Preliminary studies comparing soil labile and microbial biomass carbon under native and sown perennial grass-based pastures in northern New South Wales

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Soil organic carbon (C) is associated with aggregate stability, water infiltration and soil strength, and provides energy for soil biota. Most agricultural practices deplete soil organic matter reserves, with a decrease in organic C often being associated with degrading soil physical, chemical and biological conditions, that may be characterised as a decline in soil health. Most biological activity occurs in the top 10 cm of the soil (Hutchinson and King 1982) and is largely influenced by the type and distribution of soil organic matter, temperature and moisture. Soil biota are more sensitive to changes in soil conditions than total soil organic C status (Powlson *et al.* 1987), since most of the organic C is inactive. Soil microbial biomass represents the living component of soil organic matter and is a labile source of C and other nutrients (Dalal 1998). However, more direct measures of total labile C (which includes microbial biomass C) have also been proposed (e.g. Blair *et al.* 1995) as reflecting differences in management practices.

These preliminary studies examined the microbial biomass C and labile C status of soils at Sustainable Grazing Systems (SGS) sites in northern NSW. At each site areas with contrasting ground cover and herbage mass levels were examined. No such data have been previously reported for grazed pastures on the North-West Slopes of NSW. The aim of these preliminary studies was to examine the hypothesis that either soil microbial biomass C or labile C may be useful surrogates for soil health, by analysing samples from areas with different ground cover/herbage mass levels and soil depths. Further the data were used to determine if a 0-5 cm sampling protocol was appropriate for the main SGS studies. Mean spring values each year were reported for different grazing treatments at the Manilla and Barraba sites (Lodge *et al.* 2003*a*, *b*) and more detailed results will be presented in a subsequent paper.

Methods

Data were collected from 3 field sites on commercial properties; a fertilised Sirosa phalaris-subterranean clover (6 km north-west of Nundle), a redgrass-wiregrass-bluegrass-wallaby grass native pasture (12 km south-west of Manilla), and a redgrass-wallaby grass pasture (20 km south-east of Barraba). Sites were sampled in spring 1997, after plots were allocated to treatments, but before grazing treatments were imposed. Hence, the focus for this preliminary study was the effect of soil depth and herbage mass/ground cover on soil microbial biomass C or labile C, rather than the effect of treatments.

At each site, 2 quadrats (40 by 40 cm) in each of the proposed treatment plots in 2 replicates (8, 10 and 10 plots at the Nundle, Barraba and Manilla sites, respectively) were visually assessed as having either high ground cover and herbage mass (H quadrats) or low ground cover and herbage mass (L quadrats). Soils were sampled (5 cm diameter core) from the centre of each quadrat at depths of 0-2.5 cm, 2.5-5 cm, 5-10 cm and 10-20 cm, giving a total of 224 soil samples. At the phalaris-subterranean clover site, L quadrats had a mean ground cover of 81% and herbage mass <1500 kg DM/ha, while H quadrats had 100% ground cover and herbage mass >3500 kg DM/ha. For the Manilla native pasture, L quadrats had a mean basal cover of 21% and <1500 kg DM/ha, and H quadrats had a mean basal cover of 100% and >3500 kg DM/ha. At the Barraba native pasture site, L and H quadrats had the same herbage mass levels as those at the Manilla site, and mean ground cover levels for L and H quadrats were 33 and 94%, respectively.

For each site, soils from each depth were mixed and bulked to give 8 samples per site (i.e. 2 levels of herbage mass/ground cover (L and H), and 4 soil depths), so no detailed statistical analyses were undertaken.

Soil samples were sieved (<0.2 cm) to remove plant material, roots, large invertebrate animals and gravel and then sub-divided into 2 equal portions. One portion was analysed for microbial biomass C and nitrogen (N) based on ninhydrin-reactive N in extracts (0.5 M K_2SO_4) of chloroform fumigated soil (Amato and Ladd 1988); the other was air dried, ground (0.02 cm) and analysed for total organic C and labile C (Blair *et al.* 1995).

Values were also calculated for carbon (CI, sample total C/reference total C) and lability indices (LI, lability of C in sample/lability of reference C) and a carbon management index (CMI, CI x LI x 100) using the methods outlined by Blair *et al.* (1995), with the mean value for all sites and depths being the reference value. A microbial quotient (microbial biomass C as a proportion of total organic C) was also calculated.

Results

Both microbial biomass C (mg/g soil) and labile C (mg/g soil) were highest in the 0-2.5 cm soil layer and tended to decline as soil depth increased (Table 1). Values also tended to be higher for the high ground cover/herbage mass sites compared with those for low ground cover/herbage mass, but results were not consistent (Table1). For all data (sites and depths) microbial biomass C and labile C were reasonably well correlated (r=0.89, n=24).

Total microbial biomass and labile C levels (0-20 cm, Table 1) were always lower for the low ground cover/herbage mass sites compared with those with high ground cover/herbage mass. About 50% of the total (0-20 cm) microbial biomass C and labile C was at a depth of 0-5 cm. When averaged over all sites and depths, mean microbial biomass C was 11.6% of labile C (Table 1), and labile C was about 20% of total soil organic C, so that the mean microbial quotient was around 2.3%. Values for the microbial quotient (data not presented) were within a relatively narrow range of 1.3 to 3.8% and generally did not reflect either differences among depths or between L and H quadrats.

Table 1. Microbial biomass C (mg/100 g soil) and labile C (mg/100 g soil) values for 3 SGS pasture sites with low (L) and high (H) ground cover/herbage mass for 4 soil depths and total values (0-20 cm), sampled in spring 1997

Depth (cm)	Microbial biomass C (mg/100 g soil)		Labile C (mg/100 g soil)	
	L	H	L	H
		Phalaris-subterranean clover - Nundle		
0-2.5	82	81	955	846
2.5-5	24	52	389	498
5-10	16	49	208	405
10-20	35	61	229	371
0-20	158	242	1782	2121
		Native pasture - Manilla		
0-2.5	52	67	340	554
2.5-5	29	36	266	312
5-10	29	25	225	237
10-20	11	31	168	151
0-20	121	160	999	1255
		Native pasture - Barraba		
0-2.5	43	55	329	530
2.5-5	26	53	216	313
5-10	26	17	173	270
10-20	11	17	128	156
0-20	107	141	846	1268

The CI and LI (Table 2) reflected changes in the microbial biomass C and labile C values for depths and low and high ground cover/herbage mass. However, calculation of a CMI (Table 2) indicated clear differences among soil depths and between high and low ground cover/herbage mass quadrats.

Discussion

Blair *et al.* (1995) reported that labile C was a sensitive indicator of C dynamics for cropping soils. Results from the current studies supported its potential use, along with the CMI, for monitoring the effects of different management practices on soil health in grazed sown and native grass-based pastures. Similarly, microbial biomass C, which is a component of labile C (comprising 6.1 to 20.8% of labile C in these studies) and has a rapid turnover rate, also appeared to be sensitive to changes related to both management (reflected by ground cover and herbage mass) and soil sampling depth.

Labile C values obtained in the current study were similar to those reported by Blair *et al.* (1995) for grazed pastures and cropped lands in northern NSW, and microbial biomass C levels were comparable with those reported for arable and cropped soils (Dalal 1998), but lower than those for forest soils.

Cost of sample analyses for both measures were comparable (~$30 per sample) and processing was through laboratories experienced in these analyses. A slight disadvantage of the microbial biomass C method was its longer sample processing time, because of the 10-day incubation period required for the soils. Advantages of the labile C method were that estimates of total organic C were also obtained and that the development of a CMI accounted for both the total size of the C pool and its turnover rate (as estimated by its lability).

These preliminary results indicated that both microbial biomass C and labile C were promising, potentially useful indicators of the effects of management on soil health in grazed sown and native grass pastures in northern NSW. Soils were sampled in a range of treatments from spring 1997 to spring 2001 and analysed for both microbial biomass C and labile C, as part of the SGS grazing studies on the North-West Slopes of NSW.

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Table 2. Carbon, Lability and Carbon Management Indices for 3 SGS pasture sites with low (L) and high (H) ground cover/herbage mass for 4 soil depths, sampled in spring 1997

Depth (cm)	Carbon index		Lability index		Carbon management index	
	L	H	L	H	L	H
			Phalaris subterranean clover - Nundle			
0-2.5	2.30	1.92	1.29	1.40	98	163
2.5-5	1.13	2.23	1.01	0.61	62	92
5-10	0.65	1.22	0.93	0.97	48	80
10-20	0.63	1.17	1.08	0.91	38	44
			Native pasture - Manilla			
0-2.5	1.11	1.43	0.87	1.17	97	168
2.5-5	0.81	0.89	0.93	1.04	77	92
5-10	0.68	0.70	0.96	0.99	66	69
10-20	0.48	0.48	1.04	0.91	50	44
			Native pasture - Barraba			
0-2.5	0.96	1.31	1.07	1.24	296	268
2.5-5	1.04	0.91	0.83	1.01	114	135
5-10	1.40	0.78	0.74	1.02	60	118
10-20	0.61	0.51	1.06	0.87	68	107

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