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SOIL BIODIVERSITY OF NATURAL GRASSLANDS IN SRI LANKA; A GENERAL REVIEW

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ABSTRACT

In Sri Lanka, nearly 12,000 km^2 of the total land area (65,000 km^2) is under grasslands and they have been categorized in many ways based on their origin and evolution, geographical distribution, floristic composition and land use. Generally, natural grasslands in the country can be recognized as plant communities in which dominant species are perennial grasses and, very few or no shrubs or trees. They are likely to play an economically and environmentally vital role. However, their exploitation has been rather unsystematic due to increasing biotic interference by disorganized clearing for short term cultivation, illegal burning and extensive removal of herbages by herbivorous including domestic livestock. The influence of these factors on grasses and grasslands has resulted in some of the most characteristic features in grassland soil biodiversity. There is increasing evidence that belowground and aboveground community components are closely associated, and that belowground communities play an important role in grassland productivity and sustainability.

Grasslands of Sri Lanka have been the subject of several soil surveys, but most of these were mainly concerned with soil profile features, soil geology, and physical and chemical properties. However, in the decade of 1970, several grassland scientists performed some comparative studies of ecological resemblance of higher plants and fungal communities through ordination and association studies in a selected grassland type (e.g. Patana) in Sri Lanka. They have shown such a relationship of both the grass plants and soil micro fungi characteristics in different zones under the same grassland type. However, continuation into rest of the grassland types was incomplete after the particular decade. Earlier workers also suggested the magnitude of future work to explore the relationships of soil biodiversity and floristic relationship for sustainable use of grasslands.

Generally, information pertaining to species and functional diversity of soil fauna and flora communities over succession periods for tropical grasslands in other countries is available in significant numbers. The same methodologies could also be applied for local grassland ecosystems and authors put forward the necessity of these key issues for the sustainable management of natural grassland ecosystems of Sri Lanka. In addition to the use of conventional methodologies in grassland soil microbial research, molecular techniques could also be applied to gain insights into the soil community.

INTRODUCTION

In Sri Lanka, nearly 12,000 km^2 of the total land area (65,610 km^2) is under natural grassland cover (Pemadasa, 1990). Generally, natural grasslands can be recognized as plant communities in which dominant species are perennial grasses and, very few or no shrubs or trees. Further, ecologically, a natural grassland is a combination of climate, soil, topography, fire and many biotic factors. Grassland vegetation develops extensive root systems, and has distinct architecture and rhizospheres that affect below ground biodiversity and ecology. Like in other countries, grasslands of Sri Lanka have an economically vital and viable multifunctional role, as they provide so many-resources for the livelihood including green forages for livestock. However, in contrast with other ecosystems, their exploitation has been disorganized due to haphazard clearing for short term cultivations, illegal burning and over grazing by domestic animals. These activities have caused considerable floristic, habitat and edaphic changes and severe erosion of many types of grassland, with near complete destruction of some areas.

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Grasslands are among the most productive biomass, the rate of energy turnover is high, and about 90% of their net primary production is decomposed *in situ*. (Coleman et al., 2004). Either in contrast of intensive grassland systems (farm managed grassland systems for livestock purposes) or natural grassland ecosystems, self-regulating process in the soil become more and more important. Soil biota plays an important role in these processes by supplying of nutrients, maintenance of soil structure, water regulation and, more generally the resistance and resilience of the belowground system. Through root exudates and litter from roots and above ground parts, grasses supply nutrients to the soil food web. Therefore, the quantity and quality of root exudates and plant litter are the major factors which determine the soil microbial diversity under a specific species of grass cover. Equally, the soil biota in turn influences with their ecosystem services to production, plant quality and diversity of the grassland community.

This paper aims to outline the basic information on the Sri Lanka grasslands and important studies based on their floristic and edaphic contrast. Subsequently, a conceptual framework is proposed in regard to discover the soil biodiversity interactions under the natural grassland ecosystems in the country.

Grassland resources of Sri Lanka

Grasslands of Sri Lanka have been categorized in many ways based on their origin and evolution, geographical distribution and floristic composition. In climatic and vegetation contrast, grassland of Sri Lanka can be divided into three general categories; *Patana*, Savanna and Lowland grasslands. Further, they are sub divided into several forms. Pemadasa (1983) has carried out a comprehensive account on natural grassland resource in the country and Table 1 list the major and, sub grassland types based on this survey. Important characteristics of some economically important and most exploited grassland types, which also have a potential for livestock farming, are summarized in Table 2.

Table 1: Grassland types of Sri Lanka

Main Type	Main Sub-Type	Sub-Type
Montane (*Patana*)	Dry	Humid zone dry *Patana*
		Summer zone dry *Patana*
	Intermediate	Intermediate *Patana*
	Wet	Lower wet *Patana*
		Upper wet *Patana*
Savanna	-	Upland Savanna
	-	Lowland Savanna
Lowland	Wet zone pastures	Inland Grasslands
		Maritime grasslands
	Dry zone pastures	*Damana* grasslands
		Thalawa grasslands
		Villu grasslands
		Tank bed grasslands
	Intermediate zone pastures	Coconut grazing grounds
	Arid zone pastures	Dry pastures
		Humid Pastures
		Mixed Pastures

Source: Extracted and arranged from Pemadasa (1983); Premaratne *et al.* (2003)

Grassland soil environment

Grassland builds soil systems different from those of other terrestrial vegetation types, even from the same parent material. A key feature of grasslands is their high turnover of shoot and root biomass, and consequent large pool of liable organic matter at the soil surface. Further, heavy herbivore loads and frequent fires are also characteristic features of grassland. These experiences significantly influence the plant growth and species composition of the grassland. Herbivores consume as much as the above and below ground net primary production while the fire removes exclusively the above ground biomass for a given period. As a result of these relatively high rates of consumption, it has been suggested that the structure of grassland is a consequence of numerous interactions, many of which are either direct effects or mediated by herbivorous. Herbivores have a powerful influence on nutrient pathways in grasslands by short cutting both litter return and soil recycling process. A large percentage of nutrients taken up by plants are recycled directly through animal excreta, resulting in accelerated soil incorporation, particularly of nitrogen and phosphorus. These features combine to produce a soil environment that sustains an abundant and diverse faunal and floral community.

Grassland soil community; understanding the belowground network for sustainable grassland management

Soil micro and macro organisms in grassland play important roles in many of its ecosystem processes such as biogeochemical cycling of nutrients (nutrient transformations) and soil structural and hydrological properties. Therefore, soil biodiversity assets are often used as indicators of soil quality. Many workers in the grassland science, in global scale, recognize that the understanding of belowground ecosystem has been far poorer than that of the aboveground ecosystem. However, over the last few years, there have been substantial advances in soil biodiversity and its ecology, including the development of new technologies and methodologies (*e.g.* DNA and RNA methodologies and sampling techniques) and the recognition of the linkage between belowground and above ground components.

Globally, there has been much recent interest in the characterization of soil biodiversity and its function in grasslands. Much of this interest has come from the need to develop grassland management strategies. Authors, herein expose the inadequacy of appropriate grassland management policies in this country coupled with other functional policies such as economic, socio-economic, land use and wildlife together in considering of all possible soil biodiversity aspects.

The information, in general, pertaining to soil fauna (protozoa, nematoda, mites, collemboles, enchytraeids, earthworms, molluscs, many insects, myriapods and spiders) and flora (archea, bacteria and fungi) community compositions over succession periods, nitrogen fixation by free living and symbiotic microorganisms, soil carbon storage potential or litter quality and microbial activity relationships, soil-borne pathogens that are accountable for grass and livestock health, effect of soil fauna on floristic composition, abundance of micorrhizal fungi, temporal dominance of fungal and bacterial communities, grazing induced soil biological activities and effect of burning on soil biodiversity for tropical grasslands in other countries are available in significant numbers. The same methodologies could also be applied for local grassland ecosystems and authors put forward the necessity of these key issues for the sustainable management of natural grassland ecosystems of Sri Lanka. In addition to the use of conventional methodologies in grassland soil microbial research, molecular techniques could be applied to gain insights into the soil community.

Table 2: Important characteristics and remarks of some economically important and most exploited grassland types of Sri Lanka

Grassland Type	Rainfall(annual), climatic zone and elevation	Distributed locations	Dominant forage species found*	Potential for livestock grazing	Important remarks
Dry *Patana*	1750-2250 mm Up country intermediate 500-2000 m	*Uva Basin*	*Arundinella spp* *Pollinia spp* *Ischaemum spp* *Themeda tremula* *Andropogon spp*	Moderate	The burning of grass just before the rain results in the soil being exposed and consequently getting eroded. This probably accounts for the absence of trees.
Wet *Patana*	2500-4000 mm Up country wet > 2000 m	Horton Plains, Elk Plain, Moon Plain, *Bopaththalawa*	*Chrysopogon zeylanicum*	Poor	Grasses are tufted, coarse and wiry. Scattered trees are prominent.
Lowland Savanna	1450-1750 mm Low country intermediate 300-400 m	*Bibile* *Monaragala*	*Panicum spp* *Themeda tremula* *Themeda triandra* *Desmodium spp*	High	The grass cover is much taller. Fire tolerant species are rather sporadic.
Upland Savanna	1500-2000 mm Mid country wet 400-500 m	*Wellawaya* *Pethyagoda*	*Panicum spp* *Themeda tremula* *Heteropogon triticeus* *Desmodium spp* *Mimosa pudica*	Moderate	The grass cover is much taller. Soil is eroded and denuded as a result of frequent destruction of vegetation.
Villu	1500-2000 mm Low country dry 0-200 m	*Polonnaruwa* *Manampitiya* *Thamankaduwa* *Maduruoya* *Wilpattua*	*Cynodon dactylon* *Stenotaphrum secundatum* *Bothriocloa glabra*	High	Wet grasslands found in the flood plans of the rivers in the dry zone. Grasses are more succulent. Soil is rich in nutrients.
Damana	1250-1750 mm Low country dry 0-100 m	*Damana* *Ampara* *Inginiyagala*	*Impereta cylindrica*	High	Origin seems to be the results of forest clearing followed by repeated fire.
Talawa	2000-2500 mm Low country wet 0-200 m	*Kalutara* *Galle* *Matara*	*Cynodon dactylon*	High	Arise as results of forest felling and *Chena* cultivation in wet zone.

SOME EARLIER STUDIES ON GRASSLAND SOIL BIODIVERSITY IN SRI LANKA

The grassland research in Sri Lanka goes back to several decades and, however, most of the scientists limited their investigations into compressive floristic lists, description of climate, geology, and physical and chemical properties of the soils through repeated extensive surveys under selected grasslands. Nevertheless, in most of the Sri Lanka grasslands, so far, little is known about the dynamics of floral communities, energy relations, productivity, phenology and even general biology. It is not exceptional also for the biodiversity in grassland soil under local conditions. Consequently, more intensive and recurring experimental investigations using novel technologies and methodologies are necessary to elucidate the ecology and sustainability of the grasslands.

However, in the 1970s, few workers have repeatedly recognized the floristic composition and fungal populations in some *Patana* grassland types in the country (Muller-Dombois and Perera, 1971; Pemadasa and Muller Dombois, 1979). They further characterized the *Patana* grasslands into more precise sub types on the basis of climatic, topographic and in particular soil fungal population differences. Their methodologies and key findings of the studies are summarized below.

- Unlike the sampling and data collection on higher plant communities, same on fungal communities was a greater difficulty.
- Ordinations were made by reciprocal averaging of higher plant and fungal data in selected *Patana* zones.
- Ordination of stands based on both the higher plants and soil fungi reaffirmed the previously postulated ecological distinctiveness of different *Patana* zones.
- Applications of multivariate methods to higher plant and fungal data from the same ecosystem were recorded as an alternative approach providing complementary ecological information.
- Despite the fundamental differences in the biology of higher plants and soil fungi, the ordinations of data from the two types of communities gave remarkably similar results.
- It was shown that a combination of the above two approaches is more informative than either alone, in further classification of selected grasslands.
- Ordination of species showed the ecological affinities of both the higher plants and soil microfungal characteristics of different *Patana* grassland types.
- The fungal communities appeared to be more clearly defined than the higher plant communities.
- In conclusion, authors clearly stated that the similarity of findings of multivariate analysis in higher plants and fungi could confidently be used as a tool in this grassland classification.

RESEARCH NEEDS AND SUGGESTIONS FOR GRASSLAND ECOSYSTEMS; IN PARTICULAR SOIL BIODIVERSITY

Nowadays, the objective of grassland science cannot be only to contribute to vegetation, animal interaction and ordinary species diversity in soil organisms. It should be a broad contribution of grassland ecosystems and their response at global or local scale corresponding to the different functions assigned to grasslands. Therefore, in any scale, it is necessary for grassland research to consider this batch of factors simultaneously. However, since grassland soil biodiversity studies in local and regional conditions are in a very primeval stage, and or meager, initial studies on ecological perspective (both species and functional diversity on grassland biota) as regular surveys under most important grassland types are suggested by the authors. Additionally, novel molecular techniques to quantify key functional groups of soil micro biota; Extrapolating laboratory based results to field conditions and scaling-up the factors; Novel agents to manipulate specific microbial groups to understand the functions of them are also recommended. Linking long-term observational data to grassland sustainability under changing environment in particular on management practices and climatic changes would also be significant.

CONCLUSIONS/RECOMMENDATIONS

Generally, in contrast, natural grasslands are considered as low-input systems with heterogeneous habitats and resources. From this review, it is clear that soils of grassland ecosystems contain abundant and diverse organisms of flora, and micro, meso and macro fauna. Initially, their species and functional diversity has not been characterized and also not investigated through spatial and temporal approach. Therefore, it is currently essential to a great extent of repeated studies using novel molecular techniques and field investigations to explore this valuable resource for the sustainable exploitation of grassland resource in the country.

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