Wheat Colonization by AM and Other Endophytic Fungi and Wheat Nutrition in Canadian Prairie Soils with Different Fertility

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Introduction

Arbuscular mycorrhizal (AM) fungi play a central role at the soil-plant interface, and facilitate soil nutrients uptake with their mycelium extending beyond the rhizosphere into the soil. Information on the effect of soil properties and cropping system would help managing AM fungi in wheat production. This study (2009-2013) should develop a model to forecast the contribution of AM fungi to wheat nutrition in commercial fields. Here we present our first results.

Hypothesis:

- Soil type influences AM symbiosis development in wheat.
- Wheat fungi symbiosis is more developed in organic cropping system.

Methods

- 79 Wheat fields were sampled in the Canadian Prairie in 2009. Plant and soil samples were taken in early June and July.
- Plant Root Simulator (PRS^{TM}) was used to assess nutrient availability in early June samples.
- Nylon mesh traps were buried from June to July to measure AM fungi hyphal abundance in soil (Figure. 1) (Newman, 1966).
- Root colonization in July was determined by clearing and staining with ink and vinegar (Vierheilig *et al.*, 1998).
- Wheat tissue sampled in July was analyzed for P and N content.

Results

Table 1. Wheat and Soil Nutrients in Five Soil Types.

Soil type	Wheat		soil pH	Nutrient fluxes in soil (mg/10cm^2/day)														
	N (%)	P (%)		NO_3-N	NH_4-N	Ca	Mg	K	P	Fe	Mn	Cu	Zn	B	S	Pb	Al	Cd
Bl	2.4 ab	0.2 b	6.8 a	516 ab	5 b	1706 a	293 b	144 a	6.7 b	43 bc	28.2 ab	0.5 ab	1.6 b	0.9 ab	57 b	0.7 b	63 b	0.2 a
Br	3.2 a	0.3 a	6.6 a	386 b	5 b	1789 a	308 b	144 a	9.6 ab	38 c	33.7 a	0.9 a	1.3 b	1.0 a	37 c	1.1 ab	45 b	0.1 b
DB	2.5 ab	0.3 a	6.5 a	367 b	16 a	1729 a	303 b	116 b	10.3 ab	46 bc	35.5 a	0.7 ab	1.4 b	0.9 ab	37 c	0.9 ab	62 b	0.1 b
DG	2.6 ab	0.2 b	6.8 a	334 b	4 b	1849 a	334 b	87 b	14.7 a	60 b	22.1 b	0.3 b	2 b	0.7 b	240 a	0.6 b	61 b	0.1 b
G	2.2 b	0.3 a	5.2 b	636 a	10 ab	1085 b	508 a	50 c	12.9 a	109 a	34.1 a	0.6 ab	7.5 a	0.9 ab	51 bc	1.5 a	133 a	0.1 b

PRS^{TM} were inserted in selected site according to Western Ag Innovations protocol, and submitted to their lab for soil nutrients fluxes determination. Soil pH was measured in Swift Current AAFC physical lab with water method. N and P contents in wheat samples were analyzed using Technicon segmented flow autoanalyzer in Swift Current AAFC Chemistry Lab. Total number of samples is 25, 26, 19, 7, 2 for Bl (Black), Br (Brown), DB (Dark Brown), DG (Dark Gray) and G (Gray), respectively. The same letter means not significantly different according to the Dunnett's test at $P < 0.05$.

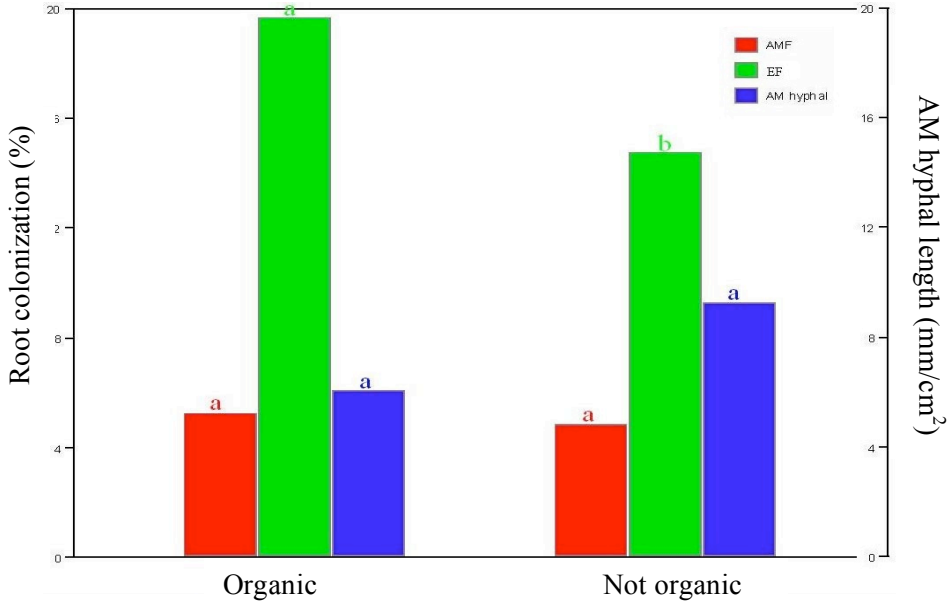

Figure. 1 Comparison amount of mycorrhizal and endophytic fungi in organic and inorganic fields. Statistical significant differences are indicated by letters ($P < 0.05$) according to ANOVA.

- Root colonization (% of root length) by AM and endophytic fungi (EF). There is no difference between organic and conventional field for AM fungi from this result. However, endophytic fungi is more in organic than conventional land.

- AM hyphal length (mm/cm^2) in wheat land. It is measure abundance of AM hyphal in cultivated soil. There is no pronounced difference between these two kinds of soil source from counting hyphal length on nylon mesh.

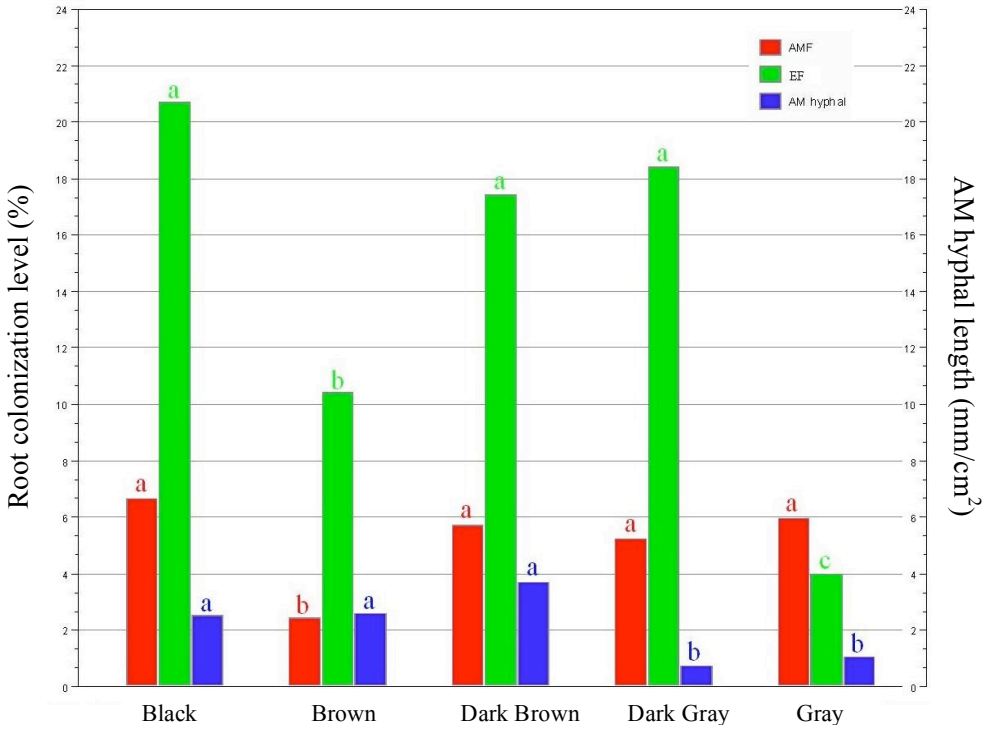

Figure. 2 Richness of AM and endophytic fungi varied in five soil types. Significant differences are indicated by different letters ($P < 0.05$, Dunnett's test) according to ANOVA.

- AMF root colonization level (% of root length) in Brown Chernozems is lower than other one.
- Endophytic fungi (EF) colonization in wheat roots is also lower than Black, Dark Brown and Dark Gray Chernozem. But the lowest one is in Gray soil.
- AM hyphal length in trap (mm/cm^2) level is lower in Dark Gray and Gray soil than other three.

Conclusions

- Wheat roots in Brown soils have low level of AMF colonization. This result is similar to Talukdar's report on VAM distribution of Saskatchewan infield in 1993 (Talukdar, 1993). Those from Gray soils host less non-AM fungal endophytes, and AM hyphal length is less in Gray and Dark Gray soils.
- The same level of AM root colonization was seen in organic and conventional systems, and non-AM endophytes are more abundant in organic systems. In contrast, AM hypha abundance is slightly less in organic than in conventional systems, as also found by Vestberg (2009) (Vestberg

et al., 2009). The positive and negative influences of different cropping practices used under organic and conventional management will be examined in the coming months.

- The abundance of indigenous AM fungi and endophytic fungi varied at different soil type.
- AM and endophytic fungi can co-exist in wheat roots, in the Prairie as in other dry ecosystems (Chaudhry *et al.*, 2009; Wu, 2009)

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Reference

Chaudhry M, Rahman S, Ismaiel M, Sarwar G, Saeed B, Nasim F-u-H. 2009. Coexistence of arbuscular mycorrhizae and dark septate endophytic fungi in an undisturbed and a disturbed site of an arid ecosystem. *Symbiosis* 49: 19-28.

Newman EI. 1966. A method of estimating the total length of root in a sample. *Journal of Applied Ecology* 3: 139-145.

Talukdar NC. 1993. Occurrence and isolation of vesicular-arbuscular mycorrhizae in cropped field soils of saskatchewan, canada. *Canadian Journal of Microbiology* 39: 567-575.

Vestberg M, Kukkonen S, Saari K, Tuovinen T, Palojärvi A, Pitkänen T, Hurme T, Vepsäläinen M, Niemi M. 2009. Effects of cropping history and peat amendments on the quality of a silt soil cropped with strawberries. *Applied soil ecology* 42: 37-47.

Vierheilig H, Coughlan AP, Wyss U, Piche Y. 1998. Ink and vinegar, a simple staining technique for arbuscular-mycorrhizal fungi. *Applied Environmental Microbiology.* 64: 5004-5007.

Wu Y. 2009. Mycorrhizal and dark septate endophytic fungi under the canopies of desert plants in mu us sandy land of china. *Frontiers of Agriculture in China* 3: 164-170.