Interactions between Microorganisms and Plant Genotype Affect Soil Carbon under Drought Conditions

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Introduction

Soil is a major terrestrial pool for carbon that contains 2.5×10^{18} g of carbon in the first 100 cm depth (Abu-hashim 2016). Small changes to soil carbon storage may have major implications for climate regulation through atmospheric CO_2. Many factors affect carbon content in the soil including temperature, water content, land use, human manipulation, soil texture, soil structure and also plant species. This experiment was designed to determine whether plant-associated microorganisms and plant genotypes interact to modulate rhizospheric carbon. For this purpose we used *Paenibacillus polymyxa* (Pp) as a plant growth promoting bacteria (PGPB), *Piriformospora indica* (Pi) as a mycorrhizal-associated plant growth promoting fungi (PGPF); and *Neotyphodium coenophialum* (Nc) as an endophyte fungi in two genotypes of *Festuca arundinacea*.

Materials and Methods

Two genotypes (75B and 75C) of tall fescue (*Festuca arundinacea* Schreb) were planted in 24 pots each or six pots per each treatment (control, Pp. Pi and Nc). Six pots were inoculated with *N.coenophialum* (Nc). All *F. arundinacea* were transplanted at the beginning of October 2013 in 48 pots (3 Kg) and buried in the field (32˚ 42' 48.6″ N and 51˚ 32' 6.10″ E, 1625 masl). After 50 days, 6 pots were injected with 30 ml of *P.polymyxa* inoculum prepared in a nutrient broth (4.6×10^{8} cfu cm^{-3}). A control group was injected with sterile bacterial culture media and another 6 pots were injected with 30 ml culture of *P.indica* with 2.8×10^{8} cell cm^{-3} that was prepared in Kaefer medium (Kumar et al., 2014) and 6 control pots were inoculated with sterile inoculum. The plants were overwintered. Beginning of March, a drought stress treatment was applied. Soil water content was maintained at 14 ± 5% of volumetric water measured by TDR (8 bars of matric potential). The whole plant growth period was 210 days with 120 days effective growth. The final 60 days included the drought stress, after-which plants were harvested and rhizosperic soil was collected for carbon analysis (Kalra, 1998).

The original culture of *P.polymyxa* PTCC 1021 (ATCC 21830) was obtained from the Iranian Research Organization for Science and Technology (IROST). Bacterial inocula were prepared in nutrient broth solution, following supplier protocols, and incubated at 30°C while shaking at 120 rpm for 48 hours. Soil organic carbon (SOC) and total soil carbon (TC) were determined by K2Cr2O7 titration and ICE-440 elemental analyzer respectively. Statistical analyses were conducted based on completely randomized factorial design using SAS 9.1 for Windows (SAS Inc., USA). Differences at P<0.05 were considered statistically significant.

Results and Discussion

Table 1 shows the effect of plant-associated microorganisms on SOC and TC. Inoculation with *N.coenophialum* (Nc) elicited increases in SOC and TC for both the 75C (1.13% and 8.37%) and 75B (12.14% and 2.29%) genotypes. Similar positive effects were elicited by inoculation with *P. polymyxa* and *P. indica* for both genotypes (Table 1).

Table 1. Effect of associated microorganisms on total and organic soil carbon (g. kg $^{-1}$ ± SE) in two genotypes of *F. arundinacea.* Different letters within columns are significantly different (*P* < 0.05).

	Total soil carbon (TC)		Soil organic carbon (SOC)	
	75C	75B	75C	75B
Control	44.94 (± 0.01)^{b}	44.89 (± 0.04)^{b}	16.95 (± 0.08)^{b}	14.83 (± 0.06)^{c}
Nc	45.45 (± 0.06)^{a}	45.92 (±0.01)^{a}	18.37 (± 0.06)^{a}	16.63 (± 0.03)^{b}
Pp	44.85 (± 0.03)^{b}	46.21 (±0.02)^{a}	17.10 (± 0.11)^{b}	17.22 (± 0.11)^{ab}
Pi	45.20 (± 0.01)^{b}	45.95 (±0.05)^{a}	17.60 (± 0.11)^{b}	18.60 (± 0.05)^{a}

Rhizosphere-associated microorganisms appear to facilitate soil carbon accumulation, a process that is mediated by plant genotype. Tan et al. (2004a,b) reported that SOC is generally affected by land use, soil texture, and drainage. However, this study showed that SOC is also affected by biological interactions with plant genotype. Unfortunately, human activities (*e.g.* fertilization, plowing) tend to reduce the abundance and activity of beneficial soil microorganisms and, based on the evidence produced here, these activities may also reduce the capacity for biologically-mediated soil C accumulation.

Conclusions and Implications

Our findings emphasized the importance of soil microorganisms in soil C accumulation and show that plant-associated microorganisms can increase in amount of C stored within the rhizosphere, a process that was mediated by plant genotype. These processes need to be understood in order to predict and manage shifts in soil C pools in response to changes in land use and climate. In conclusion, with the aim of understanding SOC dynamics and mechanisms of stabilization, it is important to consider the effects of biological interactions and plant genotype.

References

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