Impact of Biochar and Manure Additions on Canola Growth and Fate of Applied Nitrogen Fertilizer in a Humic Vertisol and Brown Chernozem After Four Years

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INTRODUCTION

- The ability of biochar to improve numerous soil physical, chemical, and biological properties (e.g., bulk density, cation-exchange capacity, pH, microbial community activity, etc.) is well established.
- Previous research has concentrated on tropical soils (i.e., old and highly-weathered, acidic pH, low organic matter content, and poor fertility). However, the influence of biochar application on the relatively young and fertile soils of Saskatchewan is largely unknown.
- The potential value of biochar soil amendments to improve plant utilization of nitrogen (N) fertilizer is not well understood.

OBJECTIVE

- Examine the effect of two biochar amendments with, and without, the addition of different animal manures on canola growth, along with the fate of ^{15}N-labelled fertilizer four years after application in two contrasting soil types.

MATERIALS & METHODS

- A two-factor (biochar and manure soil amendments) field study was set up in 2013, using a split-plot experimental design, with four replicates. The soil amendments and ^{15}N-labelled fertilizer were applied only in year one (2013).
- The study was established on two contrasting fields: Orthic Humic Vertisol (Class 1; Melfort) and Orthic Brown Chernozem (Class 4; Central Butte).
- Whole plots: 100 kg N/ha as solid cattle manure (SCM) or liquid hog manure (LHM); split-plots: 8 Mg C/ha as willow (*Salix* spp.) 'chunky' or 'powder' biochar produced using slow- and fast-pyrolysis, respectively.
- After each year of the four-year cereal-oilseed crop rotation (barley-canola-wheat-canola), the recovery of broadcast applied double-labelled $^{15}NH_4{}^{15}NO_3$ fertilizer was measured from the biochar-only treated plots.
- Variables measured: crop yield (only the fourth year canola data is presented here); accumulation of fertilizer N in the above- and below-ground crop tissues; and the distribution of fertilizer N within the soil profile.

RESULTS & DISCUSSION

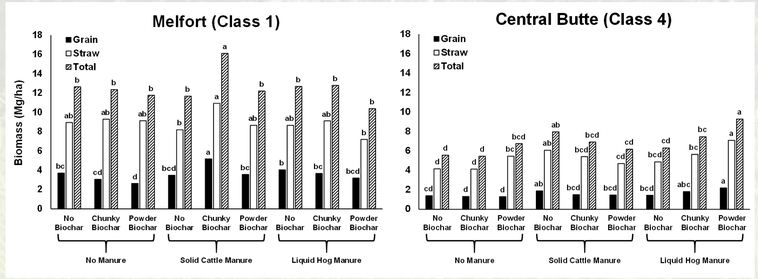

Figure 1. Mean (n = 4) canola yield four years after willow 'chunky' and 'powder' biochar additions (8 Mg C/ha) with, and without, added animal manure (100 kg N/ha; urea equivalent applied in non-manured plots), to Orthic Humic Vertisol (Melfort) and Orthic Brown Chernozem (Central Butte) soils. For each plant component (e.g., grain), columns with the same letter are not significantly different (P >0.05) using LSD.

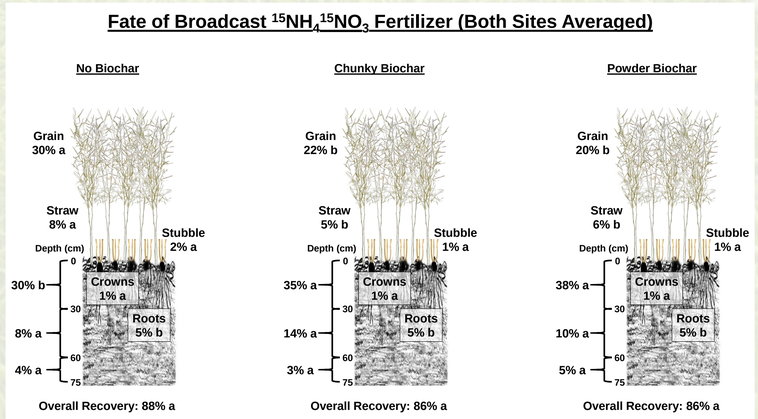

Figure 2. Mean (n = 8) fate of broadcast ^{15}N-labelled fertilizer with, and without, willow 'chunky' and 'powder' biochar additions (8 Mg C/ha), after a barley-canola-wheat-canola rotation (Note: Melfort and Central Butte results are averaged). For each corresponding fertilizer ^{15}N sink (e.g., comparing the grain ^{15}N recovery among the biochar treatments), values with the same letter are not significantly different (P >0.05) using LSD.

- Regardless of treatment, the Class 1 Melfort soil supported greater canola yield compared to the poorer quality Class 4 Central Butte soil (Fig. 1).
- Biochar with, or without manure, had a limited and variable effect on canola growth relative to the control (i.e., no biochar or manure added) four years after application. At Melfort, powder biochar alone reduced canola grain yield by 29%, while the combination of chunky biochar + SCM increased yield by 39% (Fig. 1). At Central Butte, the combination of powder biochar + LHM increased yield by 56%. These contrasting effects are interesting and may be due to the relative predominance of organic and inorganic N fractions in these manures (SCM and LHM, respectively).
- Biochar reduced the plant recovery of ^{15}N-labelled fertilizer, with a corresponding increase in the upper 30 cm of soil (Fig. 2). The upper 15 cm represented 53% of the soil fertilizer ^{15}N pool (data not shown); suggesting sorption of inorganic N by the biochar amendments.
- The majority (70%) of the plant recovered ^{15}N-labelled fertilizer was taken up by the initial barley crop, with decreasing recovery by subsequent crops (data not shown), which is likely due to fertilizer N immobilization into recalcitrant soil organic N pools resistant to mineralization.
- The unrecovered ^{15}N-labelled fertilizer is presumably lost from the plant-soil system due to leaching, denitrification, and/or volatilization.

CONCLUSION

- Biochar alone, or in combination with manure, had occasional impact on canola yield four years after application, which indicates the potential for long-term residual effects.
- Crop uptake of fertilizer N primarily occurred in the year of application, with decreasing utilization in subsequent years, due to immobilization in soil.

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