Soil archaeal communities can be influenced by land-use history in an Australian Vertisol

Gupta, V.V.S.R.[1], Coleman, D.[2*], Wakelin, S.[3], Jangid, K.[4] and Whitman, W.[2]

[1]CSIRO Ecosystem Sciences, Glen Osmond, South Australia; [2]Odum School of Ecology and Department of Microbiology, University of Georgia, Athens, USA; [3] Ag Research, Lincoln, New Zealand; [4]National Centre of Cell Science, Pune, India

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Agriculture is one of the most important human activities that exert a large impact on soils and their biota. Most research on soil microorganisms has concentrated on bacteria and fungi; only recently has the diversity and dynamics of soil archaeal communities been considered. However, there is increasing evidence to show that they are playing a significant role in the cycling of carbon, nitrogen and plant-fungal interactions[1,2]. Microorganisms in Vertisols are exposed to regular disturbances due to changes in physico-chemical properties from wetting-drying and crop management practices. Such changes have been shown to alter the diversity and activity of soil organisms including bacteria, fungi and microfauna[3]. We investigated the effects of addition of crop stubble and exposure to regular wetting-drying events on archaeal communities in soils under different cotton rotation treatments.

Methods

Surface (0-10cm) soil samples were collected from rotation treatments cotton fallow-cotton (CWC – Organic C 1.33%; C:N ratio 17.2), and cotton-wheat-vetch-cotton (CWVC – Organic C 1.18%; C:N ratio 25.1), in a field experiment started in 2002 and located at the ACRI[4]. Samples were collected in 2006 during the cotton phase, sieved through 4 mm mesh, air dried and used to set-up PVC core microcosms. Treatments included: Soil alone- Wet, Soil+stubble (wheat stubble [C:N ratio 95:1] @1%w/w;)-Wet and Soil alone-Wet Dry. Soil moisture was adjusted to field moisture capacity; 'Wet-Dry' samples were exposed to a drying regime during weeks 2, 5 and 7. All samples incubated at 25° C in dark. Individual cores were sampled after week 3 (day 21) and 8 (day 54) and analysed for the diversity of soil archaeal communities, using a PCR-DGGE profiling of archaeal 16S rRNA gene[5]. Multivariate analysis of relative abundance data was done using Primer 6 and PERMANOVA+ (Primer-E Ltd.). Archaea *amo*A abundance was quantified using q-PCR[6].

Results

- Previous land use history had a significant influence on the soil archaeal community structure (PERMANOVA CV=23.8, P<0.001) and richness and diversity was higher under the CWVC rotation compared to CWC rotation (St-Wet). Both the exposure to repeated wetting-drying regime or incubation with stubble significantly altered community structure in soils from both field treatments.
- Wetting-drying events significantly increased (day 54) the quantity of arch-*amo*A gene copy number (1.7×10^8/g soil) compared to continuously wet treatment (5.0×10^8/g soil).

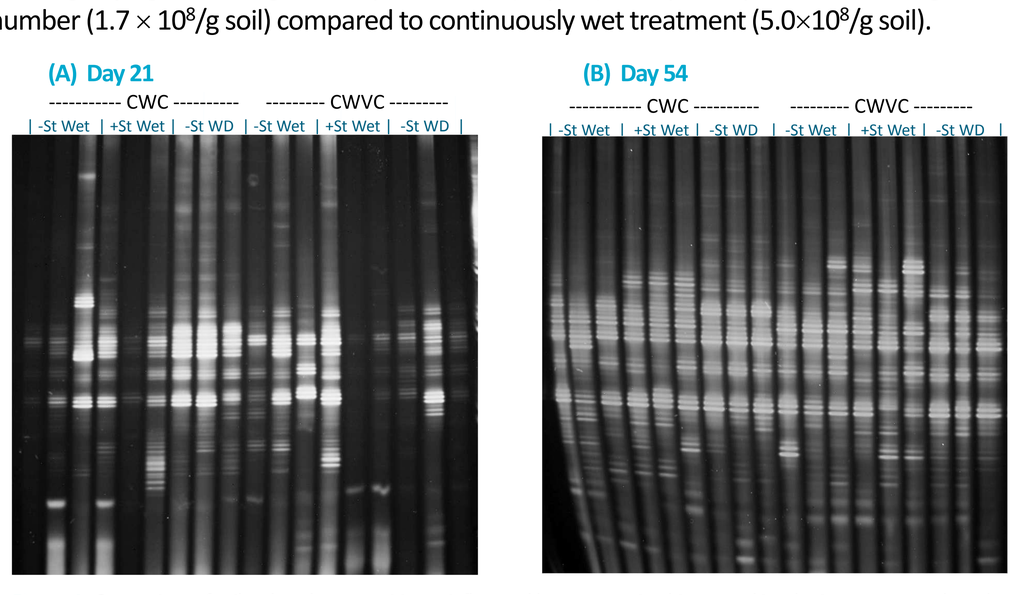

Figure 1: Comparison of soil archaeal communities as influenced by crop rotation history and incubation treatments based on nested PCR-DGGE patterns of 16S rRNA Archaea gene (V3 region) for (A) Day 21 and (B) Day 54 samples.

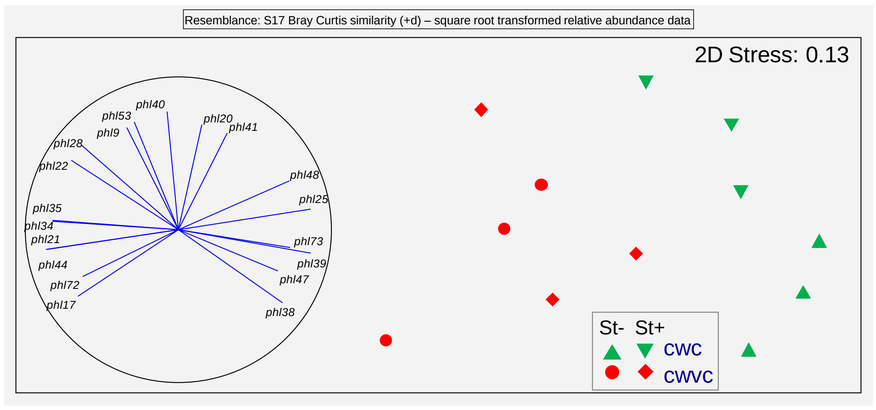

Figure 2: Non-metric MDS analysis showing dissimilarities in archaeal communities between the two stubble treatments in soils from both field rotation treatments at day 54 (ANOSIM – Stubble R=0.944; P<0.01; field rotation R=0.593; P<0.01). PERMANOVA analysis indicated that field rotation was the major driver of archaeal communities (CV=23.8%, P=0.001) but the interaction between field rotation and stubble addition also had a significant effect on community structure (CV=18.3%, P=0.029).

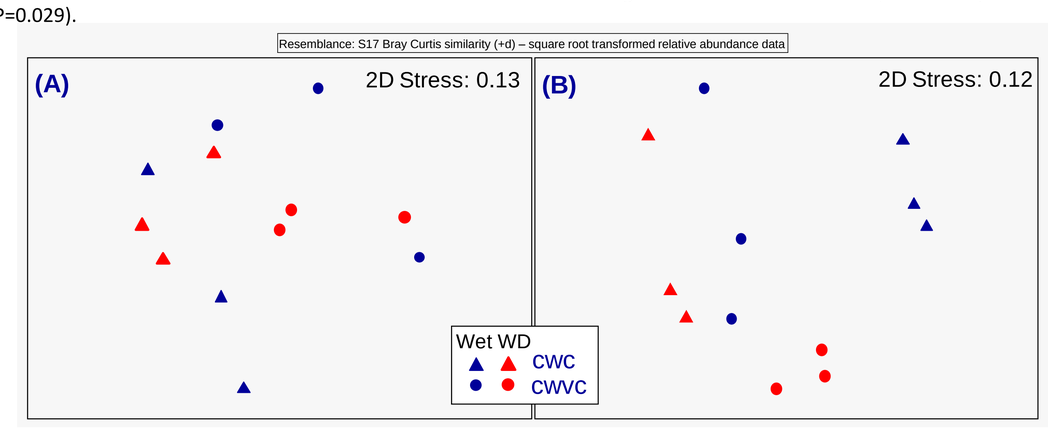

Figure 3: Effect of wetting and drying treatment on archaeal communities in soils – non-metric MDS analysis of data from day 21 (A) and day 54 (B). Clear and significant W-D treatment effects were seen by day 54 in soils from both field treatments (ANOSIM R=0.907, P<0.01). PERMANOVA analysis showed that interaction between field rotation and W-D treatments was the major driver for the variation (CV=33.9%, P=0.001).

- Cluster analysis indicates >35% dissimilarity between treatments within field rotation samples and >45% dissimilarity between field rotations.
- Species richness and diversity were significantly higher in soils incubated with added stubble or exposed to wetting-drying regime compared to control field soils. Changes were also observed between the two sampling times (Day 54 > Day 21).

Table1: Effect of field rotation, stubble addition or wet-dry treatments on the diversity indices of soil archaeal communities (average ± stderr)

Treatments		Day 21							
		Margalef sp richness		Shannon index (H')		Simpson index (1-λ)		No. of phylotypes (S)	
CWC	St-Wet	**2.51**	0.26	**2.79**	0.12	**0.939**	0.007	**16.7**	1.86
	St+Wet	**2.88**	0.72	**2.89**	0.34	**0.937**	0.023	**19.7**	5.33
	St-WD	**3.61**	0.26	**3.21**	0.08	**0.960**	0.003	**25.0**	2.00
CWVC	St-Wet	**2.90**	0.58	**2.91**	0.23	**0.944**	0.013	**19.7**	4.33
	St+Wet	**2.87**	0.86	**2.9**	0.34	**0.943**	0.019	**19.5**	6.50
	St-WD	**2.71**	0.24	**2.87**	0.09	**0.945**	0.005	**18.0**	1.73
CWC		***3.00***	*0.28*	***2.96***	*0.12*	***0.945***	*0.008*	***20.4***	*2.1*
CWVC		***2.83***	*0.26*	***2.89***	*0.11*	***0.944***	*0.006*	***19.1***	*2.0*
		Day 54							
CWC	St-Wet	**3.78**	0.09	**3.23**	0.03	**0.961**	0.001	**25.7**	0.67
	St+Wet	**4.63**	0.14	**3.44**	0.04	**0.968**	0.001	**32.0**	1.15
	St-WD	**4.42**	0.04	**3.38**	0.01	**0.967**	0.001	**30.3**	0.33
CWVC	St-Wet	**4.07**	0.40	**3.30**	0.11	**0.964**	0.004	**28.0**	3.06
	St+Wet	**4.67**	0.13	**3.47**	0.03	**0.970**	0.001	**32.7**	1.08
	St-WD	**4.61**	0.26	**3.44**	0.06	**0.968**	0.002	**32.0**	2.00
CWC		***4.27***	*0.14*	***3.35***	*0.03*	***0.965***	*0.001*	***29.3***	*1.0*
CWVC		***4.45***	*0.17*	***3.40***	*0.05*	***0.967***	*0.002*	***30.9***	*1.3*

Conclusions

- The effects of land-use history and stubble addition suggest that quantity and quality of C inputs can impact soil archaeal community.
- In a self-mulching Vertisol the effect of wetting and drying events could be due to the changes in physico-chemical characteristics.
- Implications of observed short-term management induced changes in archaeal communities to soil functions are yet to be fully understood.

FOR FURTHER INFORMATION
* David Coleman
davec@uga.edu

Vadakattu V.S.R. Gupta
Gupta.Vadakattu@csiro.au
http://www.csiro.au/

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ACKNOWLEDGEMENTS

Authors express their appreciation to Dr. Nilantha Hulugalle for providing the access to the field study, Dr. Oliver Knox with field sampling and Stasia Kroker and Marcus Hicks for technical help. This research was supported, in part, by a CSIRO McMaster Visiting Fellowship to DC and CSIRO Division of Entomology.