Rhizosphere microbial composition is influenced by crop varieties

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INTRODUCTION

Through the rhizodeposits (organic substrates released in root exudates) plants can influence the diversity and activity of a variety of key functional groups of soil microorganisms including those involved in nutrient cycling and plant health. The differential effect of plant type on the composition and activity of soil biota in the rhizosphere is well established (1,2). However, variety based differences in rhizosphere microbial communities (3) are not well understood and sometimes considered as minor and less significant, in particular in the field environment. In this paper, we present results on the phenotypic and functional composition of soil microflora and microfauna and biological activities in the rhizosphere of wheat and canola varieties from controlled environment and field based experiments, and discuss their relevance for plant growth and nutrient availability.

MATERIALS AND METHODS

Growth chamber experiments with Wheat varieties: Surface soil (0-10cm), collected from Avon and Waikerie, SA; calcareous sandy loams, pH 8.2) with continuous wheat, was used in pot assays to determine the effects of wheat varieties on rhizobiology. Rhizosphere samples collected from 4-6 week old wheat seedlings were analysed for various biological properties.

Field experiments with Canola varieties: Field experiments were conducted at Waikerie in South Australia from 2003 to 2005. Rhizosphere soils collected at different stages of plant growth were analysed for biological properties detailed below.

Laboratory analysis: Rhizosphere samples collected from field experiments and pot assays were assayed for different microbial populations using both culture based (e.g. plate counts, BIOLOG-GN and Microresp® substrate utilization profiles) and non-culture DNA techniques (T-RFLP) and biological activities using biochemical and GC-based methods.

Statistical analyses: A minimum of 4 replicates were used for all treatments in growth chamber studies and treatments in field experiments. Statistical analyses of all the results were conducted using the Genstat (VSN Intl. Ltd).

RESULTS AND DISCUSSION

Growing plants provide a constant source of easily available C and nutrient sources for microorganisms. Hence rhizosphere soils generally support 10-100-fold higher populations of microflora and microfauna and higher levels of biological processes than the bulk soil (1).

Rhizosphere biology of wheat varieties:

Results in Figure 1 show a broad range of microbial activities in rhizospheres of different wheat varieties, e.g. the highest observed microbial activity was >70% higher than the lowest value observed. These differences reflect the variation between varieties in the quantity of C inputs through rhizodeposition. Although there were significant differences in microbial biomass between varieties, trends were not always the same. Previous reports on the varietal effects on microbial activity and microbial biomass are variable and suggest impacts of crop growth stage and soil type. Rhizodeposition quantity can be influenced by the physical and chemical properties of the soil habitat and thus can interact with varietal effects (1).

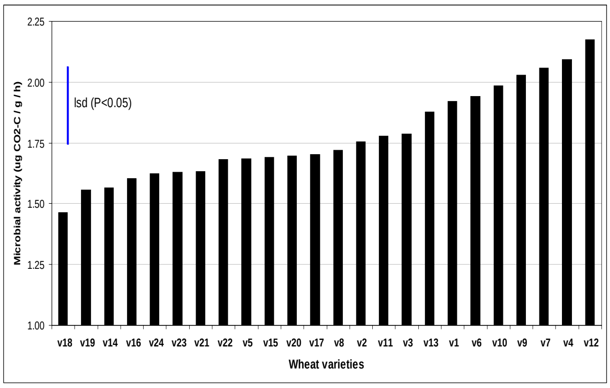

Figure 1. Microbial activity in the rhizosphere soils of a range of wheat varieties in a growth chamber experiment. Plants were grown (20 °C and 12h day/night) in alkaline calcareous loamy sand from Waikerie and rhizosphere microbial properties were measured 6 weeks after planting.

Populations of a number of phenotypic and functional groups of microflora, e.g. copiotrophic and oligotrophic bacteria, cellulolytic microflora, total pseudomonads, *P. brassicacearum*, spore forming bacteria, ammonia (AO) and nitrite oxidizing bacteria, differed in the rhizosphere soils of different varieties but no consistent trends were observed. Previous research indicated that higher populations of copiotrophic bacteria (i.e. fast growing) were found in the rhizospheres of poor performing wheat varieties compared to the best performing wheat varieties (3). Also, T-RFLP analysis of bacterial community indicated that wheat varieties differing in their performance as second wheat crops also developed different rhizosphere populations (3) i.e. response to plant variety was influenced by the previous year's variety. In this study, data on BIOLOG-GN (bacteria) and Microresp (total microflora) based C substrate utilization profiles indicated that wheat varieties differ in terms of microbial catabolic diversity in their rhizospheres suggesting variation in the quality of rhizodeposition between varieties.

Rates of nitrification showed significant variation between rhizospheres of different wheat varieties supporting the observations on populations of nitrifying bacteria. However, trends for the two properties were not proportional i.e. differences in the rate of nitrification per unit AO populations. This is probably due to variation in the diversity of AO populations and/or their metabolic status (4). Wheat varieties also differed in terms of acid and alkaline phosphatase activities (data not shown) but the differences did not show any clear relationship with microbial activity or other MB related properties. P availability to plants is influenced by the activity of phosphatase enzymes, microbial turnover of P and soil chemical properties. George et al. (5) reported that the differences in root-associated phosphatase activities of wheat varieties may not play a significant role in the P-nutrition of the plant grown in soil.

Protozoa are one of the principle microbial grazers in soil stimulating C and nutrient (N, P and S) mineralization and regulating the population densities and metabolic status of rhizosphere microbial communities. Our results showed that wheat varieties differ in terms of total and individual groups of protozoan populations. Varieties with higher protozoan populations generally exhibited higher microbial activity. Ciliates were the least abundant populations although they were >100-fold in the rhizosphere compared to the bulk soil.

Rhizosphere biology of canola varieties: Research from Canada shows that endophytic and rhizosphere bacterial communities of transgenic and non-transgenic canola cultivars grown at the same field site were different (6). Data on the populations of cellulolytic bacteria and fungi, and AO and nitrite oxidizing bacteria in rhizosphere of canola varieties indicated significant differences between canola variety Mystic and herbicide tolerant varieties such as ATR and Clearfield (data not presented). For example, populations of these microorganisms were generally higher in the rhizosphere of Mystic compared to other varieties either with or without herbicide application. Similar trends were also observed with microbial biomass properties but respiratory quotient values were generally higher for HT canola varieties. Differences in AO populations reflected rates of nitrification potentially N availability. A significant seasonal variation was found in varietal effects at all field sites.

C substrate utilization profiles can provide a good indicator of catabolic diversity of rhizosphere microbial communities reflecting the effects of quality and quantity of available C (2). Multivariate analysis of C-substrate utilization data showed consistent differences between communities associated with Mystic and HT canola varieties (Figure 2). Significant differences in catabolic diversity of rhizosphere bacterial and fungal communities were also observed at field sites in NSW (data not presented). 'In crop' application of herbicides has been shown to influence the quality and quantity of rhizodeposition thereby affecting rhizosphere biological properties (7). In addition to the varietal differences, we found significant differences in AO populations, rate of nitrification and BIOLOG-GN profiles between herbicide treated and untreated plants.

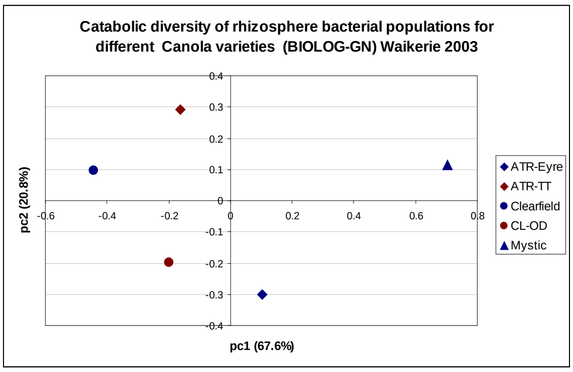

Figure 2. PCA graph of C utilization profiles for rhizosphere bacterial populations of different canola varieties (at flowering) grown in a field experiment at Waikerie, SA.

SUMMARY

- Phenotypic and catabolic diversity of rhizosphere microbial communities exist between varieties of wheat and canola.
- Root exudates act as selective carbon and nutrient sources enriching select groups of microbial communities in the rhizosphere of wheat and canola.
- Variety based root microbiome could form the basis for development of more biologically orientated and efficient farming systems.

ACKNOWLEDGEMENTS

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