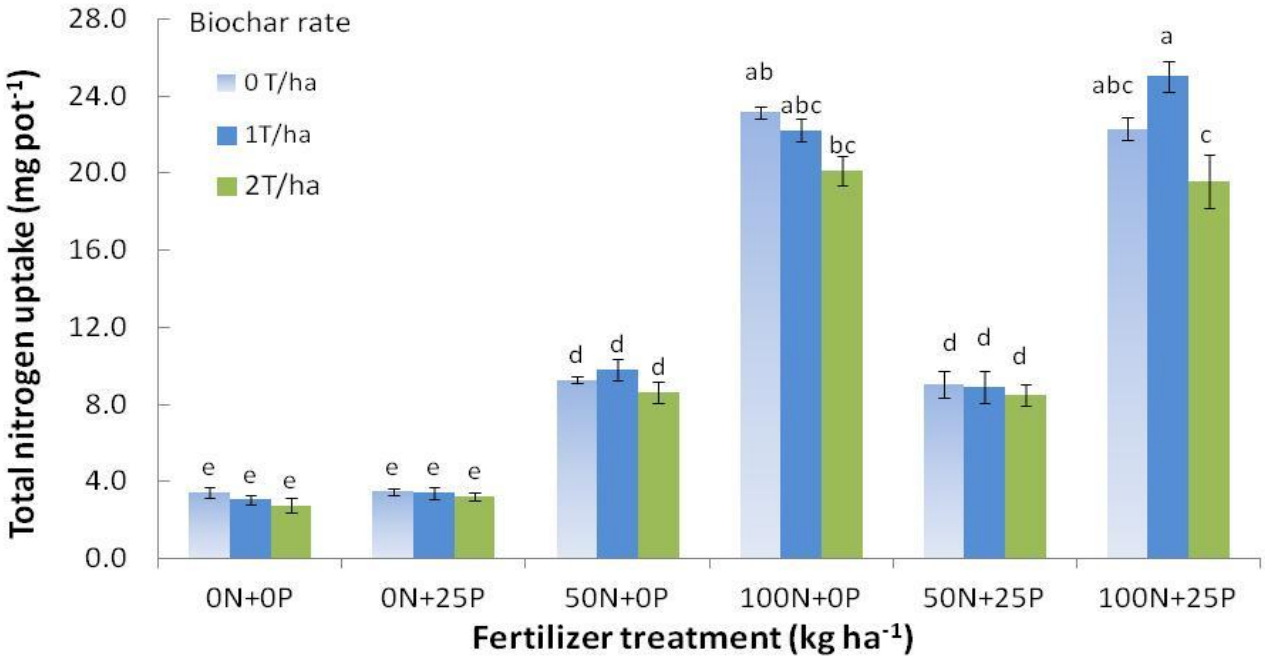

Figure 5: Total nitrogen uptake (mg pot^{-1}) of Canola grown in wheat straw (fast pyrolysis) biochar amended soil in Growth Chamber. Error bars are standard error of mean with the same letter are not significantly different (P>0.05).

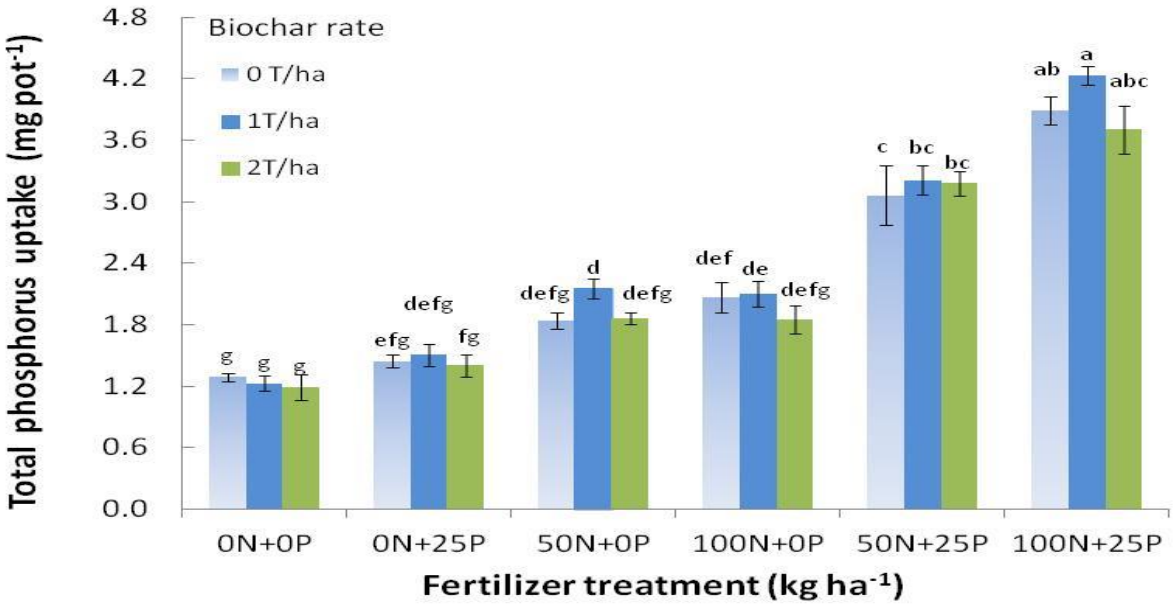

Figure 6: Total phosphorus uptake (mg pot^{-1}) of Canola grown in wheat straw (fast pyrolysis) biochar amended soil growth chamber. Error bars are standard error of mean with the same letter are not significantly different (P>0.05).

3.4 Fertilizer Recovery by Canola

Table 4: % Nitrogen and Phosphorus Recovery by Canola grown in wheat straw (fast pyrolysis) biochar amended soil in growth chamber

Fertilizer treatment	**Total Nitrogen (%)**			**Total Phosphorus (%)**		
	Biochar (t/ha)			Biochar (t/ha)		
	0	1	2	0	1	2
50N+0P	23	27	23	-	-	-
100N+25P	38	43	33	15	17	15

3.5 Biochar effects on other soil properties

Table 5: Effects of wheat straw (fast pyrolysis) biochar on soil pH, Organic Carbon (OC) and Electrical conductivity (EC)

Fertilizer Treatment	**pH**			**%OC**			**EC ds m^{-1}**		
	Biochar (t/ha)			**Biochar (t/ha)**			**Biochar (t/ha)**		
	0	1	2	0	1	2	0	1	2
0N+0P	7.87b	8.00a	8.02a	1.51a	1.62a	1.61a	0.22a	0.22a	0.19a
0N+25P	7.95ab	8.01a	8.02a	1.50a	1.57a	1.61a	0.18a	0.19a	0.22a
50N+0P	7.98a	8.03a	7.98a	1.50a	1.61a	1.63a	0.17a	0.18a	0.18a
100N+0P	8.01a	8.03a	8.02a	1.54a	1.60a	1.59a	0.17a	0.18a	0.17a
50N+25P	8.02a	8.01a	8.02a	1.53a	1.61a	1.60a	0.17a	0.18a	0.17a
100N+25P	8.04a	8.01a	8.03a	1.54a	1.59a	1.59a	0.17a	0.17a	0.17a
P Value									
Biochar Rate (RT):	0.002			<0.0001			0.5613		

Fert. Treat. (FT):	0.002	0.919	0.001
RT×FT:	0.001	0.863	0.470
SEM:	0.018	0.024	0.012

Note: Means with the same letter in the same row are not significantly different (P>0.05). (Tukey method). SEM=standard error of mean.

Why little or no effect of biochar amendment?

- Low rate: 1-2 tonnes per hectare is all that could be practically applied in the field. Biochars are powdery ash of very low density, difficult to handle and apply.
- Nature of prairie soils: Compared to many tropical soils, prairie soils have good nutrient retention ability to begin with.
- Environment: Semi-arid to sub-humid environment restricts potential nutrient leaching loss.

4. Conclusion

The crop yields were significantly increased in only a few cases with biochars, and only when in combination with fertilizer. Occasional negative effects were observed depending on biochar source. Soil amended with biochar showed increased nutrient uptake and fertilizer recovery in some cases. Liming and soil organic carbon effects were likely limited by low rates utilized.

References:

Lehmanna,J., M.C., Rillig, J., Thies, C.A., Masielloc, W.C., Hockadayd, and D., Crowleye. 2011. Biochar effects on soil biota e A review. Soil Biology & Biochemistry. 43: 1812-1836

Chan, K.Y., Zwieten, L. V., Meszaros, I., Downie, A., Joseph, S., 2007. Agronomic values of greenwaste biochar as a soil amendment. Australian J. Soil Res. 45, 629-634.Stefankiew, J. 2012

Spokas, K.A., K.B., Cantrell, J.M., Novak, D. W., Archer, J.A., Ippolito, H. P. Collins, A.A., Boateng, I.M., Lima, M.C., Lamb, A.J., McAloon, R.D., Lentz, and K.A., Nichols. 2011. Biochar: A Synthesis of Its Agronomic Impact beyond Carbon Sequestration. J. Environ. Qual. 41: 973-989.