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PHOSPHORUS FERTILIZER AND STOCKING RATE EFFECTS ON SOIL MICROBIAL BIOMASS OF A LONG-TERM DAIRY FARMLET EXPERIMENT

S.R. Aarons[1], C.R. O'Connor[2] and C.J.P. Gourley[1]

[1]Department of Natural Resources and Environment, Agriculture Victoria Ellinbank, Hazeldean Rd, Ellinbank 3821 Australia

[2]Australian Laboratory Services, Unit 6/2 Sarton Road, Clayton, 3168 Australia

Abstract

The effects of a range of P fertilizer rates and dairy cow stocking rates on microbial biomass carbon and phosphorus were compared in a long-term farmlet trial in southeastern Australia. Pastures were stocked at 2, 3, or 4 cows/ha and received fertilizer at rates of 0, 35, 70 or 140 kgP/ha. There was no effect of either P fertilizer rate or stocking rate on microbial biomass C from 1995 to 1998. Increasing P application rate significantly increased the chloroform-released microbial P flush measured, but stocking rate had no effect on microbial P. There were significant temporal changes, with the seasonal effects of soil temperature and moisture overriding treatment effects on these microbial measurements.

Keywords: P, cow, microbial P flush, microbial biomass carbon, Australia

Introduction

There has been increased intensification of dairy systems in Australia in the last 10 years, resulting in an increase in fertilizer use and higher stocking rates. As these grazing systems become more intensive, there is a need to ensure that they remain environmentally sustainable. Microbial biomass measurements are considered good bioindicators of soil health and quality, as the soil microflora are likely to be very responsive to changes induced by farm management inputs (Turco *et al*., 1994, Roper and Gupta, 1995). A large long-term farmlet experiment was undertaken in southeastern Australia to determine pasture and milk production under different input systems (Gourley *et al.*, 2001). This study was undertaken to compare the effects of different P rates and stocking rates on soil microbial biomass measurements, and to determine whether inputs of P fertilizer were detrimental to the microbiology of these pasture soils.

Material and Methods

This study was undertaken at the Dairy Research Institute, Ellinbank , (38^{o} 15'S; 145^{o} 93'E), comparing 4 rates of P fertilizer (0, 35, 70 and 140 kgP/ha) applied to 10 farmlets grazed at 2, 3 and 4 cows/ha. For further details of the farmlet design see Gourley *et al*., (2001). The cows rotationally grazed 13 paddocks within each farmlet, with samples collected from 3 of the 13 paddocks. At least 30 soil (2.5 x 10 cm) cores were collected along transects within each paddock and bulked. Microbial biomass carbon was determined from the release of ninhydrin positive compounds, after chloroform fumigation of moist sieved soil samples (10g) for 7 to 10 days (Joergensen and Brookes, 1990, Sparling and Zhu, 1993). Chloroform-released microbial P flush was determined based on the method of McLaughlin and Alston (1986). All data were subject to ANOVA.

Results and Discussion

Neither P rate nor stocking rate had a significant ($p>0.05$) effect on soil microbial biomass carbon in the first 2 1/2 years of the farmlet experiment. However, at 3 cows/ha the soil microbial biomass carbon was generally greatest at the highest P rate of 140kgP/ha (Figure 1). This soil has a high P fixing capacity and, as a result, Olsen P levels (0-10cm) at the highest rate of P increased from 13 kgP/ha in 1995 to 20 kg/ha in 1998. This increase in available soil P did not have a significant ($p>0.05$) effect on microbial biomass carbon over this time period. The increased return of excreta to the pasture at higher stocking rates did not significantly ($p>0.05$)affect microbial biomass carbon, possibly due to the relatively high levels of organic matter present in these pasture soils. Seasonal fluctuations in microbial biomass carbon appeared to be greater than that caused by either P or stocking rate. The cold wet winter of July 1996 and decreasing soil moisture due to drought in February 1997 and 1998 had a greater negative impact on soil microbial biomass carbon than the P rate treatments (Figure 1). Temperature, moisture and the availability of substrates are factors that can significantly affect soil microbial biomass (Dalal, 1997). Both Sarathchandra *et al*.,

(1988) and Tate *et al*., (1991) observed significant temporal effects on microbial biomass carbon, which were greater than the differences due to soil fertility.

Phosphorus application rate significantly increased chloroform-released microbial P flush (Figure 2), whether analysed for the effect of P within the 3 levels of stocking rate ($p=0.009$) or analysed for the effect of P within the medium (3 cows/ha) stocking rate ($p=0.008$). There was no effect of stocking rate on microbial P flush. Microbial P flush fluctuated significantly ($p<0.001$) over time, but there were no significant time x treatment interactions. The increased P applied as fertilizer was generally immobilised within the soil microorganisms, but did not appear to increase the microbial biomass, as measured by ninhydrin positive compounds. Compared with the rates of P applied in fertilizers (0, 35, 70 and 140 kgP/ha), the additional P returned to pastures due to increased stocking rates ranged from 6 to 9 kgP/ha, explaining the lack of a significant stocking rate effect on microbial P flush.

It is concluded that temperature and moisture effects were greater than the effects of increased stocking rate (and therefore greater return of excreta) and increased P fertilizer application rate on microbial biomass C. Large inputs of P were not detrimental to the soil microbial biomass and significantly increased microbial P flush.

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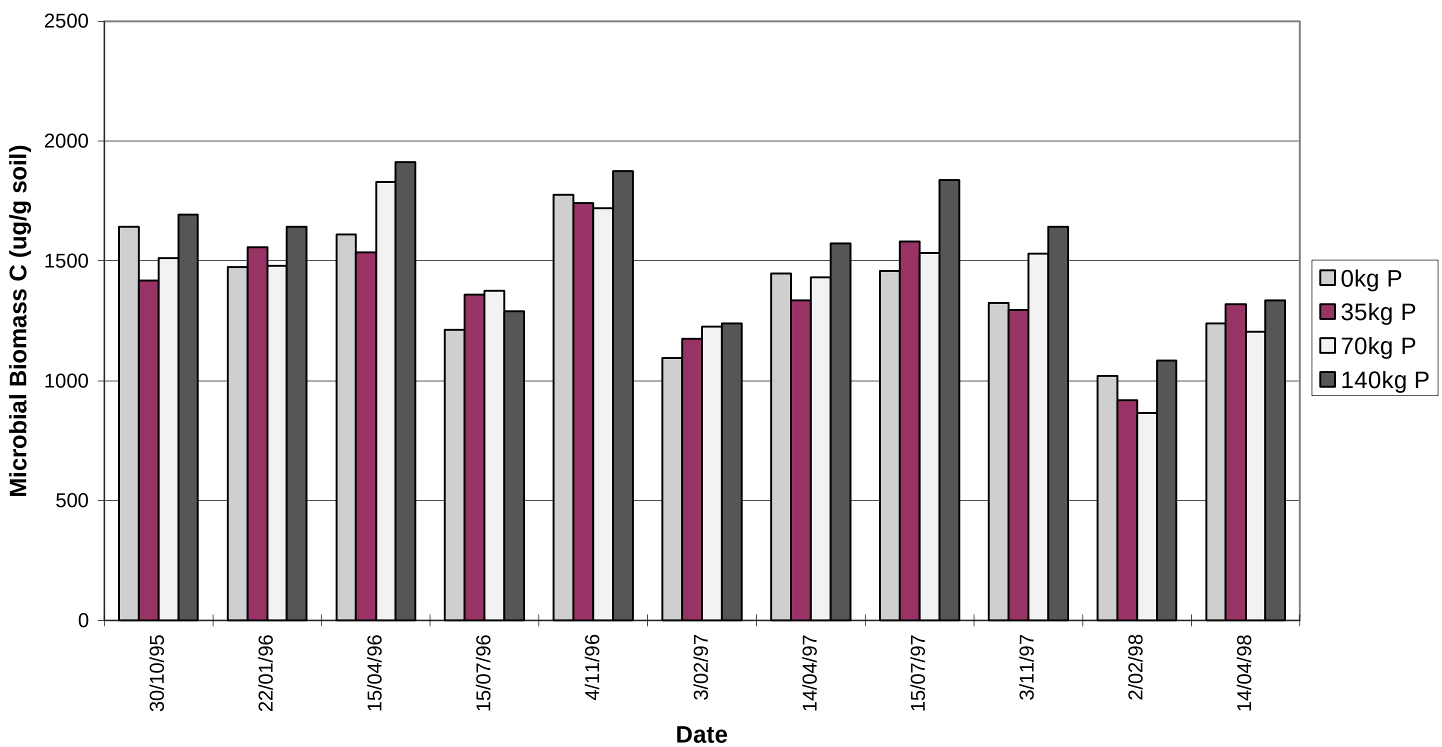

Figure1 - Changes in soil microbial biomass carbon (μg/g soil) under pastures receiving 0, 35, 70 and 140 kgP/ha stocked at 3 cows/ha from October 1995 to April 1998.

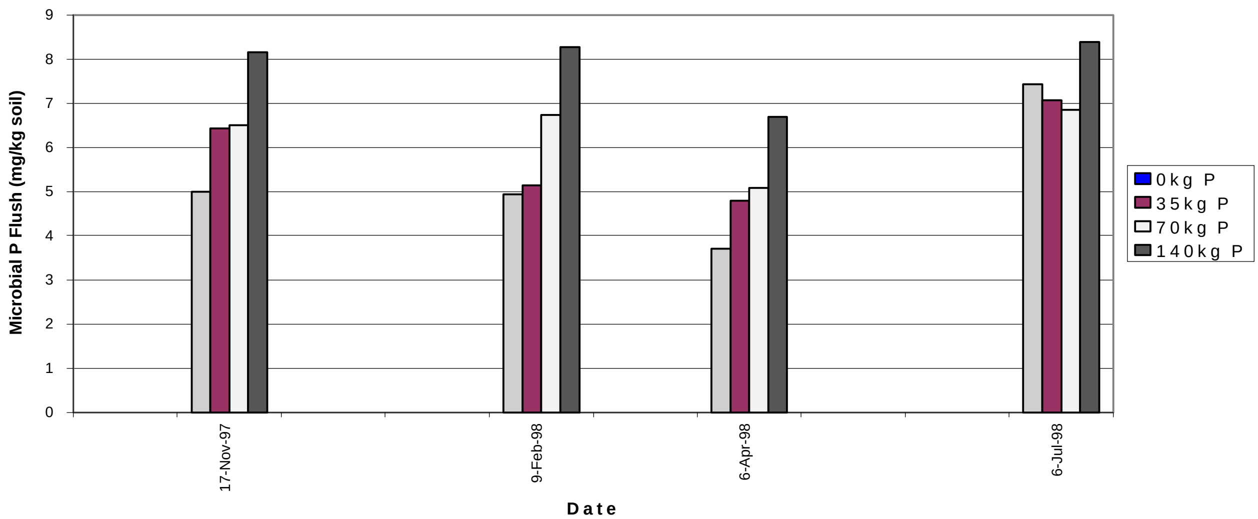

Figure 2 - Changes in soil microbial P flush (mg/kg soil) under pastures receiving 0, 35, 70 and 140 kgP/ha stocked at 3 cows/ha.