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The Influence of Plant Growth Conditions on Rangeland Management in Kordofan Region

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ABSTRACT

This study was conducted for two consecutive years (2008 and 2009) on the natural rangeland of greater Kordofan region at three sites; the main objective was to investigate the variation in rangeland vegetation as indicated by different growth conditions. The fieldwork was carried out at the start of rainy seasons and seed setting stages in the three locations. Results showed that the biomass production at Dilling showed highest values followed by Demokeya and then Bara. Plant composition in Dilling, showed highest values followed by Demokeya and then Bara. Litter % in Dilling showed lowest values. The variations investigated by the study justify differential management prescriptions that cater for activities such as seed broadcasting and enrichment of range with certain plant species. Vegetation cover% was lowest in Bara followed by Demokeya and then Dilling. Bare soil incidents were higher in Bara and Demokeya than in Dilling. The crude protein content of herbaceous biomass was higher in Bara and Demokeya (sandy soil) than in Dilling (clay soil). The crude fiber content (CF) decrease or increase according to the plant age in the three sites. The high ash content was in Dilling compared with Bara and Demokeya. However, in time of sampling, the differences were recorded in ash but their values decreased by the plant growth. The differences in dry matter between the seasons and among sites were minor. The grasses were the dominant plants in the three sites. The similarity index indicated that there was minor similarity recorded between Bara and Demokeya (45%), followed by Demokeya and Dilling (30%) and dissimilarity was between Bara and Dilling (3%).

INTRODUCTION

In Sudan, livestock depends mainly on range land plants all year round. Forage quantity and quality are major determinants of carrying capacity and performance of grazing animals (Valentine, 1990). Greater Kordofan region is rich in rangeland resources. Nonetheless, the economic planning and development of rangelands is hindered by lack of proper assessment. Variations in growth conditions known to lead to different growth performance and hence different management implications. There is a need for detailed investigation of these variations in order to consider in range management process.

Natural range supports and provides feed for large number of livestock, which plays a vital role in national economy through provision of animal products for local consumption and foreign exchange.

The Sudan ranks at the top of African and Arab countries in livestock owning. The latest estimates of the livestock population of Kordofan (MOA, 2007) indicated that there are now 31 million heads, composed of 8, 12.5, 8, and 3 million of cattles, sheeps, goats and camels respectively. Totaling about 13 million animal units. Climatic features, soils and other factors like diseases and parasites, govern the management of flocks and the rangeland utilization (ARC, 2007).

Most of the livestock in the Kordofan are kept under extensive management systems and are fed exclusively on range land resources. This practice is facing considerable difficulties due to many interacting factors. Other factors adversely affecting nomadic systems are the seasonal fires, over grazing and drought spells and desertification (Abdel, 1994).

According to the agricultural survey for season 2008-2009, cultivated area in the State was estimated as 4.2 million hectares, while the area of rangeland was estimated at 14 million hectares (RPA-NKS, 2008). Buderson (1984) reported that only 6-10% of the net primary production of range was consumed by livestock on annual basis. In African countries, with similar ecological conditions, this percentage reaches up to 25 and 35 %. Annual grasses and perennials become completely dry and display a reduction in growth and nutritive value during the dry season (Khalid, 1984). The nutritive value of pasture and range in the Sudan is greatly affected by seasonal changes in the summer (dry period). The moisture content, crude protein and total soluble sugars decrease and the plants tend to be fibrous with a high ash and a relatively poor nutritive value (Elhag, 1985).

MATERIALS AND METHODS

Sampling design

Three range sites were selected in each of the three geographical areas, within each site in an area of 1kmx1km was marked based on Relevé (Greig-Smith 1979 and Barbour et al 1987) each containing three smaller circular plots of a radius of 200m, marked

based on the minimum area principle. Within each sampling plot 20 quadrates was selected randomly from the plot centre. Sampling was done for two years (2008 and 2009). Biomass and forage quality was assessed as follows:

- The first 20 quadrates at the start of rainy season.
- The second 20 quadrates at the seed setting stage.

Ground vegetation measurements

Vegetation measurements were done to collect data for the following:

- Herbaceous biomass
- Herbaceous cover
- Dominant species

Herbaceous biomass

Forage yield is the weight of forage produced at a given area during a certain period of time (Darrag, 1996). Forage yield helps in determining carrying capacity and has a link with range condition. Biomass was determined by using direct sampling methods. Direct methods involve techniques that weigh or estimate the actual biomass of plants in quadrates. Sampling was made by cutting the herbaceous vegetation at 2.5-3 cm above ground level using a pair of scissors. The harvested plants species were placed in paper bags. The plant materials in the bags were oven dried at 70° C for 48 hours (AOAC, 1990). Biomass value was subsequently converted to a grams / m².

Herbaceous cover

It is the percentage of the quadrat area covered by vegetation canopy. Herbaceous cover helps in determining range condition, production and soil protection (Abuswar, 2007). At each site, there were about 20 measurement points and 20 quadrates at each visit were taken to create 40 quadrates per site. Herbaceous cover percentage was estimated for each quadrat and recorded. The average covers of all quadrates used to determine total ground cover for each site by the number of quadrat taken at each site. Ground cover percentage was estimated by looking to the quadrat from above and estimating approximately the covered part of the quadrat.

Climatic data

Measurements of climate variables (air temperature, relative humidity, soil moisture and soil temperature) were performed by instruments supplied with sensors for each one of the above mentioned climatic factors. These instruments were installed in the three study areas by Lund University (Sweden) as part of CARPOAFRICA project activities. All instruments were intercalibrated at location before and after each

growing season. Sensors were mounted on a 6-m aluminum mast, and data was collected using data loggers that recorded data every 30 min (Table 1).

Dominant species

Dominant plants are species or groups, which by means of their number, coverage or size, have considerable influence or control upon the condition and existence of associated species (Frost and Ruyle, 1993). In each quadrat, three dominant species were recorded according to their coverage.

Proximate Chemical composition

The sampling for chemical composition was done for the harvested plant materials at two times of stage growth (Start of rainy season and seed setting stage).

$$J \text{ class} = \frac{A}{A + B + C}$$

Where:

J class = Jaccard similarity index.

Jaccard similarity index range from 0 (no similarity) to 1 (100% similarity).

A = number of species shared by the two compared sites.

B = number of species unique to the first site.

C = number of species unique to the second site.

Data analysis

Excel software program was used to organize and tabulate the collected data. Rangeland standard assessment equations were used.

RESULTS AND DISCUSSION

Cover and biomass of herbaceous plants

Results of Range measurement in terms of cover percentages at different sites were presented in Table (1) and table (2). In table (1), there were differences in plant cover among the three sites (Bara, Demokeya and Dilling) early in the rainy season. The results of plant cover for Bara, Demokeya and Dilling were 15.25%, 36.25% and 45% respectively, and in the seed setting were 16.25%, 47% and 72% respectively for the first season (table 1). The results of plant cover for Bara, Demokeya and Dilling early in the rainy season were 40%, 14.5% and 24.2% respectively, and in the seed setting stage were 14.25%, 37.75% and 28% respectively (table 2). It was clear that in the first year, the plant cover in Dilling had higher values than Bara and Demokeya. These differences may be attributed to severe grazing pressure in Bara and Demokeya. The biomass production had higher values in Dilling than in Bara and Demokeya. The biomass production in

Each sample of selected plant materials were dried to constant weight. These samples were then analyzed for Crude Protein (CP), Crude Fiber (CF), (Ash), Nitrogen Free Extract (NFE), and Organic Matter (OM). The method for the chemical analysis followed that of the (AOAC, (1990).

Similarity index

The method compares similarity of species composition between each pair of sites based on presence or absence of the species after (Chao *et al.*, 2005). To calculate floristic similarity, a checklist of herbaceous plants in each site was obtained. Jaccard similarity index was used because it is the most commonly used index and is widely used in previous studies examining biotic homogenization (Olden and Rooney, 2006).

Dilling in the seed setting stage was 300.54g/m² followed by Demokeya 59.8g/m² and finally Bara 38.02 g/m² (table 1). In year two, early in the rainy season and in the seed setting stage, Dilling recorded 70.91 g/m² and 114.43 g/m² respectively followed by Demokeya 18.62g/m² and 53.48 g/m² and finally Bara 21.71 g/m² 16.17 g/m² respectively (table 2). The variations in biomass production along the three sites may be due to the variation in rainfall, soil types and grazing. Litter% in Dilling had lower values than Bara and Demokeya especially in year one. Litter% in Dilling recorded 4.25%, 8.5% and in Bara 5.5%, 10.5% and in Demokeya 5.5%, 12.5% in the early rainy season and in the seed setting stage respectively. The low litter % in Dilling may be attributed to insufficient utilization of range. The results were in line with (Lazim, (2009). The amount of litter in a pasture is a function of forage growth, harvest and decomposition (Coleman, 1992).

Moreover, Bara and Demokeya had intensive grazing pressure compared with Dilling according to the observations during the study period. That is reflected in declining vegetation cover in Bara and Demokeya and increase of bare soil %. Bara had the highest values in bare soil in two years (table 1 and table 2). Bara recorded 79.25%, 63.5% and 54.25%, 71%, followed by Demokeya 58%, 41% and 79.5%, 50%; finally Dilling recorded 49.75%, 19.5% and 50.75%, 58.75% in the early part of the rainy season and in the seed setting stage respectively. Similarly, other studies showed that, standing and fallen litter mass and vegetation cover generally decrease while amount of B.S (bare soil) increases with increased grazing pressure. The Grazing can increase B.S percentage. The results of this study are in close agreement with the findings of Naeth *et al.* (1991) and Lazim (2009) who observed that standing and felling litter mass generally decreased while bare soil increased with increasing grazing intensity.

Generally, in this study in two years, plant cover and biomass production had higher percentage in Dilling (South Kordofan) than Bara and Demokeya

(North Kordofan). That is evident by the increase in plant cover and biomass production in Dilling while the bare soil% and litter% were increased in Bara and Demokeya. This may be attributed to the lower livestock numbers in the start of rainy season and seed setting stage in Dilling. WASRP (1985) reported that there is low density of livestock in South Kordofan particularly during the wet season.

Management implications are needed including the facilitation the process of animal transition from the north to the south of the region and this process may be helpful to avoid the severe soil erosion hazard in the north. Reid et al. (1958) reported that when the bare soil percent is more than 51% that means there is severe erosion hazard.

Proximate chemical composition and dry matter of herbaceous plant

The results in table (3) indicated that Bara and Demokeya had higher crude protein CP content than Dilling. Demokeya recorded 8.64%, 3.20%, Bara 8.41%, 2.95% and Dilling 4.12%, 4.06% in early rainy season and seed setting stage respectively. The variation of crude protein content between Bara and Demokeya compared with Dilling may be attributed to the variation in species composition. Moreover, in Dilling, the course annual grasses were dominant such as *Hyparrhenia confines* (Umraggio) and *Cymbopogon Nervatus* (Nal) which are characterized by low crude protein content. The variation in CP content among plots may be attributed to the variation in species composition. This was in accord with the findings of (Lazim, (2009) who stated that the variation in crude protein content among plots attributed to the variation in species composition.

Crude fiber content in Bara was 41.01%, 40.01%, Demokeya 34.37%, 42.38% and Dilling 35.39%, 36.74% in early rainy season and seed setting stage respectively. The increase in crude fiber content in Demokeya and Dilling from start of the rainy season to the seed setting stage may be due to plants maturity. At sampling the differences in CP and CF among the three sites were cleared and their differences were observed in the different plant stage of growth, whereas in early stage of growth low CF and high CP is noticed. This result agreed with findings of Lazim, (2009) and Butler and Baily (1973) who stated that at early stage of forage leaves content, high protein and low fiber was recorded. Anon (2004) recoded sharp decline in CP and increase in CF at maturity stage in South Kordofan. When livestock return to south Kordofan at the start of the dry season the grasses have already lost much of their nutritive value (WASRP, 1982; El-Hag, 1992).

The ash content in Bara was 9.3%, 7.30%, Demokeya 9%, 7.37% and Dilling 11%, 8.78% in early rainy season and in seed setting stage respectively. The variation in ash content between Bara and Demokeya compared with Dilling may probably be due to the variation in species composition. The variation in ash content between early rainy season and seed setting stage in the same site may be attributed to the mineral concentration dynamics from rainy season to

the dry season. The results agreed with (Lazim,(2009) who reported the variation in mineral content in protected plots and open plots in the late rainy season and mid dry season which was attributed to the variation in species composition and mineral concentration dynamics from rainy season to the dry season.

The dry matter (DM) in Demokeya is 96.57%, 96.62%; in Bara 96.06%, 96.37% and in Dilling 96.13%, and 95.86% respectively. The results indicated that the differences in dry matter between the seasons and among sites were minor (table3).

Generally, in the dry season the moisture content, CP, soluble sugar decrease and the plant tend to be fibrous and with relatively poor nutritive value (Fatur and Abdelati, 2007).

Dominant species

The results in table (4), indicated that the dominant plants in Bara were *Cenchrus biflorus* (Haskaneet Khashen), *Fimbristylis dichtomo* (Umfesaseyat) and *Aristida spp* (Gaw).In Demokeya, the dominant plants were *Echinochloa colona* (Difra), *Eragrostis termula* (Bano) and *Cenchrus biflorus* (Haskaneet Khashen).

The dominant plants in Dilling were *Hyparrhenia confines* (Umraggio), *Newtonya* (Newtonya) and *Cymbopogon Nervatus* (Nal). The results indicated that the grasses were dominant in the three sites. However, tall course annual grasses were dominant in Dilling. The results indicated that *Cenchrus biflorus* (Haskaneet Khashen) was dominant in both Bara and Demokeya. Dominance may be attributed to response to site characteristics, time and pattern of utilization. The dominance of *Cenchrus biflorus* (Haskaneet Khashen) may be attributed to its palatability to the animals and can be transferred by animals from one place to another. The dominance of *Hyparrhenia confines* (Umraggio) and *Cymbopogon Nervatus* (Nal) may be due to their ability to compete with other herbaceous and their low palatability. The dominance of *Echinochloa colona* (Difra) may be attributed to its ability to produce high quantity of seeds and palatability which helps seeds to be transferred by animals. Furthermore, there was absence of forbs dominance in the three sites. However, reseeding of high productive and palatable forbs could contribute positively in range improvement in the three sites. Strang, (1980)stated that the main problem associated with rangeland management is over-stocking, leading to progressive reduction in biomass production and plant cover. This result may indicate the need for a special consideration in the management process at the three study areas.

Similarity index

The results of similarity index of herbaceous cover in the three sites were presented in table (5). The results indicated that there was minor similarity between Bara and Damokeya (45%); followed by Damokeya and Dilling (30%), and dissimilarity between Bara and Dilling (3%).The similarity or dissimilarity is a reflection

of variation in topography and soil properties among the different sites. The dissimilarity between Bara and Dilling may be due to increasing distance between the two sites and variation in topography, soil properties and rainfall amount. This finding agrees with (McKinney,(2004) and (Nasra,(2008) who found that floristic similarity decreases exponentially with increasing distance between localities. It is clear that there was dissimilarity in the species composition across the three sites. This fact should be considered in management activities related to range plants enrichment.

CONCLUSION

Climatic data verified that there were differences in growth conditions that may influence growth performance of range plants, which may imply different management implications on rangeland.

Further studies are needed to cover the best methods for range improvement in each of the three sites.

Table (1): Average variation of Relative humidity (RH), Soil moisture content (SM) and Temperature (C) along the three sites (2008)

Site	Growing season	RH (%)	SM (%)	Temperature(C)
Bara	Early rainy season			
	Seed setting	29.02	14.2	31.70
Demokeya	Early rainy season	48.79	15.1	30.00
	Seed setting	44.42	27.5	27.73
Dilling	Early rainy season	60.83	29.1	26.23
	Seed setting	70.09	49.7	25.35
	Seed setting	80.89	52.2	23.97

Table (2): Percentage of plant cover, Litter, Bare soil and biomass (g/m²) along the three sites early and late in the rainy season (2008) and (2009)

Site	Growing season	%Plant	%Litter	%Bare soil	Biomass (g/m) ²
Bara	Early rainy season(2008)	15.25	5.5	79.25	6.48
	Early rainy season(2009)	40	5.25	54.25	21.71
	Seed setting(2008)	26.25	10.25	63.5	38.02
	Seed setting(2009)	14.25	14.25	71.5	16.13
Demokeya	Early rainy season(2008)	36.25	5.5	58	59.8
	Early rainy season(2009)	14.5	6	79.5	18.62
	Seed setting(2008)	47	12	41	106.5
	Seed setting(2009)	37.75	12.25	50	53.48
Dilling	Early rainy season(2008)	46	4.25	49.75	15.98
	Early rainy season(2009)	24.2	26	50.75	70.91
	Seed setting(2008)	72	8.5	19.5	300.54
	Seed setting(2009)	28	13.25	58.75	114.43

Table (3): Dry matter and proximate chemical composition (Ash, Crude protein and Crude fiber) Percentage of herbaceous plant in the three Sites (2008)

Site	Growing season	DM (%)	Ash (%)	Crude protein (%)	Crude fiber (%)
Bara	Early rainy season	96.09	9.3	8.41	41.01
	Seed setting	96.37	7.30	2.95	40.01
Demokeya	Early rainy season	96.57	9.0	8.64	34.37
	Seed setting	96.62	7.37	3.20	42.38
Dilling	Early rainy season	96.13	11.0	4.12	35.39
	Seed setting	95.86	8.78	4.06	36.74

DM=Dry Matter

Table (4): Dominant species in the three sites

Site	Dominant species	
	Latin name	Local name
Bara	<i>Cenchrus biflorus</i>	Haskaneet Khashen
	<i>Fimbristylis dightomo</i>	Umfesaseyat
	<i>Aristida spp</i>	Gaw
Demokeya	<i>Echinochloa colona</i>	Difra
	<i>Eragrostis termula</i>	Bano
	<i>Cenchrus biflorus</i>	Haskaneet Khashen
Dilling	<i>Hyparrhenia confines</i>	Umraggo
	<i>Cymbopogon nervatus</i>	Nal
	<i>Newtonya</i>	Newtonya

Table (5): Similarity index among the three sites (2008)

Site	Bara	Demokeya	Dilling
Bara	#	45%	3%
Demokeya	45%	#	30%
Dilling	3%	30%	#

COMPETING INTERESTS

None

AUTHORS' CONTRIBUTION

Research activities:

1. Reconnaissance survey for range condition in South Darfur State.
2. Assessment of range condition in South Darfur State and North Darfur State.
3. The Influence of plant growth conditions on rangeland management in Kordofan region.
4. Assessment of range condition in White Nile state.

5. Study the effect of sowing methods on seed yield and forage biomass of cowpea (*Vigna unguiculata*) under irrigated White Nile State condition.
6. Effect of seed rate on forage potential of sorghum varieties under White Nile State and West Darfur State condition.
7. Effect of spacing on forage biomass and seed productivity of Cowpea (*Vigna unguiculata*) in White Nile State.
8. Effect of seed rate on plant performance of Abunigagira (*Alysicarpus ovalifolius*) Under Rainfed in Semi-arid zone of Sudan, North Darfur.
9. Effect of seed rate on forage yield of the recommended sorghum hybrid "Mabrouk".
10. Effect of intra row spacing on growth and yield of BT cotton in Elsuki .
11. Introduction of perennial cultivars to alleviate fodder bottlenecks in Sudan.
12. The impact of intra raw spacing on the growth and yield of sorghum (Hagen Dra 2 and Wafer) under irrigation system

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