Perennial pasture leys enhance soil health compared to continuous cropping

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Abstract
Perennial pastures offer potential to rebuild soil health in cropping systems, yet more knowledge is needed about the impacts that subtropical grass-based pastures have on soil borne pathogens, beneficial soil biology and soil structure. In this study, a range of soil health indicators were compared between 14 paired paddocks across southern Queensland and northern NSW. The paired paddocks had a common cropping history and they had either been returned to a 4-10 year phase of a perennial pasture or continued to be continuously cropped. We found much lower populations of root lesion nematodes and crop fungal pathogens (*Fusarium* spp and *Bipolaris* spp.) under pastures at sites where these pathogens were present. Soil under pastures had higher arbuscular mychorizae fungi populations at half the sites and free-living nematode populations were higher at all but one site. Soils under the pastures also had better aggregate stability, with the fraction of macro-aggregates 10-40% higher than under continuous cropping at 13 of the 14 sites. This study shows that pastures were consistently beneficial for soil health across many sites and different pasture mixtures in subtropical regions of Australia. However, the benefits that this improvement could have for subsequent crop productivity are yet to be confirmed.

Keywords
Nematodes, carbon, AMF, aggregates, structure, grass.

Introduction
In northern cropping systems of Australia, continuous cropping is leading to severe deterioration of soil fertility and physical structure, a decrease in beneficial biological activity, increased incidence of soil pathogens and diseases and an increase in soil erosion, all of which result in lower crop yield and quality (Dalal and Mayer 1987; Silburn et al. 2007; Bell et al. 2006). Large inputs are required to achieve profitable crop yields; however these inputs can be expensive and they may cause alternate environmental impacts. The use of perennial pasture phases in crop rotations may have a potential to aid soil restoration and increase subsequent crop yields (Bell et al. 2006; Thomas et al. 2008). However our understanding of the impacts of ley pastures on a range of soil health measures is poor, particularly the pathogen and disease populations. This research investigated the differences in a range of measures of soil health through paired paddock sampling, comparing adjacent fields that had remained under continuous cultivation to fields that had been sown and remained under a perennial tropical grass-based pasture during the past 4-10 years.

Methods
Sampling was conducted at 14 sites distributed throughout south-east Queensland and north-east New South Wales between November 2014 and April 2015. A requirement of the sites were that there were adjacent ‘paired’ fields that shared a common cropping history and soil type, where one field had remained under continuous, long-term cropping and the adjacent field is currently under a perennial tropical grass-based pasture, planted within the last 10 years. All pastures were at least four years old but they varied in their composition and management. Pastures mainly included panic grasses (*cv*. Bambatsi, *cv*. Gatton) and/or Rhodes grass, with several other tropical grasses also present at some sites. Half the sites also had accompanying legumes (e.g. medics, lucerne, leuceana). Eleven of the sites had high clay content (vertosol) soils, while the other three had lighter textured soils.

In each field, four replicate samples were collected approximately 20-50 m into the field. In each replicate, six 50 mm diameter soil cores were taken approximately 5 m apart (i.e. 24 cores per field and separated into layers (0-10, 10-30, 30-60 cm) – these samples were split evenly for chemical and Predicta-B analysis. Chemical analysis was conducted by the University of New England soil laboratory which included a range of inherent chemical attributes (e.g., pH, CEC, EC, ESP) to ensure soils were sufficiently similar for chemical comparison; the analyses of soil available P, total N and organic C are not presented here. Predicta-B analysis using DNA extraction technique was used to compare soil-borne crop pathogens (Northern grains set), arbuscular mychorizae fungi (AMF) and free-living nematode (FLN) populations (Ophel-Keller et al.

2008). To assess soil aggregate stability, six 30 mm diameter soil cores were taken per replicate to a depth of 10 cm. These were air dried for two days and stored before wet sieving could be undertaken. From each replicate, duplicate subsamples of approximately 60 g were wet by capillary action on tension tables for an average of two days. The wet sieve technique, where soils are agitated over a range of sieves in a water column for 15 mins, was then used to separate the water stable aggregates into 8 fractions (<0.125 mm, 0.125-0.25 mm, 0.25-0.5 mm, 0.5-1.25 mm, 1.25-2.5 mm, 2.5-5 mm, 5-10 mm and >10 mm)]

Results

Crop pathogen populations

The two most common species of root lesion nematode, *Pratylenchus thornei* and *P. neglectus* were found throughout the soil profile (0-60 cm) at levels > 1/g at eight of the 14 sites sampled. At these sites, these populations were significantly lower under the pasture phase than under the corresponding crop fields (Figure 1). At five of these sites this difference was high with the pastures having negligible root lesion nematode populations while the adjacent cropping field had populations' > 4/g (i.e. twice the yield reducing threshold in susceptible crops).

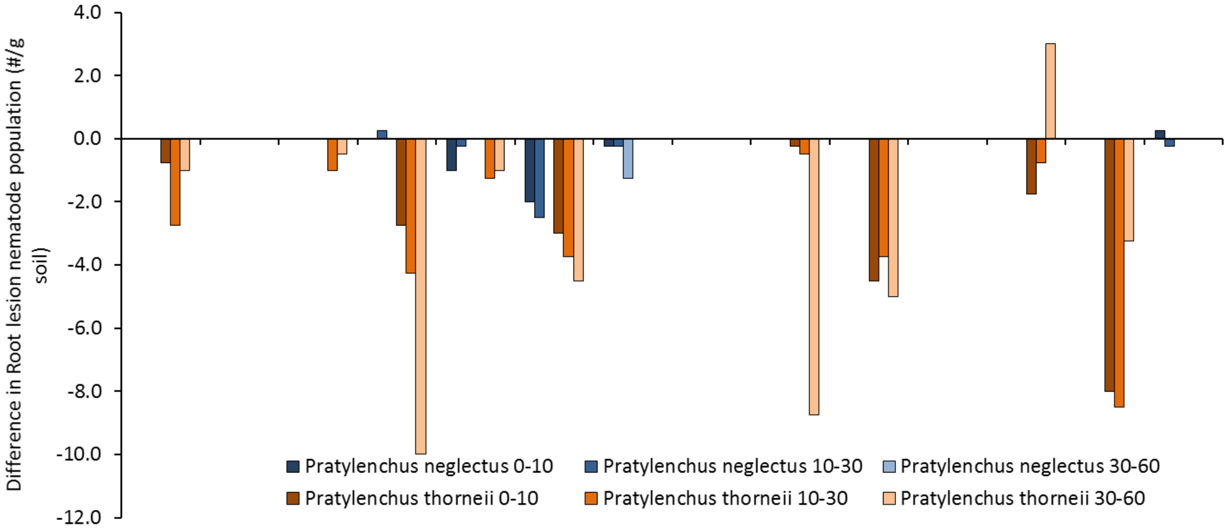

Figure 1. Difference in root lesion nematode populations between a perennial pasture for 4-10 years compared to under continuous cropping at 14 paired paddock sites in southern Queensland and northern NSW.

A variety of fungal diseases were found across the various sites, but the most common were the crown rot inducing species, *Fusarium pseudograminearum* and *F. culmorum*, and yellow leaf spot fungi (*Bipolaris* spp.). High inoculum levels of these species were found at seven of the 14 sites (Figure 2). In most cases the paired pasture fields had lower populations of these diseases than the adjacent cropping fields, but at a few sites we found similar or slightly higher populations of one of the Fusarium fungi in the pasture fields. This occurrence was not clearly related to the presence of a particular pasture species, but may have been induced by the presence of other annual grasses within these pastures.

Beneficial biota populations

A greater diversity of arbuscular mychorizae fungi (AMF) and free-living nematodes (FLN) were found within the pasture fields than their paired cropped fields (data not presented). Populations of all AMF groups (a-d) were significantly higher at seven of the 14 sites (Figure 3). In particular the pastures had higher populations of AMF_a and AMF_c across the sites though in a few cases the pastures had lower populations of AMF_d and AMF_b than the cropped fields. FLN were higher under the pastures at all locations except one (Figure 3).

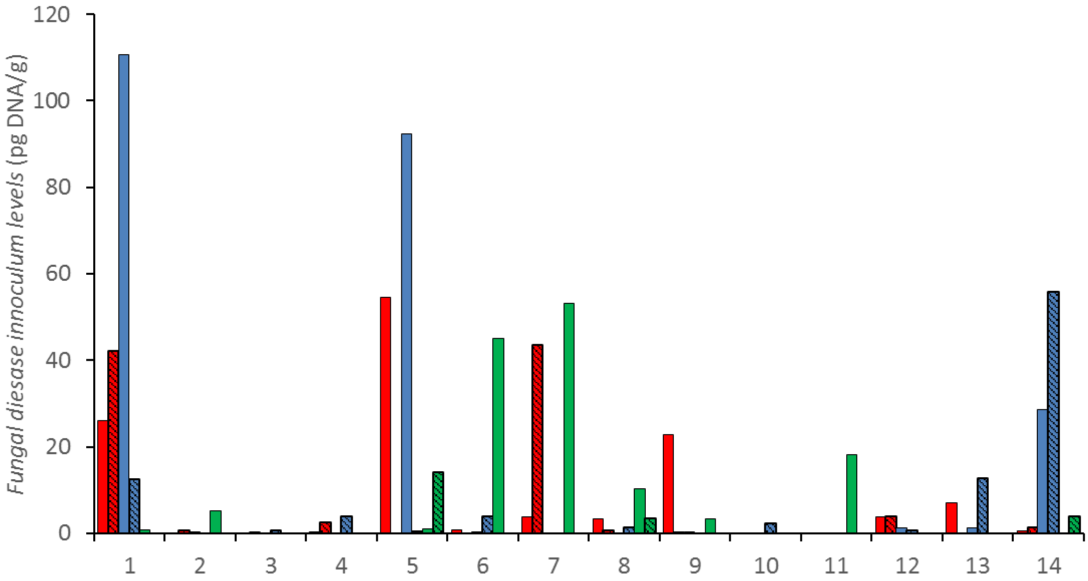

Figure 2. Fungal disease populations (*Fusarium pseudograminearum* – red; *F. culmorum* – blue; *Bipolaris* – green) between under continuous cropping compared to under a perennial pasture for 4-10 years (hatched) at 14 paired paddock sites in southern Queensland and northern NSW.

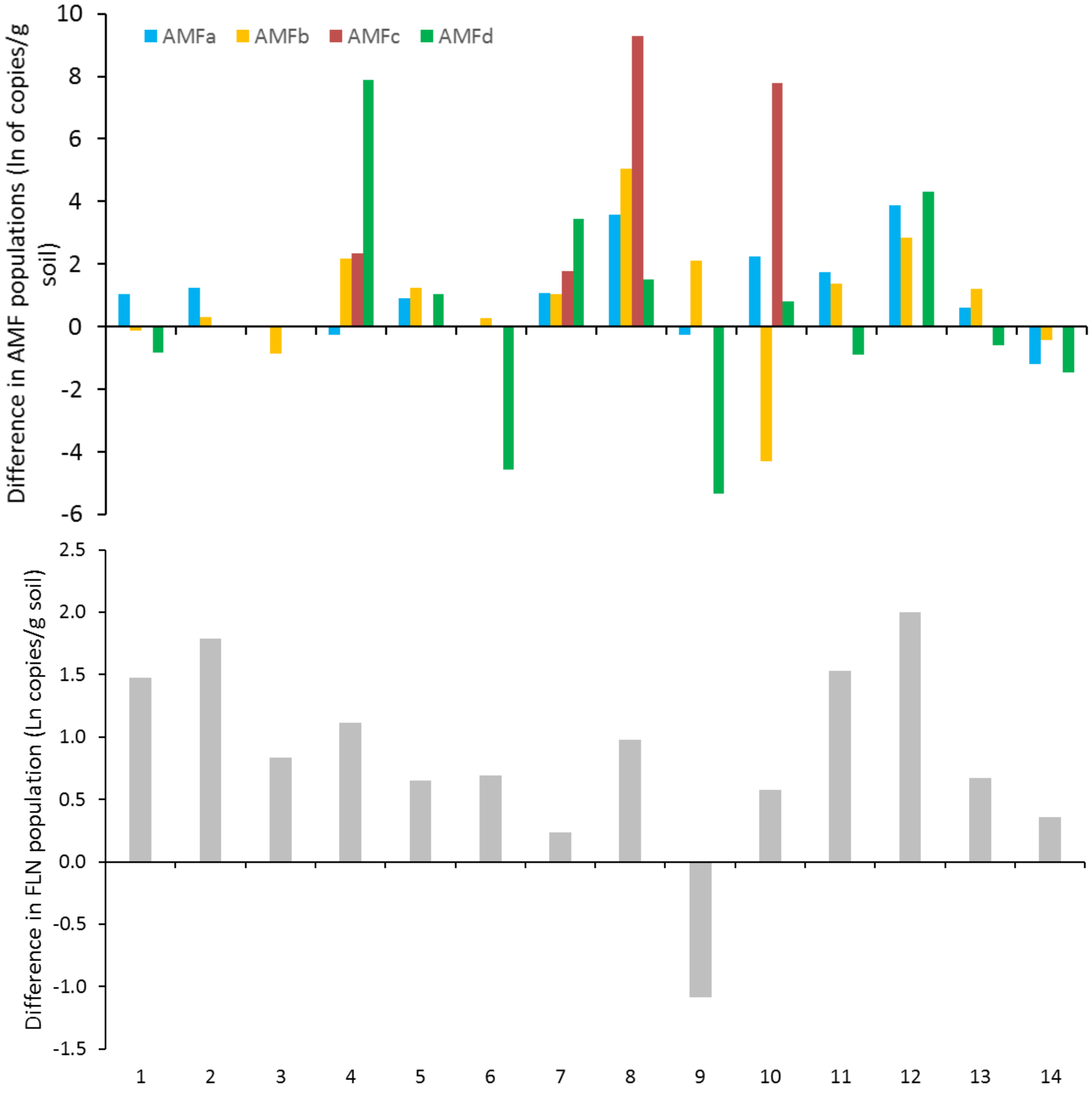

Figure 3. Differences in arbuscular mychorizae fungi (AMF) (top) and free-living nematode (FLN) (bottom) populations between perennial pasture for 4-10 years compared to continuous cropping at 14 paired paddock sites in southern Queensland and northern NSW.

Soil aggregate stability

At every site sampled, the pasture fields were found to have a greater percentage of macro-aggregates (>10 mm), and a smaller percentage of aggregates <5 mm, than their corresponding cropped fields (Figure 4). In the aggregate fractions >5 mm, the difference between the pasture and its corresponding cropped field ranged from 2% up to 45%. However one of these sites, which possessed the lightest texture (a sandy loam soil) the differences were small. All cropped sites were found to have a higher fraction of the soil in the smallest aggregate size classes (<0.25 mm) than in their corresponding pasture field except for one site, which was similar. The differences between the cropped and pasture fields for the other 13 samples ranged from 3% to 28%.

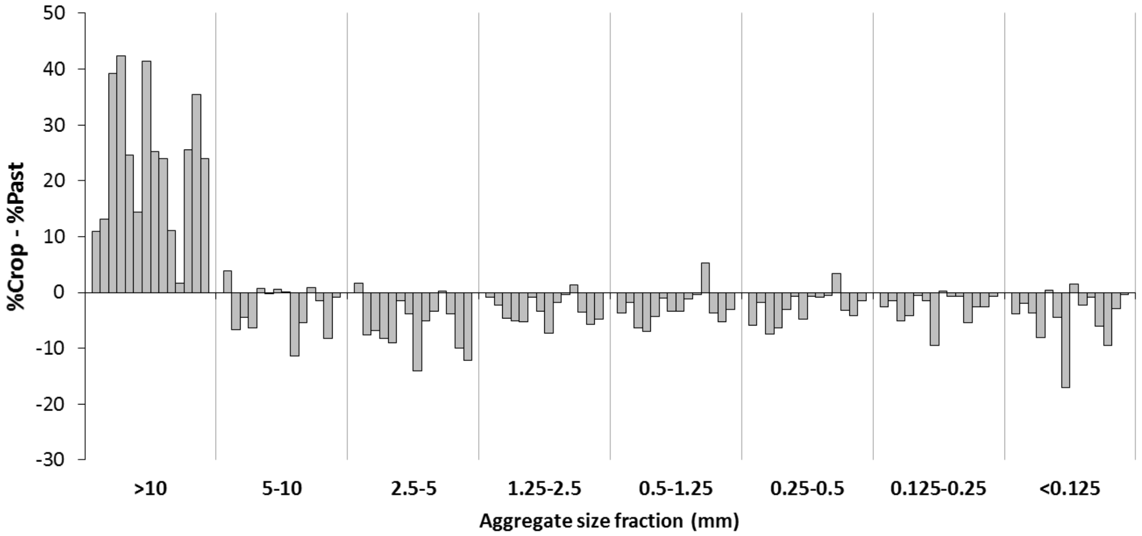

Figure 4. Difference in aggregate size fractions of soil (0-10 cm) under a perennial pasture for 4-10 years compared to under continuous cropping at 14 paired paddock sites in southern Queensland and northern NSW.

Conclusion

This study has clearly shown the benefits perennial pasture phases can have for improving the biological and physical health of soils across a variety of pasture mixtures, soil types and management in Australia's northern cropping zone. Pastures are likely to be an effective means of rebuilding soil health when used in crop rotations. While a pasture phase may benefit subsequent crop production, this benefit remains to be quantified across a diverse range of environments and seasons.

Acknowledgements

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