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GRASSES AND THEIR HYDRO-EDAPHIC CHARACTERISTICS IN THE GRASSLAND HABITAT OF NILGIRIS BIOSPHERE RESERVE, TAMIL NADU

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ABSTRACT

The present investigation is aimed at to study the incidence of grass species at varied elevations alongwith their hydro-edaphic characteristics in Nilgiris Biosphere Reserve, Tamil Nadu. The results show that grasses exhibit high species diversity and some confine to lower elevation (range 500 m to 1500 m); while others to higher elevation (range 1800 m to 2750m). Some others show no elevation impact (range 850 m to 2750 m). The edaphic characteristics and soil systems associated with the grasses are ecologically balanced at present, barring soil of Mashinaguri grass field, which is highly fragile. The soils irrespective of their location and elevation possess a high pool of energy materials (1.86% to 4.96%), clays (36.8% to 57.8 %) and exhibit good water holding capacity (72.2% to 94.8%). They are feebly to moderately acidic (ph 4.4 to 5.8), moderate to high silica content (65.6% to 85.1%) and with sesqui-oxides producing a low silica/sesqui-oxides ratio. Soil saps are dominated by calcium within cations and bicarbonate within anions. Waters are neutral to feebly alkaline, bereft of charge carrying particles but dominated by calcium ions. The hydro-edaphic chemistry appears quite conducive to the flora and fauna of the area.

INTRODUCTION

The grasses form a natural and homogeneous group of plants with remarkable diversity and belong to family Poaceae. The grassland occupy about 20% of the earth's land surface (Moore, 1964). According to one estimate 3.9% of total area of our country is occupied by grasslands. They are the natural source of quick renewable bio-energy. The grass dominating habitats usually show superiority over other habitats in respect of soil energy materials (organic carbon) and soil-proteins. Their economic importance lies in their paramount role as food and fodder. Mineral potentialities of a few forage grasses (Singh & Shastry 1985), the role of herbage layer in Indian Botanic Garden (Singh & Ghosh 1991), as a balancing agent

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between herbivores and carnivores (Singh & Mudgal 1998, 1999 and 1999a) in respect of some essential minerals needed for their growth and development; empowering the habitat with conducive edaphic conditions on one hand and protecting its top layer against soil erosion on the other. The botanical/ecological works of Champion (1936); Bor (1940 & 1960); Bharucha and Shankaranarayan (1958); Agarwal & al (1961); Mehar-Homji (1965); Gupta & al. (1967); Champion & Seth (1958); Gupta (1971); Yadav & Singh (1977); Jain (1986); Nayar & Shastry (1987, 1988 & 1990); Jeeva & Ramakrishnan (1997); and Singh & Mudgal (1998 & 1999) have been reviewed here.

Nilgiris Biosphere Reserve (NBR) situated in Western-Ghat between the co-ordinates of 76°-77°45′ E and 11°15′-12°15′ N, encompassing the adjoining territories of Tamil Nadu, Kerala and Karnataka, is one of the richest centres of biological diversity in peninsular India. Its total area is c. 5520 km^2, of which, c. 2537.6 km^2 falls under Tamil Nadu portion. The Tamil Nadu portion of NBR demonstrates the varieties of climatic type. The region shows variable rainfall, the south-west area experiences as high as 7620 mm per annum but the north-east part receives merely 1777 mm. Temperature shows a wide range of variation, the rain shadow zone of NBR experiences 40°C temperature in summer and frost is a regular phenomenon in winter in higher grassy meadows. The vegetational types vary from scrub vegetation at south-east part to dry deciduous, deciduous and moist deciduous towards north-west portion. The region is bestowed upon with montane wet temperate evergreen species locally called "Sholas" that harbour members of families Celastraceae, Elaeocarpaceae, Myrtaceae, Symplocaceae, Ternstroemiaceae, etc.

Topography and climate divide the area into four distinct regions, namely Nilgiris-plateau, Sigur plateau, Nilgiris Wynaad and outer slope facing the plains (Jayadev, 1957). The present study has been undertaken to understand the role of grasses in their hydro-edaphic characteristics that may prove significant in the scientific management of biosphere reserve.

MATERIALS AND METHODS

At higher elevation particularly in Mukurty National Park and Reserve Forest, the grasses grow in pure stand on hill tops dotted sporadically with *Rhododendron arboreum* ssp. *nilagiricum*. At lower elevation their occurrence is only due to biotic disturbances at

the cost of natural forest. In persuation of our main objective to study the biosphere reserve for its phyto-edaphic relationship, the occurrence of grasses have been studied from lower to higher elevation in all three seasons. To study their hydro-edaphic characteristics, ten representative spots were chosen at varied elevations, namely, Shiruvani, Gudalur, Mudumalai, Mashinaguri, Pykara, Parson valley, Dodabetta, Avalanche reserve forest, Upper Bhavani and Mukurty National Park. Composite soil samples have been collected at surface level *i.e.* 0-25 cm taking care that collected soil samples belong to active root zone of the plant and are true representative of maximum grass species. The soil samplings have been replicated thrice in identical methods *viz.*, November/December 2000, May/June 2001 and January/ February 2002 to get consistency in the observation of edaphic conditions. For soil sampling, rainy season has been avoided. The collected soil samples have been analyzed for mechanical make up, physico-chemical characteristics, HCL extract analysis and soil sap properties. The methods of soil analysis described in Jackson (1958); Piper (1966) and Rechards (1954) were followed. The water body form has been sampled water to assess their chemistry and possible impact on species growth. The water samplings were replicated thrice including rainy season. The collected water samples were analyzed for various cations, anions, pH and electrical conductivity. Sodium adsorption ratio (SAR), soluble sodium percentage (SSP) and residual carbonate in m.e./l. were also computed. Sodium and potash were analyzed by flame photo-meter, whereas pH by potentiometric method and electrical conductivity by solu-bridge. For other chemical analysis hand book no. 60(1954) U.S.D.A. has been followed.

RESULTS AND DISCUSSION

Elevation-wise indicence of grass species and their respective distribution within biosphere reserve (T.N.) are given in the Fig.-1 and table -1. These grasses may be categorized into three groupes *viz.*, lower elevation grasses (range 500 m to 1500 m) but a few of them seldom grow up to 1850 m (table 1a). Secondly, high elevation grasses- (table 1b)-they grow in an elevation range of 1800 m to 2750 m and their occurrence below 1500 m are rare to nil. The third category of grasses (table 1c) occur at wider elevation range between 850 m and 2750 m. These grasses can endure the chill of frost which is a regular feature of high elevation and also higher temperature at lower elevation. The high degree of species diversity may be attributed due to varied topography and climatic conditions coupled with large scale grazing and burning of the forest. It is observed that the grass species of higher elevation are chiefly governed by their aerial factors for their distribution, growth and

development rather than on edaphic factors. While working on natural habitat of *Rhododendron arboreum* ssp. *nilagiricum* in the same biosphere reserve, it has been observed pertinently that with ssp. *nilagiricum* in the grass-fields of higher elevations a few woody species might also have existed in the past and the formation of grass-fields is a sequel to biotic disturbances. Similar opinion has also been expressed by Nobel (1967) while working on shifting balance of grasslands in upper Nilgiris area. He felt that constant fires set by pastoralists of hundred of years have contributed to the formation of grasslands. Grasslands of higher altitude and their ecological status have always been a controversial subject. On one hand the grasses are considered to be the vegetation climax (Ranganathan, 1938) but on other hand, it has been claimed as pre-climax (Jayadev, 1957) and sub-climax (Champion, 1936).

The edaphic characteristics in which these grasses nurture are presented in table 2-5. The mechanical composition of soil in table-2, demonstrates that there are only three dominant textural classes *viz.*, clayey, clay-loam and sandy-loam, in which clayeys are the most common and sandy loam is the most rare. A clay dominant texture of an area/region is a clear pointer towards oblivion impact of total precipitations on edaphic mechanical factors. Observations further reveal that Mashinaguri grass field is the only exception where soils mechanical compositions are ecologically fragile but other grass fields, rich in clay content enable the soil system to fulfil the water requirement of grasses. The soils also exhibit the presence of appropriate quantum of sands which may indirectly be helping the system to create proper porosity for exchange of gases and development of healthy root system. Physico-chemical characteristics of soils are presented by table-3. Energy materials in soils are expressed in the form of organic carbon. Barring soil of Mashinaguri grass field, the other soils are rich in energy contents, the values range between 1.86% (grass field of Avalanche' reserve forest) and 4.96% (grass field of Upper Bhavani). For Mashinaguri, its status is merely 0.54%. The value of 4.96% of organic carbon is considered high for any soil but this values seem to have fallen in comparison to that of 1970 status which was estimated to be 6.09% in the same forest (Yadav & al. 1970). Similarly, Singh and Shastry (1982) recorded 6.15% of organic carbon in the soils of silent valley forest of Kerala. After organic carbon, the next vital element is its nitrogen. Since it is not the part of rock, therefore, the soil system solely depends on organic compounds for this element. Data on available nitrogen depict its close link with organic carbon. Its values vary from a minimum of 0.165% in the grass field of Avalanche' reserve forest to the maximum of 0.389% in the soil of Upper Bhavani grass field but in Mashinaguri its value is as low as 0.034%. The pH determines the availability of macro and

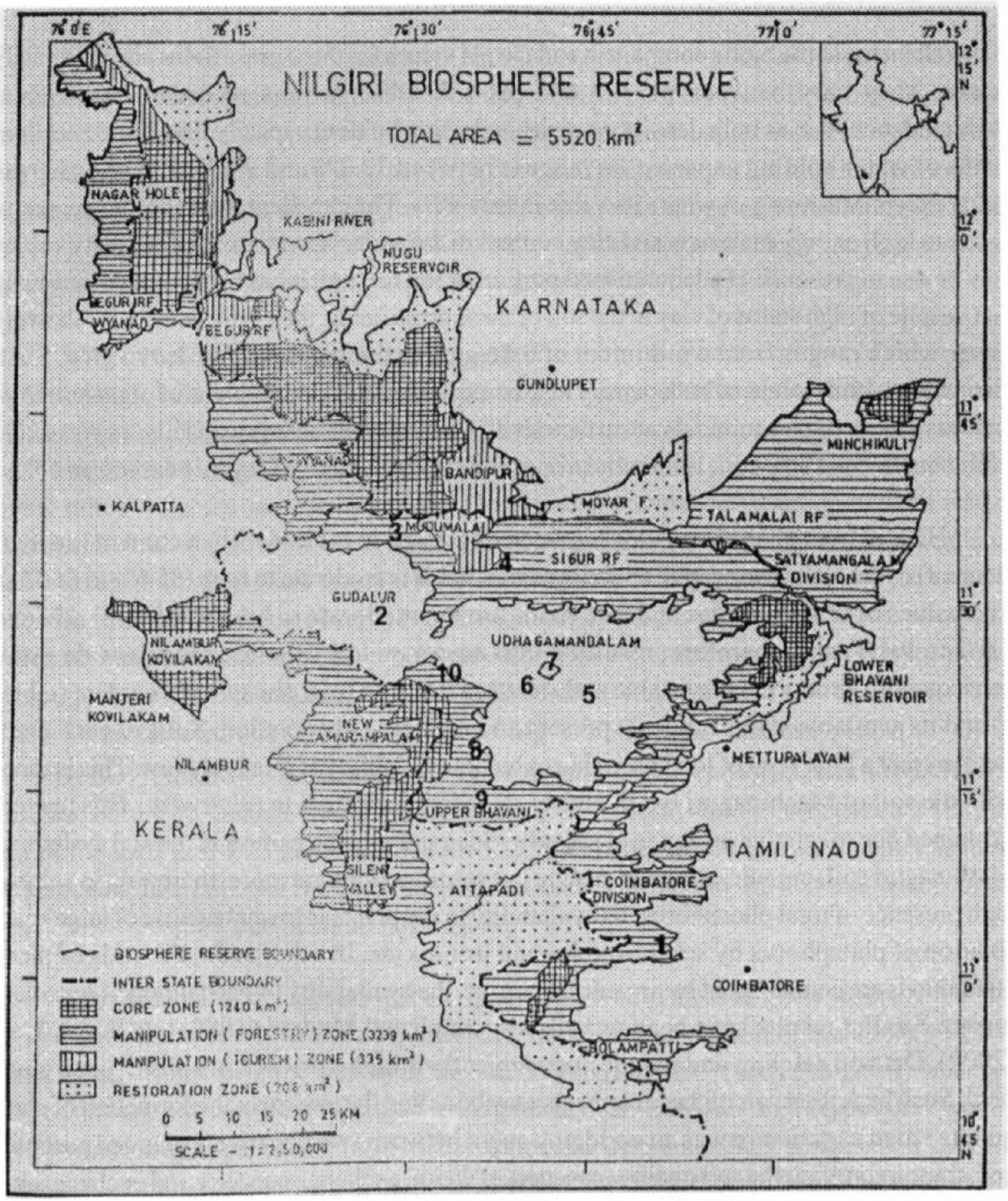


Fig. 1 : Location of various Grass-fields under investigation in NBR (Tamil Nadu)
1. Shiruvani; 2. Gudalur; 3. Mudumalai; 4. Mashinaguri; 5. Pykara; 6. Parson valley;
7. Dodabetta; 8. Avalanchè Reserve Forest; 9. Upper Bhavani and 10. Mukurty National Park.

micro elements to the biotic component and the pH values for these grass fields are moderately acidic. They vary between pH 4.4 and pH 5.8. Observations recorded on physical characteristics such as bulk density, porosity and water holding capacity reveal the excellent status of water holding capacity. Its range is between 72.2% and 94.8% in various grass fields except Mashinaguri where its value is only 40%. The excellent water holding capicity is due to high energy materials and clay content in the soils. The fairness of porosity values may be due to presence of adequate sand portion in soil texture. It has been noticed curiously that despite of high status of clay in the soil of these grass fields, their bulk density is relatively lower which ranges from a minimum of 0.86 g/cc to the maximum of 1.496 g/cc. Such distinction within values of bulk density may be explained due to high status of organic crabon and less values of free minerals at surface level. The cation exchange capacity, expressed in milli equivalent/100 g soil, is directly proportional to the values of organic carbon and clay.

HCL extract analysis of soils has been expressed in table-4. Silica content (an inert element) of the soils irrespective of various grass fields is moderate to high (65.6% to 85.1%). The values of sesqui-oxides and iron oxide are too moderate to high (11.5%-21.1% and 3.9% to 9.4%) and, therefore, resulting into moderate to low silica/sesqui-oxide ratio, consequently, produce a very stable soil structure. Data on total phosphorus content (table-4) and its available status (table-3) present an interesting observation. Soils of each grass field present a high pool of total phosphorus but its availability is relatively low. This is more with the soil of Mashinaguri but the other soils demonstrate it in otherwise. This may be explained due to relative presence of sesqui-oxides and organic carbon in the soil system. In Mashinaguri soil, organic carbon is meagre but sesqui-oxides are more, therefore, in spite of high presence of total phosphorus, its availability to the plants is lower because of large scale fixation of phosphorus by sesqui-oxides and iron-oxide. In other soils, the odds of these compounds are counteracted by organic carbon, so, the availability of phosphorus is relatively higher. Similar results have been recorded by Singh and Mudgal (1999) and Singh & al. (2002). Data on calcium and magnesium depict their high presence in soils of each grass field. Such high reservoir of these elements may be aiding the system in the formation of clay-humus union as cations act as an abridging agent between two negatively charged particles and, thus, improving the soil quality in respect of cation exchange capacity and exchangeable calcium. The soil sap characteristics (table-5) are dominated by calcium and magnesium within cations and bicarbonate and chloride within anions, whereas, the carbonate ions are conspicuously absent. The cations and anions may be arranged as per their dominance as

$Ca^{++} > Mg^{++} > Na^{++} > K^{+} >$ (cations) and $HCO_3 > Cl^{-} > CO_3^{=}$ (anions). Electrical conductivity values indicate that soil of Mukurty National Park grass field has the highest salinity (E.C. 2.6 m.mhos/cm) and lowest being shown by Mashinaguri Soil (E.C. 0.8 m.mhos/cm), whereas, the soils of other grass field have E.C. in between 1.4 m.mhos/cm and 2.4 m.mhos/cm. Saturation percentages demonstrate a wide range of variations (42.5% to 82.4%). Such fluctuations may be explained due to variable status of charge carrying particles, energy materials and clay within soils of these grass fields.

Water quality/composition are presented in table -6. Water regimes of these grass fields are quite bereft of dissolved minerals as evident from low value of electrical conductivity (E.C.). Waters of Dodabetta grass field and Pykara exhibit the least value of conductance *i.e.* 80 micro mhos/cm at 25°C, whereas, waters of Mudumalai show the highest value 210 micro mhos/cm at the same temperature. The pH values reveal that reaction of these waters is either neutral or feebly alkaline. The alkaline pH indicates their suitability to both plants and animals of the biosphere reserve. Even soils of the area may be benefited by such waters because their pH has been observed to be moderately acidic in reaction. Both cation and anion contents are quite meagre in per unit volume of water irrespective of their locations. Among the cations the calcium ions and bicarbonate within anions show their dominanc. Their dominance may be arranged as $Ca^{++} > Mg^{++} > Na^{++} > K^{+}$ (cations); $HCO_3^{-} > Cl^{-} > SO4^{=} > CO^{=}_3$ (anions). The carbonate ions are absent. Sodium adsorption ratio (SAR) and soluble sodium percentage (SSP), residual carbonate indicate variations between 0.158 and 0.338 for SAR and 11.1% and 22.2% for SSP. The residual sodium carbonate has been observed nil in all the waters. Such an observation is a pointer to the fact that waters of all grass fields are quite free of alkali hazards.

The present study suggests that biosphere reserve richness in grass species diversity has positive link with its hydro-edaphic characteristics. Barring soil of Mashinaguri grass field, the other soils are quite healthy in their acquired charateristics and ecologically balanced at present. The soils with existing physico-chemical characteristics may support any woody species and are quite capable to fulfil water requirement demands of any dimension. However, the rampant biotic disturbances have left these soils with herbage flora. It is, therefore, suggested that to get back original ecosystem, its biotic interference may be brought to minimum level. It is highly needed for its proper conservation and appropriate safeguard for its rich biodiversity.

Table I. Distribution of Grass species at varied elevations in Nilgiris Biosphere Reserve (T. N.) (1a) Lower elevation (range 500 m to 1500 m; (1b) Higher elevations (range 1800 to 2750 m); (1c) No elevation impact range 850 m to 2750 m).

Grass Species	Their availability in various localities									
	1	2	3	4	5	6	7	8	9	10
1(a)										
Acrachne racemosa (B. Heyne) Ohwi	+	+	+	+						-
Alloteropsis cimicina (L.) Stapf	-	+	+	+	+	+				
Aristida adscensionis L.		+	+							
Aristida setacea Retz.	+	+	+							
Arundinella leptochloa (Nees ex Steud.) Hook.f.	+	+	+	+	+			-		-
Axonopus compressus (Sw.) P. Beauv.		+	+		+	+	+			
Bothriochloa pertusa (L.) A. Camus	+	+	+	+						
Brachiaria ramosa (L.) Stapf		+	+	+						
B. remota (Retz.) Haines	+	+	+	+	-			-		-
B. semiverticillata (Rottler) Alston	+	+	+	+					-	
B. eruciformis (Sm.) Griseb.	+	+	+	+				-	-	
B. reptans (L.) C.A. Gardner & C.E. Hubb.	+	+	+	+						
B. setigera (Retz.) C. E. Hubb.	+	+	+	+		-		-	-	
B. distachya (L.) Stapf	+	+	+	+					-	

Capillipedium huegelii (Hack.) A. Camus		+	+		+	+	+	+		
Cenchrus ciliaris L.	+	+	+	+			-			
Centotheca lappacea (L.) Desv.	+	+	+			-				-
Chloris dolichostachya Lag.	+	+	+	+						-
C. roxburghiana Schult.	+	+	+	+			-			
C. barbata Sw.	+	+	+	+		-		-		
Chrysopogon aciculatus (Retz.) Trin.	+	+	+	+	+		-	-		-
C. orientalis (Desv.) A. Camus		+	+		+		-			
Cyrtococcum deccanense Bor		+	+		+	-				
C. longipes (Wight & Arn. ex Hook.f.) A. Camus		+	+		+	+	+	+		
C. oxyphyllum (Steud.) Stapf	+	+	+		+	+	-			
Dactyloctenium aegyptium (L.) P. Beauv.	+	+	+	+			-			-
Dendrocalamus strictus (Roxb.) Nees	+	+	+	+	+			-		-
Digitaria albudens (Roem. & Schult.) Veldkamp		+	+	+	+	+				
D. griffithii (Hook.f.) Henr	+	+	+	+	+	-				-
Dimeria ornithopoda Trin.	+	+	+	+	+		-			
Echinochloa colomum (L.) Link	+	+	+	+	+	-	-	-	-	
Eleusine coracana (L.) Gaertn.		+	+		+	+	+	+	-	
Eragrostis aspera (Jacq.) Nees	+	+	+		+	+	-	-		-
E. cilianensis (All.) Vignolo	+	+	+		+	+	-		-	
E. tenella (L.) P. Beauv.	+	+	+	+	+			-		-

Eulalia trispicata (Schult.) Henrard	-	+	+	-	+	+	+	+	-	-
Garnotia arundinacea Hook.f.		+	+	-	+	+	+	+	+	-
G. elata (Arn. *et* Miq.) Janowski	+	+	+	-	+	-		-	-	-
G. stricta Brongn.	+	+	+	-	+	+	-	-	-	-
Hackelochloa granularis (L.) Kuntze	+	+	+	+	+	-		-	-	-
Imperata cylindrica (L.) P. Beauv. var. *major* (Nees) C.E. Hubb.	+	+	+	+	+		-	-	-	-
Isachne oreades (Domin) Bor	+	+	+	+	-		-		-	-
Ischaemum nilagiricum Hack.	+	+		-	+	+	+	+	-	-
Jansenella griffithiana (C. Muell.) Bor		+	+	-	+	+	-	-	-	
Leptochloa obtusiflora Hochst.	+	+	+	+	+					
Ochlandra setigera Gamble	+	+	+	+	+			-		
Oplismenus burmanii (Retz.) P. Beauv.	+	+	+	+		-		-		
Oxytenanthera monadelpha (Thwaites) Alston	+	+	+	-	+	+	+	+	+	-
Paspalidium flavidum (Retz.) A. Camus	+	+	+	+	+	-	-	-		
Pennisetum hohenackeri Hochst.	-	+	+	-	+	+	+	-		-
Pogonatherum paniceum (Lamk.) Hack.	+	+	+	-	+	+	+	-		-
Saccharum spontaneum L.	+	+	+	+	+	-	-	-		-
Sacciolepis interrupta (Willd.) Stapf	+	+	+	+	+	-		-	-	
Setaria palmifolia (D. Koenig) Stapf	+	+	+	-	+	+	+	+	-	-
S. verticillata (L.) P. Beauv.	+	+	+	+	+		-			-

Themeda cymbaria Hack.	+	+	+	+	+					-
T. tremula (Nees *ex* Steud.) Hack.	+	+	+		+	+	+	+	+	
Trachys muricata (L.) Pers. ex Trin.	+	+	+	+						
1(b)										
Agrostis peninsularis Hook.f.					+	+	+	+	+	+
A. pilosula Trin.					+	+	+	+	+	
A. stolonifera L.					+	+	+	+	+	+
Andropogon lividus Thwaites						+	+	+	+	
A. longipes Hack.					-	+	+	+	+	
Anthoxanthum odoratum L.			-		+	+	+	+	+	
Arthraxon quartinianus (A. Rich.) Nash					+	+	+	+		
Arundinaria wightiana Nees						+	+	+	+	+
Arundinella purpurea Hochst. ex Steud.				-		+	+	+	+	+
A. purpurea Hochst. ex Steud. var. *laxa* Bor					+	+	+	+	+	
Arundo conspicua Forst.f.					+	+	+	+	+	
Avena sativa L.					+	+	+	+		
A. sterilis L.				-		+	+	+	+	
Bothriochloa foulkesii (Hook.f.) Henrard						+	+	+	+	+
B. glabra (Roxb.) A. Camus						+	+	+	+	+
Brachypodium sylvaticum (Huds.) P. Beauv.						+	+	+	+	+
Briza maxima L.						+	+	+	+	+

Briza minor L.					+	+	+	+	+	+
Bromus arvensis L.						+	+	+	+	
B. ramosus Huds.					+	+	+	+	+	+
Chrysopogon zeylanicus (Nees ex Steud.) Thwaites					+	+	+	+	+	+
Coelachne perpusilla (Arn. ex Steud.) Thwaites					+	+	+	+	+	
Cortaderia selloana (Schult.) Asch.& Graebn.					+	+	+	+		
Cymbopogon martinii (Roxb.) J.F. Watson					+	+	+	+		
C. polyneuros (Steud.) Stapf					+	+	+	+	+	+
Dactylis glomerata L.						+	+	+	+	
Dichanthium oliganthum (Hochst. ex Steud.) Cope										
Eragrostis pilosa (L.) P. Beauv.				-	+	+	+	+		
Eriochloa procera (Retz.) C.E. Hubb.					+	+	+	+		
Eriochrysis rangacharii C.E.C. Fisch.					+	+	+			
Festuca ovina L.							+	+	+	+
Helictotrichon asperum (Munro) Bor					+	+	+	+	-	
Hordeum vulgare L.					+	+	+	+		
Isachne deccanensis Bor						+	+	+	+	
I. elegans Dalzell *ex* Hook.f.				-	+	+	+	+		
I. kunthiana (Wight & Arn. ex Steud.) Miq.						+	+	+	+	+
I. walkeri (Arn. ex Steud.) Wight & Arn. ex Thwaites					+	+	+			
Ischaemum commutatum Hack.	-				+	+	+	+	+	

Miscanthus nepalensis (Trin.) Hack.					+	+	+	+	+	
Oplismenus undulatifolius (Ard.) P. Beauv.						+	+	+	+	+
Panicum maximum Jacq.						+	+	+	+	+
P. repens L.					+	+	+	+	+	+
Paspalum dilatatum Poir.					+	+	+	+		
P. scorbiculatum L.			+		+	+				
Pennisetum clandestinum Hochst. ex Chiov.					+	+	+	+	+	+
Sacciolepis indica (L.) A. Chase			+		+	+				
Themeda quadrivalvis (L.) Kuntze			+		+	+	+	+	+	
Tripogon bromoides Roem.& Schult.			+		+	+	+	+	+	
T. jacquemontii Stapf			+		+	+				
Vulpia myuros (L.) Gmel.					+	+	+	+	+	+
Zenkeria elegans Trin.			+		+	+		-		
1(c)										
Apluda mutica L.	+	+	+		+	+	+	+	+	+
Aristida adscensionis L.	+	+	+		+	+	+	+		+
Arundinella ciliata (Roxb.) Nees ex Miq.	+	+	+		+	+	+	+		
A. setosa Trin.			+		+	+	+		+	+
Brachiaria semiundulata (Hochst.) Stapf		+	+		+	+	+	+		+
Cymbopogon flexuosus (Nees ex Steud.) J. F. Wats.	+	+	+		+	+	+	+	+	+
Cyrtococcum longipes (Wight & Arn.) A. Camus	+	+	+		+	+	+			

C. patens (L.) A. Camus	+	+	+		+	+				
Digitaria ciliaris (Retz.) Koeler	+	+	+		+	+				
D. longiflora (Retz.) Pers.		+	+		+	+	+			
D. wallichiana (Wight & Arn.) Stapf		+	+		+	+	+	+	+	+
Eleusine indica (L.) Gaertn.		+	+		+	+				
Eragrostis gangetica (Roxb.) Steud.	+	+	+		+	+	+	+	+	+
E. tenuifolia (A. Rich.) Hochst. ex Steud.		+	+	-	+	+	+		+	
Eulalia phaeothrix (Hack.) Kuntze					+	+	+	+		-
Glyceria spicata Guss.			+		+	+	+	+	+	+
Heteropogon contortus (L.) P. Beauv.	+	+	+		+	+	+	+	+	+
Isachne bourneorum C.E.C. Fisch.					+	+	+	+	+	+
I. dispar Trin.		+	+		+	+	+			
Ischaemum indicum (Houtt.) Merr.		+	+		+	+	+	+		
Oplismenus compositus (L.) P. Beauv.			+		+	+	+	-	+	+
Setaria pallide-fusca (Schumach.) Stapf		+	+		+	+	+	+	+	+
S. palmifolia (D. Koenig) Stapf	+	+	+		+	+	+		+	
S. intermedia Roem. & Schultes		+	+		+	+	+			
Sporobolus indicus (L.) R. Br.										
var. *purpureosuffusus* (Ohwi) Koyama										
Themeda triandra Forssk.					+	+	+	+	+	+

1. Shiruvani; 2. Gudalur; 3. Mudumalai; 4. Mashinaguri; 5. Pykara; 6. Parson Valley; 7. Dodabetta; 8. Avalanchè Reserve Forest; 9. Upper Bhavani; 10. Mukurty National Park.

Table – 2. Mechanical composition of Soils

(Mean values of three replicates)

Sl. Nos.	Name of the Site	Coarse Sand %	Fine Sand %	Silt %	Clays %	Textural Class
1	Shiruvani	20.4	14.2	10.8	54.5	Clayey
2	Gudalur	19.8	15.2	21.5	43.5	Clay-Loam
3	Mudumalai	24.6	15.4	23.2	36.8	Cloy-Loam
4	Mashinaguri	42.8	32.6	7.8	16.8	Sandy-Loam
5	Pykara	14.8	16.2	18.3	50.7	Clayey
6	Parson Valley	18.2	15.5	8.5	57.8	Clayey
7	Dodabetta	18.2	12.8	19.6	49.4	Clayey
8	Avalanchè	10.5	8.8	25.2	55.5	Clayey
9	Upper Bhavani	12.9	9.8	25.6	51.7	
10	Mukurty National Park	25.7	18.2	18.4	37.8	Clay-Loam

Table – 3. Physico-chemical characteristics of soils

(Mean values of three replicates)

Sl. Nos.	pH	Organic Carbon %	Bulk Density in g/cc.	Porosity %	Water Holding Capacity %	Av. N_2 %	Av. P_2O_5 %	Cation Exchange Capacity in m.e./100g
1	5.8	2.56	1.085	47.6	76.4	0.216	0.005	24.8
2	5.7	2.32	1.126	45.3	78.4	0.225	0.005	27.2
3	5.3	2.18	1.185	51.9	72.2	0.195	0.003	18.76
4	4.6	0.53	1.496	46.4	40.0	0.034	0.002	6.85
5	5.6	3.06	0.962	58.9	91.4	0.287	0.005	26.3
6	4.4	3.10	0.936	50.9	89.0	0.295	0.004	28.56
7	5.7	2.80	0.952	57.2	89.2	0.268	0.005	23.25
8	5.0	1.86	0.950	56.8	80.4	0.165	0.003	22.82
9	5.3	4.96	0.860	57.5	94.8	0.389	0.006	32.43
10	4.8	3.02	0.945	57.8	76.2	0.298	0.005	30.20

Table – 4. HCL Extract properties of soils

(Mean values of three replicates)

Sl. Nos.	Silica %	R_2O_3 %	Fe_2O_3	Total P_2O_5 %	CaO%	MgO %	Silica/R_2O_3 Ratio
1	74.60	12.50	4.20	0.282	0.508	0.384	5.9 : 1
2	78.50	14.60	5.80	0.271	0.614	0.294	5.4 : 1
3	78.30	15.60	5.10	0.301	0.516	0.287	5.0 : 1
4	85.10	16.50	7.20	0.185	0.178	0.068	5.2 : 1
5	70.50	11.50	3.90	0.395	0.682	0.401	6.1 : 1
6	76.25	19.25	6.80	0.265	0.642	0.324	3.9 : 1
7	80.40	14.50	5.60	0.249	0.532	0.310	5.6 : 1
8	78.40	14.30	4.90	0.274	0.432	0.187	5.4 : 1
9	65.60	21.10	9.40	0.416	0.925	0.516	3.1 : 1
10	69.20	18.25	8.60	0.284	0.712	0.345	3.8 : 1

Table – 5. Saturation extract characteristics of the soils

(Mean values of three replicates)

Sl. Nos.	Saturation %	Electrical Conductivity in milli mhos/cm at 25°C	Values in m.e./l						
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3	Cl^{-}
1	60.2	1.4	2.9	1.7	1.0	0.21	--	2.8	0.9
2	62.8	1.6	3.0	1.2	0.9	0.24	--	3.0	1.6
3	58.2	2.3	3.8	2.0	1.2	0.34	--	3.1	2.0
4	42.5	0.8	1.6	0.8	0.3	0.08	--	1.2	0.8
5	58.4	1.6	2.8	1.8	0.8	0.24	--	1.9	1.6
6	62.5	1.8	4.0	1.2	0.8	0.25	--	3.6	2.1
7	59.4	1.8	3.2	1.0	0.4	0.18	--	2.8	1.9
8	57.4	1.9	3.6	1.5	0.9	0.34	--	2.8	2.0
9	82.4	2.4	4.9	2.8	1.2	0.39	--	4.0	3.2
10	64.5	2.6	4.2	2.6	1.4	0.30	--	3.2	2.4

Table – 6. Chemical characteristics/composition of Waters

(Mean Values of three replicates)

Sl. Nos.	Name of the Site	Name of the Water Body	pH	Electrical Conductivity in micro mhos/cm at 25°C	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3^-	Cl^-	$SO_4^{=}$	SAR	SSP	Residual Na_2CO_3 in m.e./l
1	Shiruvani	Stream	7.2	180	0.4	0.3	0.2	0.1	--	0.5	0.3	0.2	0.338	22.2	0
2	Gudalur	Nala	7.0	160	0.5	0.3	0.1	0.01	--	0.6	0.2	0.3	0.158	11.1	0
3	Mudumalai	River	7.6	210	0.6	0.5	0.2	0.1	--	0.8	0.3	0.2	0.270	15.4	0
4	Mashinaguri	Nala	7.4	150	0.5	0.4	0.2	0.1	--	0.7	0.3	0.2	0.298	18.1	0
5	Pykara	Stream	7.1	80	0.3	0.2	0.1	0.01	--	0.4	0.1	0.2	0.200	16.6	0
6	Parson Valley	Nala	7.3	140	0.5	0.4	0.2	0.1	--	0.6	0.2	0.1	0.297	18.2	0
7	Dodabetta	Stream	7.2	80	0.3	0.1	0.1	0.05	--	0.4	0.1	0.1	0.227	20.0	0
8	Avalanchè	Stream	7.0	100	0.3	0.2	0.1	0.01	--	0.4	0.2	0.1	0.200	16.7	0
9	Upper Bhavani	Stream	7.1	160	0.4	0.3	0.2	0.06	--	0.5	0.3	0.2	0.338	22.2	0
10	Mukurty National Park	Stream	7.0	180	0.5	0.3	0.1	0.01	--	0.6	0.2	0.2	0.158	11.2	0

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