Soil quality under permanent and annual pastures: its implications for soil microbial activity and nutrient turnover

R.J. Haynes[1], R.M. Milne[1] and N. Miles[2]
[1]*School of Applied Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, South Africa, Email: haynesd@ukzn.ac.za,* [2]*Cedara Research Station, KwaZulu-Natal Department of the Agriculture, Environmental Affairs, Private Bag X9059, Pietermaritzburg 3200, South Africa*

Keywords: microbial biomass, soil organic matter, tillage

Introduction Dairy farming in humid, subtropical parts of South Africa is based on permanent kikuyu grass (*Pennisetum clandestinum*) swards. However, there is a shortage of feed during the winter because low temperatures limit kikuyu growth. As a result, annual pastures incorporating temperate grasses, are grown for winter feed production. The grasses used are typically annual ryegrass (*Lolium multiflorum*) and sometimes perennial ryegrass (*Lolium perenne*). Kikuyu is so invasive in the locality that it becomes dominant within a few years, even if the field is sown to perennial ryegrass. For that reason, the swards are usually incorporated using a rotary cultivator, each summer and resown. Concern has arisen in recent years about soil degradation that is possibly occurring under annually-tilled pastures. Observations have suggested that with time, production has progressively declined and this is suspected to be related to soil degradation, particularly a decrease in organic matter content and a loss of related soil microbial and physical properties. The purpose of this study was to compare the effects of permanent pasture and annually-tilled ryegrass pasture on soil organic matter content, size and activity of the microbial biomass and aggregate stability.

Materials and methods Four commercial dairy farms were selected in the Tsitsikamma region of the Eastern Cape, South Africa. Three fields were chosen. They were under: (1) annually tilled ryegrass, (2) permanent kikuyu pasture and (3) undisturbed native vegetation. Study fields were about 20ha in size. The fields were divided into 100m^2 plots and three separate plots were randomly chosen and sampled to a depth of 10cm. Twenty five samples were taken from each plot and these were bulked and sieved (<2mm). Soils were analysed for organic C, soluble C, microbial biomass C, basal respiration, arginine ammonification rate, the activities of protease, phosphatase and sulphatase and aggregate stability according to the methods described by Dominy & Haynes (2002) and Nsabimana *et al*. (2004).

Results and discussion In comparison with soils under sparse, native grassy vegetation, those under both annual ryegrass and permanent pasture had a higher soil organic C content on very sandy soils of the eastern end of the region. By contrast, in the higher rainfall western side, where native vegetation was coastal forest, there was a loss of organic matter under both types of pasture. Nevertheless, soil organic C, soluble C, microbial biomass C, basal respiration, arginine ammonification rate, protease, phosphatase and sulphatase activities and aggregate stability were substantially less under annual than permanent pasture at all sites. These results reflect the degrading effect of annual tillage on soil organic matter and the positive effect of grazed permanent pasture on soil organic matter, nutrient turnover and aggregation. The lower protease, phosphatase and sulphatase activities under annual than permanent pasture suggest a lower rate of turnover of N, P and S in the annually-tilled soil. This reflects a much lower organic matter (organic N, P and S) content in the tilled soil and the substantial nutrient turnover rate under grazed permanent pasture. There was also a difference in measured soil properties with soil depth. For example, organic C and related soil microbial properties decreased markedly with increasing soil depth under native vegetation and permanent pasture. This is because the input of fresh organic material decreases with depth. By contrast, under annual pasture there was no significant stratification of organic matter. This is due to regular downward redistribution of organic matter during annual tillage. Thus, while microbial activity and nutrient turnover concentrated in the surface few cm under permanent pasture, they are more evenly distributed in the surface 15cm under annual pastures. It was concluded that annual pasture involving conventional tillage results in a substantial loss of soil organic matter, soil microbial activity and soil physical condition under dairy pastures and that systems that avoid tillage and/or increase the longevity of temperate pastures need to be developed.

References

Dominy, C.S. & R.J. Haynes (2002). Influence of agricultural land management on organic mater content, microbial activity and aggregate stability in the soil profiles of two Oxisols. *Biology and Fertility of Soils,* 36, 298-305.

Nsabimana, D. R.J. Haynes & F.M. Wallis (2004). Size, activity and catabolic diversity of the soil microbial biomass as affected by land use. *Applied Soil Ecology*, 26, 81-92.