Grass Species Density and Biomass of South African Communal Property Association Farms Differing in Soil Properties

K. E. Ravhuhali
North West University, South Africa

B. Moyo
Fort Cox Agriculture and Forestry Training Institute, South Africa

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Ravhuhali, KE [*]; Moyo B[†].

*Department of Animal Science, School of Agricultural Sciences, Faculty of Natural and Agricultural Sciences, North West University, Mmabatho 2735, South Africa

†Department of Animal production, Fort Cox Agriculture and Forestry Training Institute, Middledrift 5685, South Africa.

Abstract

Attempts to monitor and mitigate rangeland deterioration in Communal Property Associations projects require some understanding of the knowledge of species composition and distribution. The study was conducted to compare the herbaceous in three selected CPAs projects (Mashung Matlala - Sandy loam, Mawela - clay loam, and Bela-Bela - clay) in South Africa. Mawela and Mashung Matlala CPAs were overgrazed. For species density, basal strike, and biomass, three transects (500m), which served as replicates, were established at two camps of each of the selected CPAs. Variation in herbaceous vegetation parameters was explored through SAS software. Clay soil type had better ($P < 0.05$) mineral concentration levels when compared to other two soil types. Pooled data from all sites revealed that, in terms of grazing value, all CPAs share the same amount (33 %) of species. *Eragrostis curvula* was dominant in clay-loam and common in clay and sandy loam. *Eragrostis rigidior* was common in clay and clay loam and rare in sandy loam. Clay soil type had the highest ($P<0.05$) DM yield (711.8 kg/ha ±54.82) and Basal strike (38% ± 3.28) and less forbs (0.46 % ± 0.98). The results suggest that there should be an improvement in the utilisation of rangelands in CPA through administering proper stocking rate in line with carrying capacity of the rangelands.

Introduction

Rangeland management affects soil condition and land productivity. Communal area rangelands are mismanaged resulting in species composition, biomass and basal cover changes. Mismanagement is characterised by excessive utilisation from heavy stocking (Lesoli, 2008) leading to bare soil that suffer top soil loss during heavy rains, and this affects species composition. The composition and distribution of plant species is influenced by soil nutrients (Critchley et al., 2002), soil type (Ravhuhali 2018) and animal management practices (Liu et al., 2012). Common Property Association (CPA) farms slightly mimic communal rangelands in utilisation practices, and there is little knowledge on the spatial variation in grass species and their distribution in relation to soil type and inherent grazing management practices in most of CPA's grazing lands in South Africa. Knowledge of soil type and grazing management effect on herbaceous composition and distribution is important in developing sustainable grazing management plans in CPA farms in South Africa. Therefore, the objective of the study was to assess the grass species density as influenced by soil in selected communal property association projects of South Africa.

Methods and Materials

Study site: The study was carried out in 3 selected CPAs (Mashung Matlala, Mawela and Bela Bela) that are 20 km from each other and differ in soil types. Mashung Matlala (Farm obtained in 2007; farm size 3404 ha; number of camps -5; soil type = Ecca-Sandy loam; altitude- 1100 m; coordinates 25° 13' 13.00'' S, 28° 24' 07.05'' E; current number of animals 905; Previous GC 6 ha/LSU). Mawela (Farm obtained in 2008; farm size 1457 ha; number of camps -16; soil type = Hutton-Clay loam; altitude- 1069 m; coordinates 24° 55' 43.9'' S, 28° 10' 34.48'' E; current number of animals 400; Previous GC- 6.5 ha/LSU). Bela-Bela (Farm obtained in 2002; farm size 308 ha; number of camps -5; soil type = Hutton-clay; altitude- 1121 m; coordinates 25° 05' 10.93'' S, 28° 14' 27.28'' E; current number of animals 33; Previous GC 5.4 ha/LSU). Mashung Matlala and Mawela CPAs were heavily grazed, while Bela-Bela CPA was moderately grazed. The areas received rainfall ranging from 500-600 mm/annum, winter and summer temperature of 5°C, and 35° C, respectively. The vegetation type is Springbokflakte thornveld with acacia species dominating the area.

Biomass determination: In three camps per CPA three 500 m transects, 50 m apart and replicated three times per camp were used. At 100 m intervals, $1m^2$ quadrats were used to collect grass species for biomass and grazing capacity (van Oudtshoorn 2014). *Grass species identification*: In the same transect species were identified and counted within 10cm radius at every 50m intervals. Height, diameter, basal cover, life form, grazing value and ecological status of the species was recorded. Occurrence of species was classified as follows: dominant->13%, common- >3-13%, rare 1-3 % and present- <1%. *Soil samples*: Samples were collected at each 100 m interval in all transects at 0-15 depth for minerals, and pH determination (Agrilasa, 1998). *Statistical analysis*: One-way ANOVA was used to analyse the data.

Results

Species frequency: Twenty-seven grass species were found across all soil types with perennials dominating (89 %) (Table 1 & 2). Grass species grazing value distribution among soil types was equal (33 % / soil type). In terms of classification of species according to occurrence, *Eragrostis curvula* was dominant in clay-loam and common in clay and sandy loam. *Eragrostis rigidior* was common in clay and clay loam and rare in sandy loam. *Aristida congesta* was rare (P<0.05) in clay loam and equally dominant in clay and sandy loam (P>0.05). *Digitaria eriantha* was dominant (P<0.05) (16.68 %) in sandy loam compared to clay loam and clay (0 %). *DM yield, Basal cover, desirability frequency groups, forbs and grazing capacity*: Clay soil type had the highest (P<0.05) DM yield (711.8 kg/ha ±54.82) and Basal strike (38% ± 3.28) when compared to all other soil types. Forb distribution was less in clay soil than in sandy loam soil type. Clay soil type had better (P <0.05) grazing capacity when compared to both clay loam and sandy loam which were similar. Clay loam and sandy loam had the highest (P<0.05) frequency of high grazing value as compared to clay. *Height and Diameter*: *Eragrositis curvula*, *Themeda triandra*, and *Aristida congesta* had similar height (P>0.05) across all soil types. *Hyparrhenia filipendula* and *Panicum maximum* were the tallest (P<0.05) in clay soils. *Eragrostis Lehmanniana* was the tallest (P<0.05) in sandy loam when compared to other soil types which were similar. *Eragrositis curvula* and *Themeda triandra* had the same (P>0.05) diameter across all soil types. *Aristida congesta* and *Eragrostis Lehmanniana* had a broader (P<0.05) shoot in sandy loam than in both clay and clay loam. *Cymbopogon. pospischilii* had higher shoot diameter than in clay soil type. Clay soil had the highest (P<0.05) concentration of C, K, Ca, Mg Cu, Zn when compared to two other soil types which also differed significantly from each other. Clay soil had pH value of 6.40 ± 0.05. Clay loam had the highest (P<0.05) concentration of Mn, followed by clay (23.1 mg/kg ± 0.293) and sandy loam (15.6 mg/kg ± 0.293).

Table 1: Life form, grazing value and abundance of grass species based on mean values in three soil types (Clay-loam, Hutton, Sandy-loam)

Species	Common name	Life form	Ecological status	Grazing value	Clay Loam	Hutton	Sandy loam
Cymbopogon pospischilii	Giant Turpentine	Per	Inc i	LP	C	+	-
Cymbopogon caesius	Turpentine	Per	Inc iii	LP	+	R	-
Eragrostis curvula	Wheeping love grass	Per	Inc ii	HP	D	C	C
Urochloa mosambicensis	Bushveld signal grass	Ann	Inc ii	MP	D	C	-
Heteropogon contortus	Spear grass	Per	Inc ii	MP	C	D	+
Aristida congesta	Spreading Three-awn	Per	Inc ii	LP	R	D	D
Aristida stipitata	Long-awned grass	Per	Inc ii	LP	-	+	+
Aristida diffusa	Iron grass	Per	Inc ii	LP	-	-	+
Panicum maximum	Guinea Grass	Per	Dec	HP	C	C	D
Cynodon dactylon	Couch Grass	Cre Per	Inc ii	HP	R	-	+
Melinis repens	Natal Red Top	Per	Inc ii	LP	+	R	R
Eragostis rigidior	Curly leaf	Per	Inc ii	MP	C	C	R
Themeda triandra	Red grass	Per	Dec	HP	R	C	R
Hyparrhenia filipendula	Fine Thatching grass	Per	Inc i	MP	+	D	-
Schmidtia pappophoroides	Sand quick	Per	Inc i	HP	-	+	R
Inschaemum fasciculatum	Hippo grass	Per	Inc i	MP	-	R	-
Hyperthelia dissoluta	Yellow Thatching grass	Per	Inc i	LP	-	+	-

Perotis patens	Cat's tail	Ann	Inc ii	LP	-	-	C
Setaria sphacelata	Bristle grass	Per	Dec	HP	-	-	R
Digitaria eriatha	Finger grass	Per	Dec	HP	+	-	D
Eragrostis Lehmanniana	Lehmann's love grass	Per	Inc ii	MP	+	+	C
Trungus berteronianus	Carrot-seed grass	Per	Inc ii	LP	-	-	+
Pogonarthria squarrosa	Herringbone grass	Per	Inc ii	LP	+	-	+
Eragrostis superba	Saw-tooth love grass	Per	Inc ii	MP	+	-	-
hyparenia hirta	Thatching grass	Per	Inc i	MP	-	-	+
Poa Annua	Annual bluegrass	Ann	Inc ii	HP	+	-	-
Enneapogon cenchroides	Nine-awned grass	Per	Inc ii	MP	-	-	+
Forbs					C	+	C

Per= perennial, Cre Per= creeping perennial grass, Inc i= increaser i, Inc ii= increaser ii, Inc iii= increaser iii, Dec= decreaser, LP=low palatable, MP=Medium palatable, HP=High palatable, D=dominant (>13%), C=common (>3-13%), R=rare (1-3%), P= present (<1%)

Table 2: Grass species composition (%) based on the frequencies of occurrence of dominant and common grass species in all soil types.

	Soil type			
Species	Clay-loam	Hutton	Sandy-loam	SE
C. pospischilii	6.85^{a}	0.40^{b}	-	0.40
E. curvula	15.67^{a}	4.95^{b}	3.94^{b}	3.94
U. mozambisens	34.54^{a}	4.44^{b}	-	3.89
H. contortus	11.65^{b}	27.12^{a}	0.91^{c}	0.91
A. congesta	3.34^{b}	18.43^{a}	24.44^{a}	3.34
P. maximum	12.18^{a}	8.34^{b}	30.61^{a}	8.34
E. rigidor	7.54^{a}	4.95^{a}	2.66^{a}	2.21
T. triandra	2.84^{a}	6.37^{a}	2.47^{a}	2.72
H. filipendula	0.26^{b}	16.56^{a}	-	0.26
P. patens	0.29^{b}	-	4.06^{a}	0.91
D. eriantha	0.29^{b}	-	16.68^{a}	0.30
E. lehmanniana	0.26^{b}	0.32^{b}	6.32^{a}	0.26

^{abc} :Shared lower-case superscripts letters within a row indicate a non-significant difference in abundance among soil types (P > 0.05).
SE: standard error

Discussion

Species frequency and distribution: Understanding factors influencing species composition is essential for sustainable utilisation of natural resources (Thammanu et al., 2021). These include soil properties, moisture and other anthropogenic factors such as grazing habit and stocking rate (Sollins 1998; Ravhuhali et al 2020). Though Mashung Matlala CPA (Sandy loam soil type) had better species composition, together with Mawela clay loam soil type they were overgrazed as inferred from corresponding stocking and the grazing capacity of the respective overgrazed CPAs. The mismanagement of rangelands normally has an influence on the herbaceous layers of affected areas. *Panicum maximum* was common across all soil types, and its prevalence in both overgrazed areas might have been influenced by the growing conditions of the species. van Oudtshoorn (2014) stated that *Panicum maximum* favours canopy understory layer where there is little or no access by ruminants. A similar observation was reported by Ravhuhali (2018). *Themeda triandra* dominated Bela-Bela CPA (clay soil). The presence of *Themeda* species in clay soil is an indicator of good veld condition (Foran et al 1978). This species has higher grazing value and is regarded a palatable grass for ruminants. Novellie and Kraaij (2010) stressed that *Themeda,* a decreaser species can increase only to better grazing management practices with frequent burning. Better grazing management practices normally improves veld condition and that lead to a high carrying/grazing capacity as seen in clay soil and high livestock production. *Perotis patens* was common in sandy loam. This species is known as a pioneer and aggressive and its presence is an indicator of poor grazing management practices (van Oudtshoorn 2014). *Cynodon dactylon* was not found in clay soil and rare in clay loam and present in sandy loam. This highly palatable increaser species was expected in heavily grazed areas due to its poor accessibility by large herbivores (Ravhuhali 2018) due to its creeping growing habit and height (van Oudtshoorn 2014).

Biomass, basal strike and frequency of desirability groups: Even though clay soil had lower high grazing value species, it however, had higher biomass, basal strike, less forbs and better grazing capacity. Good management and fertility status of clay soil might have contributed to better biomass when compared to other soil types. Together with heavy grazing, less concentration of minerals such as phosphorus and potassium in clay loam and sandy loam soil type might have significantly decreased biomass production (Ohmunn 1981). The increase of pioneer species such as forbs in both sandy loam and clay loam might be due to mismanagement of the land. van Oudtshoorn (2015) stressed that overgrazed areas are a breeding ground of pioneer species which are of little or no ecological value to livestock. In line with the results from this study, less forbs were expected in clay soil type. The common forbs available in sandy loam and clay loam were *Conchorus tridens L., Amaranthus spinosus L., Sida cordfolia L., Aloe and Tragia rupestris*. Species such as aloe can be an invasive if left unattended and it can be a threat to forage availability to livestock (van Wky and Smith 2014).

Height and diameter: Variations in grass species height was observed among species. Most of grass species (*Cymbopogon pospischilii*, *Panicum maximum*, *Hyperrhenia filipendula*) height were within the range reported by Oudtshoorn (2014). Ravhuhali (2018) reported the same height on *Cymbopogon pospischilii*. The height variation among species was expected due to their genetic make-up. Msiza et al (2021) stated that the genetic variation among grass species contribute to the differences in the morphological patterns of grass species. *Urochloa mosambicensis, heteropogon contortus* and *Hyperrhenia filipendula* in clay soil type had a wider shoot/tuft than the same species in other two soil types. Diameter of turf is normally influenced by the number of tiller available, and this gives plant better mechanical support (dos Santos Oliveira et al 2019). Laidlaw (2005) and Mganga et al (2016) stated that tillers have a direct link to the diameter of the plant, and are a crucial adaptability plant parts in grasses as they aid plant in overcoming both biotic and abiotic stress and assist in protecting top soil.

Soil nutrients: Soil fertility influences species composition, distribution, yield and nutritive value (Nadeau and Sullivan 2015). There was variation in soil mineral concentration with soil type. Higher nutrient concentrations were found in clay soil type compared with other soil types. As stated by Blank et al (2007), when the area is over grazed, it normally reduces the availability of C, and minerals such as Ca, Na and Mg in the soil which may result in reduction of the nutritional status of the soil as seen in the clay loam and sandy loam soil types in this study. Oudtshoorn (2014) highlighted that low profile and shallow soils with less nutrients can only accommodate species such as pioneer with less nutrient requirement from the soil. Clay soil had better pH value of 6.40. Viljoen (2012) indicated that pH value found in clay soil type can be regarded the best for most grass species as it influences the translocation of nutrients to the plant and it can affect the interaction among nutrients. Lond et al (2006) emphasized the relationship between pH and nutrients in such that some of minerals tend not be available to plant when the soil pH is low whereas some can be more available and become toxic to the plant.

Conclusion

Mismanagement of CPA grazing lands led to overgrazing which caused a decrease in palatable species. There was less biomass and basal cover in mostly heavily grazed CPAs with less carrying capacity and high grazing capacity. Most heavily grazed areas compromised the availability of the nutrients in the soil. The results suggest that there should be an improvement in the utilisation of rangelands in CPA through administering proper stocking rate in line with carrying capacity of the rangelands. There is also a need to assess the nutritive value of rangelands in these CPAs farms in South Africa.

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