Spring Wheat Growth and Nutrient Uptake in the Second Year After Biochar Amendment

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INTRODUCTION

Biochar has been shown to increase cation exchange capacity (CEC), nutrient cycling, and help retain plant available nutrients and water. Therefore, the use of biochar as a soil amendment may increase nutrient retention and thereby enhance agronomic crop productivity (Liang et al., 2006).

The persistence of biochar application effects beyond the season of application requires evaluation in prairie soils.

OBJECTIVES

Field plot trials were continued for a second year at experimental sites in the Brown and Black soil zones (CB-Brown and CLC-Black) to evaluate the effect of biochar amendment on wheat (*Triticum aestivum*) yield and N and P fertilizer recovery the year after biochars were applied and canola was grown.

MATERIALS AND METHODS

Experimental plots were established in fall 2011 at two sites, Central Butte on a Brown Chernozem (CB-Brown) and Conservation Learning Centre, Prince Albert on a Black Chernozem (CLC-Black).

A total of four biochars were obtained from three different feedstock sources: 1) wheat straw (*Triticum aestivum* L.) derived fast pyrolysis fine fraction biochar (WSB-Fine); 2) flax straw (*Linum usitatissimum* L.) derived fine fraction biochar (FSB-Fine); and 3) willow stem (*Salix spp.)* derived slow pyrolysis fine fraction biochar (WB-Fine) and 4) chunky fraction biochar (WB-Chunky).

Biochars were added to both sites in April, 2012. The experiment at each site was designed as a split-split plot design with three biochar rates (0, 1 and 2 t ha^{-1}) alone and with or without 50 or 100 kg N ha^{-1} and 25 kg P_2O_5 ha^{-1} added fertilizer. The sites were cropped with canola-wheat rotation, with canola grown in 2012 followed by wheat in 2013. No fertilizer or biochar amendments were made before the wheat (Hard red spring wheat var. Waskeda) was grown in 2013. Results of the 2012 season with canola are reported in Ahmed et al. (2013).

RESULTS

The ANOVA indicated that biochar type, biochar rate, biochar type plus fertilizer treatment interactions were non-significant (P>0.05) for CB-Brown site for total wheat above-ground biomass and grain biomass (Table 1).

For CLC-Black site, fertilizer treatment, biochar rate, and biochar rate - fertilizer treatment interactions were found to be significant (P<0.05) for total wheat above-ground biomass and grain biomass (Table 1).

RESULTS

Table 1. The influence of 2012 biochar and fertilizer treatments and their interactions on 2013 wheat above ground total biomass and grain biomass.

Sources of Variation	CB-Brown				CLC Black			
	Total biomass		Grain biomass		Total biomass		Grain biomass	
	F†	*P*†	F	*P*	F	*P*	F	*P*
Biochar type (BT)	0.3	0.813	0.5	0.689	1.0	0.406	1.0	0.415
Biochar rate (BR)	0.3	0.746	0.5	0.626	6.7	**0.002**	7.7	**0.001**
Fertilizer treatment (FT)	0.6	0.725	1.0	0.393	9.5	**0.001**	8.5	**<0.001**
BR × FT	1.1	0.346	1.2	0.289	3.0	**0.022**	3.4	**0.012**
BR × BT × FT	0.6	0.986	0.6	0.980	0.7	0.835	0.8	0.765
Contrast¶								
BR 0 vs (1+2) t ha^{-1}	0.0	0.994	0.1	0.803	2.5	0.118	3.3	0.074
BR 0 vs 1 t ha^{-1}	0.1	0.708	0.1	0.803	0.1	0.782	0.0	0.855
BR 0 vs 2 t ha^{-1}	0.2	0.698	0.5	0.495	9.1	**0.003**	10.9	**0.001**

† P and F values for treatment effects and interaction terms and single-degree-of -freedom orthogonal comparison derived from an ANOVA (P<0.05)

¶ Orthogonal contrast = Classes compared biochar rates (biochar 1 t ha^{-1}, biochar 2 t ha^{-1}, or biochar average of 1 t ha^{-1} + 2 t ha^{-1}) as a class vs. no biochar treatments (control, no biochar)

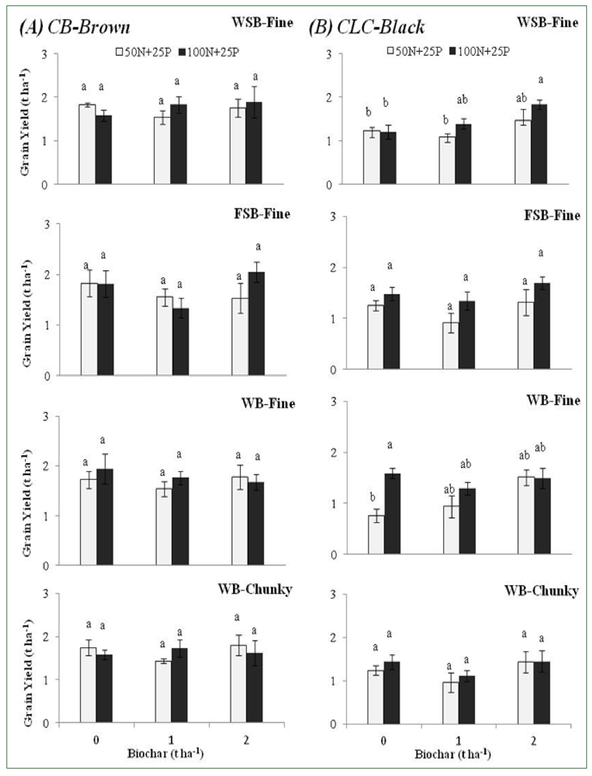

Fig. 1. Mean (n=4) grain yield (t ha^{-1}) of wheat grown in the second year as a second crop in a canola-wheat rotation in biochar amended (A) CB-Brown and (B) CLC-Black soil. Error bars are standard error of mean (biochar rate x fertilizer treatment). For a soil and biochar type, means with different letters are significantly different (Tukey's HSD, *P*<0.05)

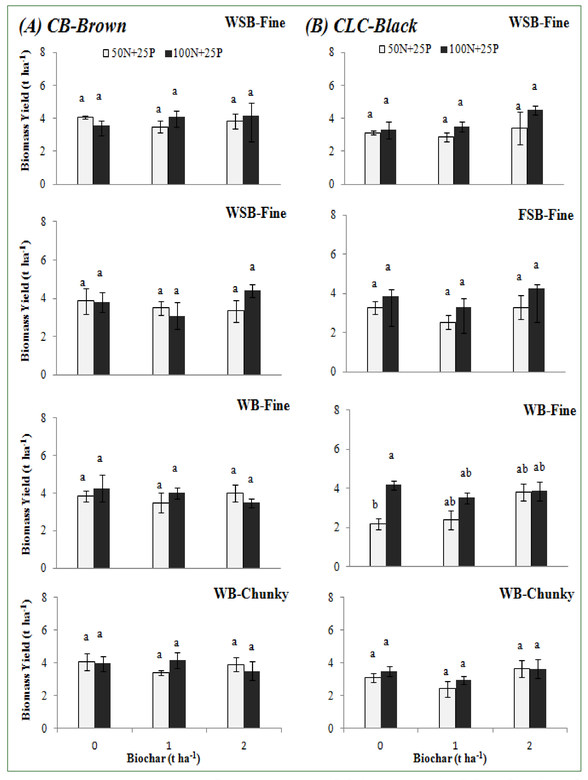

Fig. 2. Mean (n=4) above-ground biomass yield (t ha^{-1}) of wheat grown in the second year as a second crop in a canola-wheat rotation in biochar amended (A) CB-Brown and (B) CLC-Black soil. Error bars are standard error of mean (biochar rate x fertilizer treatment). For a soil and biochar type, means with different letters are significantly different (Tukey's HSD, *P*<0.05)

DISCUSSION

Application of biochar had no residual effects on wheat grown in rotation as a second crop in the second year on CB-Brown site while CLC-Black sites showed variable effects on wheat grain yield and above-ground biomass yield (Fig. 1 and Fig. 2).

Between the two field sites, the CLC-Black Chernozem soil, characterised by greater organic matter (OM) and soil available N content, appeared to be more responsive in yield to biochar amendment than CB-Brown Chernozem soil. Also, the slight increase in OC and pH in CLC-Black soil from the biochar amendment may have been beneficial to increase the availability of soil nutrients to plants.

Among the biochar types, the wheat straw fast pyrolysis biochar did produce a yield increase in the CLC-Black soil. This may be due to the higher retention of residual nutrients by the WSB-Fine biochar, that could be taken up by the wheat in the following year.

CONCLUSION

Biochar addition increased wheat yield only on one soil: the Black Chernozem, and only for one biochar type: a wheat straw fast pyrolysis fine biochar. The fast pyrolysis fine biochars with high CEC appeared to be more effective in promoting crop growth and nutrient uptake and recovery than slow pyrolysis types.

Overall, wheat grown as the second crop in the rotation showed limited response to biochar amendment, likely as a result of nutrient depletion by the previous canola crop. In both soils, biochars at the rates applied (1 and 2 t ha^{-1}) had no significant effect (>0.05) on soil EC, organic carbon concentrations, or soil moisture content.

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