The Effects of Silicon (Si) and Fiber Composition from Canola and Wheat Residue on Soil Quality

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Introduction

Arid and semi-arid agronomic regions that have adopted conservation management practices, such as reduced tillage, may be prone to soil crusting. Surface crusting is predominantly caused by the combination of raindrop impact and excessive Si in the soil (Wakindiki and Ben-Hur, 2002). It can reduce water infiltration, enhance runoff & erosion, and interfere with seed germination. Structural components (e.g. lignin and silicon (Si)) vary between crop types. Grasses such as wheat tend to have higher levels of Si and lower amounts of lignin when compared to oilseeds (Stubbs et al., 2009). When such residue is left on the soil surface these components, specifically Si, may contribute to soil crusting. Therefore, it may be beneficial to consider crops with lower amounts of Si when planning crop rotations in areas where soil crusting can be a concern.

Objective

To determine if introducing canola into a crop rotation could reduce the occurrence or severity of soil crusting in comparison to wheat dominated systems.

Goals

1) To determine the role and allocation of fiber and Si in both wheat and canola grown with varying N rates.
2) Evaluate the decomposition and release of Si into the soil from wheat and canola residue and its effect on soil crusting.

Methods

Crop residue:

- Wheat *(Triticum aestivum) and* canola *(Brassica napus)* were grown in a greenhouse with a 50:50 mixture of Palouse silt loam and Sunshine Mix #2. Upon harvest residues were analyzed for:
  - •hemicellulose, cellulose, and lignin using a modified version of the VanSoest et al. (1991) procedure using the ANKOM automated system
  - •total carbon (C), and nitrogen (N) (LECO)
  - •and plant Si using modified methods from Van der Vorm (1987).

Residue Incubation (20 weeks):

- 0.8 g of either wheat or canola residue from the greenhouse study was applied to 100 g of Ritzville silt loam. Every 2 weeks samples were analyzed for soil and plant Si content utilizing modified methods from Van der Vorm (1987).

Decomposition Study (12 weeks):

- 1.5 g of either wheat or canola greenhouse residue was applied to 15 g of sand and inoculated with 2.5 mL of a microbial and modified Hoagland's solution. Destructive sampling at week 0, 8, and 12 occurred for weight loss and residue Si levels (Van der Vorm, 1987).

Rotational Comparison (28 days):

- A Ritzville silt loam collected from two different fields were used. The first field was previously cropped in wheat while the second field was previously cropped in canola. Four rates of silica solution (SiO_2) was added to both soils: 0 g/kg soil (control), 0.42 g/kg soil (low), 4.2 g/kg soil (medium), and 42.0 g/kg soil (high). Soil samples were analyzed for surface resistance (Humboldt pocket penetrometer), crust thickness, and amorphous Si (ASi) (Van der Vorm, 1987).

Image 1. Greenhouse seedlings

Image 2. Residue incubation crust development

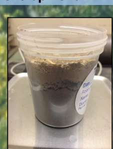


Image 3. Soil Incubation with additions of SiO_2

Image 4. Soil samples prepared for analyses

Table 1. Fiber components (g), silicon (g), total aboveground biomass (g), and carbon to nitrogen ratios of wheat and canola greenhouse residues

Crop	Soluble	Hemicellulose	Cellulose	Lignin	Si	Total	C:N
Wheat	4.1 b	5.0 a	7.3 ba	1.3 b	0.71 a	18.4 b	80.8 a
Canola	7.0 a	2.9 b	8.9 a	3.1 a	0.34 b	22.3 a	100.1 a

Figure 1. Wheat and canola residue Si concentration (%) over a 20 week period

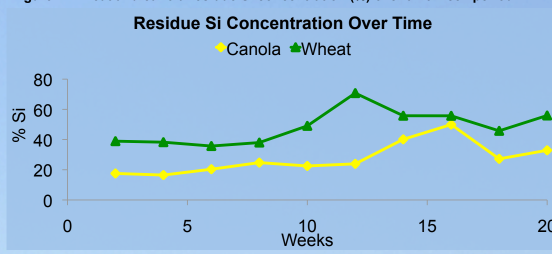


Figure 2. Wheat and canola residue weight (g) over time.

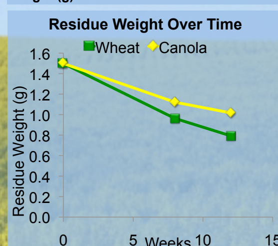


Figure 3. g of Si in wheat and canola residue over time

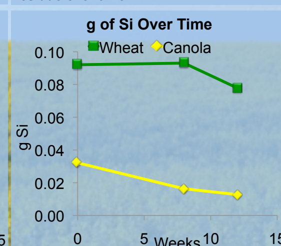


Figure 4. Average crust thickness of SiO_2 treatments on soil previously cropped in wheat and canola.

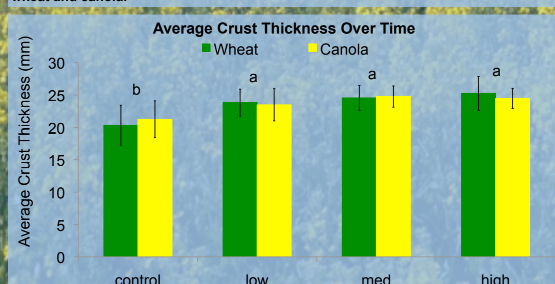


Figure 5. Average surface resistance (oz) of SiO_2 treatments on soil previously cropped in wheat and canola.

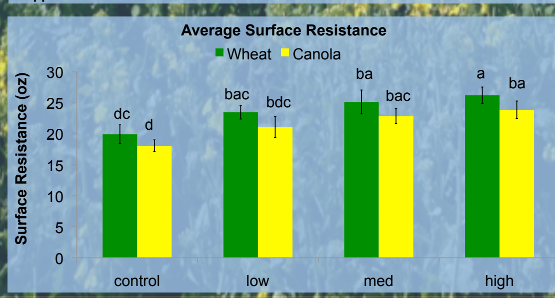
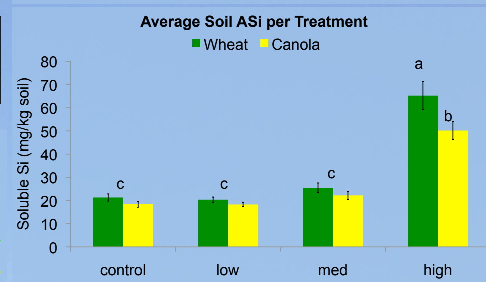


Figure 6. Average Asi of SiO_2 treatments on soil previously cropped in wheat and canola.



Results and Discussion

Crop residue:

- Wheat relies more on hemicellulose (5.0 g) and Si (0.71 g) for structural support while canola relies on cellulose (8.9 g) and lignin (3.1 g) (Table 1).
- C:N ratios did not change between crop types.

Residue Incubation:

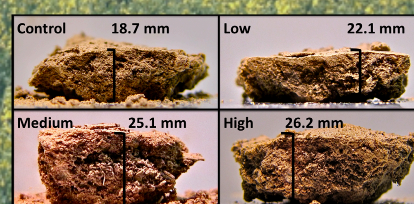
- The Si concentration in the wheat residue began to increase at week 8 while the canola Si concentration did not increase until week 12 (Figure 1). This suggests that over time soluble components were decomposed first leaving the more recalcitraint materials such as Si to decompose at a slower rate.

Decomposition Study:

- Over time, both residues decreased in weight with the wheat having a slightly faster rate of decomposition (Figure 2).
- The Si levels in the wheat residue was much higher initially and began to slightly decrease after week 8. The Si levels in the canola residue slightly decreased from week 0 to 12 (Figure 3).

Rotational Comparison:

- Both crust thickness (Figure 4) and surface resistance (Figure 5) increased as more SiO_2 solution was added.
- Surface resistance was significantly higher (p-value <0.05) in soil previously cropped in wheat compared to canola.
- ASi was higher in soil collected from the wheat field and increased with increasing SiO_2 levels (Figure 6).



Conclusions

- Wheat is a Si accumulator and relies on both hemicellulose and Si for structural composition, while canola relies predominantly on cellulose and lignin.
- Over time, soluble components are decomposed first, raising the Si concentrations in the plant residue to await further decomposition.
- Although decomposition is occurring, loss of Si during the 12 week period was only slight.
- High amounts of SiO_2 solution had a positive effect on soil crust thickness and surface resistance.
- These results suggest that crop rotations including crops such as canola may help alleviate the negative effects caused by soil crusting.

References

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