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THE IMPACT OF SOIL TYPE ON PRODUCTIVITY AND CARRYING CAPACITY OF ELSEMEIH RANGELAND OF NORTH KORDOFAN STATE, SUDAN

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ABSTRACT

This research was conducted at Elsemeih area during the period (2013-2014). The objective was to study the impacts of soil types and rainfall parameters on productivity and carrying capacity of the rangeland in the study area. The vegetation measurements were carried out using quadrate methods. Systematic random samples techniques were used. The number of line transects were identified according to point of diminishing return method. Accordingly, (40) lines transect (20 lines for each season) were made. Each twenty lines were further divided in to ten lines transects for the sandy soil and (10) line transects for the clay ones for both seasons (2013 and 2014). The data were processed and analyzed using statistical package of science soft ware (SPSS). T-test statistical analysis method was used. The results showed that, there were significant differences ($P<0.0001$& $P<0.05$) in vegetation cover and productivity between sandy and clay soil in the two seasons, respectively. The average percentages of vegetation cover were 50% and 62% for sandy and clay soils, respectively. Whereas the average productivity were 0.5625 tan/ha and 0.615 tan/ha for sandy and clay soils, respectively. These differences were attributed to the environmental factors such as shortage and fluctuations of rainfall of dry seasons and manmade activities such as trees cutting, overgrazing, over cultivation and using plough in the fragile soils. Despite the two soils face the same challenges but the results showed that, the deterioration of productivity and the impacts on carrying capacity were highly in the sandy soils rather than the clay ones.

KEYWORDS: Soil types, rainfall parameters, productivity, carrying capacity.

INTRODUCTION

In the management and improvement of grasslands, the administrators and the grassland managers are faced with certain pertinent questions, where grassland is producing up to the capability of the particular site, if not, what is the highest ecological level would be, which the site might eventually produce, what ecological status of the present cover is in relation to the optimum, how the optimum may be achieved and what visible criteria may be used in judging whether a particular grass cover is undergoing a change in a desirable direction or otherwise?. The reconnaissance of grasslands, therefore, aims at studying the various grasslands communities as occurs in varied climatic conditions and recording these changes in relation to the ecological factors of the environment (whether natural or introduced by man) (Stoddart *et al.*, 1975). Assessments help to identify areas where problems occur and areas of special interest. Land managers can use this information and other inventory and monitoring data to make management decisions, which, in turn, affect soil quality. When assessments or comparisons are made, the rangeland ecological site description is used as the standard. For the soils associated with a given ecological site, the properties that change in response to management or climate are used as indicators of change (USDA, 2001).

Physical factors determine the kind of vegetation available, the manner and degree of possible use. Physical features include climate, soil and topography. Together they cause grass to grow in the plain, forests to grow in the mountains and shrub to grow in the deserts. Plant communities have constantly changed through geological time. At any particular time, the flora available to constitute the vegetation is a product of the climate, soil, and organisms available. The composition of the vegetation, however, is determined by grazing pressures from major herbivores. Soil is produced by the action of climate and vegetation upon the parent rock materials, (Stoddart *et al.*, 1975). Rangelands health and soil quality are interdependent. Rangelands health is characterized by the functioning of both the soil and the plant communities. The capacity of the soil to function affects ecological processes, including the capture, storage, and redistribution of water; the growth of plants; and the cycling of plant nutrients. For example, increased physical crusting decreases the infiltration capacity of the soil and thus the amount of water available to plants. As the availability of water decreases, plant production declines, some plant species may disappear, and the less desirable species may increase in abundance (Fashir, 2008). Changes in vegetation may precede or follow changes in soil properties and processes. Significant shifts in vegetation generally are associated with changes in soil properties and processes and/or the redistribution of soil resources across the landscape. In some cases, such as accelerated erosion resulting in a change in the soil profile, this shift may be irreversible, while in others, recovery is possible **(**USDA, 2001, Fashir, 2014 and Salih *et al.*, 2019).

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, sustain plant and animal productivity, maintain or enhance the quality of water and air, and support human health and habitation. Changes in the capacity of soil to function are reflected in soil properties that change in response to management or climate. (IASC, 2010: and USDA, 2001).Changes in soil quality that occur as a result of management affect: the amount of water from rainfall and snowmelt that is available for plant growth; runoff, water infiltration, and the potential for erosion, the availability of nutrients for plant growth, the conditions needed for germination, seedling establishment, vegetative reproduction, and root growth and the ability of the soil to act as a filter and protect water and air quality (Donkor, *et al*., 2001 IASC, 2010; and USDA, 2001). Soil quality on rangelands can affect plant production, reproduction, mortality, erosion, water yields, water quality, wildlife habitat, carbon sequestration, vegetation changes, establishment and growth of invasive plants and rangeland health **(**USDA, 2000).Thus, the current study is aiming to study the impacts of soil types and rainfall on carrying capacity and productivity at Elsemeih area of North Kordofan State, Sudan.

RESEARCH METHODOLOGY

Study area

This study was conducted during the years 2013-2014 at Elsemeih area of North Kordofan State which lies approximately between longitude (27.05-32^0) East and latitude (11.15 - 16.45^0) North. The average elevation is149 m above the sea level (Ministry of information, 2011).The climate of Elsemeih area is low rainfall woodland savannah with an average rainfall of 380 mms, the high temperatures range from (22-30^0 c) and the low temperatures range from (13-24^{0}c).The average yearly evaporation is about (1800 mm).The moisture range from 30% to73%.

Sampling procedure

The sampling procedure for herbaceous cover was based on the species area curve method for the determination of the number of samples to be taken. In this method the number of line transects were identified according to point of diminishing return (Salih, 2008). Accordingly, (40) lines transect (20 lines for each season) were made. Twenty samples in season 2013 (ten line transect for the sandy soil and ten line transects for the clay ones) and other twenty samples in season 2014 (ten line transects for sandy soil and ten line transects for the clay ones) were done. The number of species determined in each sample was recorded in the vertical axis of the curve. When the number of samples completed twenty no new plant species was appeared. This point called "the point of diminishing returns" after which no species was recorded.

Measurements

Vegetation cover

Vegetation cover was determined by locating 1X1m quadrate. It was estimated as a visual percentage of the quadrate covered by plant material (Bonham, 1989). Cover% = (the total sum of the estimated percent of the vegetation cover in all quadrates ÷ the total number of quadrates) × 100.

Density

Density is the number of plants recorded within each quadrate. The average density per quadrate of each species can be extrapolated to any convenient unit area (Elawakeel, 2001). Density is the number of individual plants per unit area (Stinsby and Cook, 1986). Density has a considerable influence upon the number and kind of stock which can be introduced in to the grazing lands without endangering it (FAO, 1953).

Total plant density

Total plant density was determined by locating 1x1 quadrate. It was determined by calculating the number of individual species plant species /m^2.

Species plant density

Average species plant density was determined by locating 1x1quadrate. It was determined by calculating the number of all plant divided by the total sum of all species plants.

Biomass production

Biomass was determined using Quadrate (1m x1 m). All the above plants were clipped from the square meter quadrate at the grazing level (3 cm) and dried by an oven at 105 C° to get dry matter content, until the weight is obtained.

Carrying capacity

Carrying capacity defined as the number of livestock that can be grazed on a defined size of rangeland for a specified period of time and is expressed as (Fed., /Au/Year). Carrying capacity is determined by the forage production and the yearly livestock feed consumption. According to Gazala Gawazat Range Research Station the feed consumption per year by one animal unit is equal to 3 Tons dry matter. It was determined by using the below formula:

$$\text{Carrying capacity} = \frac{AU\ feed\ requirement}{forage\ yield\ (ton.fedd)}\ x\ Fedd/AU/\text{YR.}$$

Data analysis

Two-sample t-test was used to determine the significance between means using SSPS statistical software program.

RESULTS AND DISCUSSIONS

Vegetation cover percentage/m²

Results of the study showed highly significant difference (P<0.0001) in means of vegetation cover percentage between sandy and clay soil (Table 1). According to table (1) the vegetation cover% in 2013 was 55% in the sandy soil and it was 65% in the clay soil, while in 2014 the vegetation cover was 45%in the sandy soil and 60% in the clay one. However, the reduction of vegetation cover percentages in both soils in 2014 may be due to the increase of the grazing of livestock that happens yearly to the area and varying animal combinations which affects largely on the soil type especially the sandy one. This agreed with Van and Wine (1966) who related the reduction of plant cover to sacrifice areas along livestock routes, around water points and homestead.

Table 1: Vegetation cover percentages/m² (2013, 2014).

Soil Types	season		Mean
	2013	2014	
sandy soil	55	45	50
clay soil	65	60	62.5
SE			2.2719979
P-value			0.0001
Significance			***

***= highly significance (P<0.0001), SE= standard error

Total Plant Density/m²

The study revealed that the difference in the means of the total plant density between the two types of soils was not significant (Table 2). Based on table(2) the average total plants density in the sandy soil in 2013 was 103 and it was 87 in 2014.While in the clay soil it was 118 in 2013and 107 in 2014 (Table 2).

Table: 2 Average total plants density/m² (2013, 2014).

soil types	season		Mean
	2013	2014	
sandy soil	103	87	95
clay soil	118	107	113
SE			15.8
p-value			0.84
significance			Ns

The reduction of average total plants density in the two types of the soils (sandy and clay) from103 and 118 in 2013 to 87 and 107 in 2014 respectively, may be attributed to heavy and permanent grazing which hinder the natural rehabilitation of grasses, as a result of open grazing practices. Amin (1986) reported that this system (open grazing practices) leads to degradation.

In the year 2013 the six dominant species at the sandy soil were *Dactyloctenium aegyptuim*, *Zornia spp*, *Sida cordifolia*,*Cenchrus spp*,*Requtenia obeordate and Echinochola colona*, respectively. While in the clay one the six dominant species were *Zorina spp*, Dactyloctenium aegyptuim, *Requtenia obeodate*, *Aristida mutabilis* , *Cenchrus spp* and *Echinochola colona*, respectively. In the year 2014 the six dominant species in the sandy soil were *Dactyloctenium aegyptuim*, *Echinochola colona*, *Aristida mutabilis*, *Sida cordifolia*, *Indigofora aspera* and *Zornia spp*, respectively. While the six dominant species in the clay one were *Dactyloctenium aegyptuim*, *Ergrostis spp*, *Echinochola colona*, *Trinthema pantandra*, *Requtenia obeordate* and *Cassia spp*, respectively (table3).

Table 3: Average species plants density/m².

NO.	Species Name	Sandy soil		Aver-age	Clay soil		Aver-age
		2013	2014		2013	2014	
1	*Zornia sp*	7	6	7	6	5	7
2	*Dactyloctenium aegyptium*	0.18	4.41	9	6	7	7
	Sida cordifolia	1.22	1.06	7	3	4	4
4	*Aristida sp*	0.31	0.80	7	5	3	4
5	*Erogrostis tremula*	6.13	6.68	5	4	7	6
6	*Indigofora aspera*	5	7	6	3	3	3
7	*Cencherus spp.*	0.18	0.26	6	5	3	4
8	*Brachiaria obtusiflora*	4	4	4	3	3	3
9	*Trianthema pantandna*	4	5	5	5	5	5
10	*Requtenia oberdate*	7	5	6	6	5	6
11	*Echinochloa colona*	7	8	8	5	6	7

12	*Cassia spp*	5	5	5	3	5	4
13	*Euophorbia spp*	4	6	5	4	4	4
14	*Tophrosia gracilis*	4	4	4	2	3	3
15	*Ipomea cardiofolia*	3	3	3	3	2	3
16	*Ruellia patual*	3	2	3	4	2	3
17	*Chorchorus olitoruis*	2	2	2	4	3	4
18	*Arstochlaena lachnospermum*	2	1	2	3	2	3
19	*Ocimum spp*	-	-	-	3	4	4
20	*Justica schimperi*	-	-	-	3	5	4
21	*Cassia tora*	4.29	2.94	-	3	4	4
22	*Cyperus mundtii*		-	-	1	1	1
23	*Commlina spp*	-	-	-	1	1	1
24	*Pennisetum pedicellatum*	-	-	-	1	2	2
25	*Acanthospermum hespidum*	0.06	0.80	-	2	1	2
26	*Aristolchia bracteolate*	-	-	-	1	1	1
27	*Leptadenia hastate*	-	-	-	1	1	1
28	*Ipomea repens*	-	-	-	1	1	1
29	*Eorghum purpureosiceum*	-	-	-	1	1	1

The variations in the dominances of the different species in the area in the two seasons and between the two types of the soils may be attributed to the type of soil and the rainfall parameters. This agreed with Leopold (1939) who stated that plant populations change under the reduced native animal's impact and increased grazing pressure of domestic animals especially in the wet season. Harrison (1955) observed the high grazing pressure upon *Blepharis linarifolia* and he related this palatability to the high protein content, especially during the wet season. Wickense (1962) following the assessment of Range Vegetation within Kordofan special fund area concluded that the major factors causing eradication of perennial species are over-grazing, fire, and the seasonal short-run fluctuation in soil moisture. He concluded that causes of denudation of natural vegetation include drought, wind, flood, bush, fire and over-grazing. It was concluded that under the stress of harsh environmental sequences, annual herbs are the only species that are able to survive because of their efficient utilization of the available soil surface water moisture, and the fact that annuals usually mature and shed their seeds well ahead before the incidence of soil moisture stress and seasonal fires out-break.

Average Biomass Productivity ton/ha

The study results revealed that there was significant difference (P<0.05) in the means of biomass productivity between the two soils in the two seasons. In 2013 the biomass productivity in the sandy soil was 0.600 ton/ha and it was 0.525in 2014.While in the clay soil it was 0.635 in 2013and 0.585 in 2014 (table 4).

Table 4: Biomass productivity ton/ha (2013, 2014).

Soil types	**season**		**Mean**
	2013	**2014**	
sandy soil clay soil	0.600 0.635	0.525 0.585	0.563 0.615
SE			4.718
p-value			0.05
Significance			*

*= significant (p<0.05)

The decrease of biomass productivity in 2014 in the two types of the soils may reflect the impacts of environmental factors which include climatic factors such as: rainfall, temperature, radiation and humidity etc which determine the quantity and the quality of forage. This agreed with Fashir (2014), who stated that production is determined by environmental factors. It also may be due to the rainfall parameters. This agreed with Ridder (1982). He stated that growth is determined by rainfall parameters such as: distribution, number, amount and intensity of individual rains. Leeuw and Tothill, 1990 stated that the inter-annual variations in forage production are caused by many factors, the major one being the effect of rainfall. In the Sahel, the coefficients of variation along the 200 to 600 mms gradient are usually 20% to 30%. They also stated that in India, the results indicate that with adequate protection and controlled grazing the forage yield on the rangeland practically doubled in about 3 to 5 years. It has been estimated that during years of a normal rainfall, air-dried forage production in " very poor ", " poor ", " fair ", and " excellent" grassland is 200, 500, 750, 1000, and 1500 kg/hectare, respectively, when protected, fertilizer application and reseeding with better grasses, suiting different soil and rainfall conditions give increased yields of forage material, amongst the different soil and water conservation measures on rangelands.

Carrying Capacity AU/ha/year

Results of the study showed that there was variation in the carrying capacity between the two season and the two types of soils (sandy and clay). According to the results (table 5) in the season of 2013 the carrying capacity in the sandy soil was 0.222 and it was 0.235 in the clay one but in season 2014 the carrying capacity in the sandy soil was 0.19 while in the clay soil it was 0.216. The variation in carrying capacity in the two seasons may be attributed to rainfall parameters, soil type and the impacts of the nomads arrival to wet season area, they enter the area with their animals before plants reach its full maturity stage, and this leads to the reduction of the growth in the coming years causing the degradation of the area, because the animals eat the plants before it produces the seeds. The same results were mentioned by Laude and Robet, (1968) who stated that seed production is especially important to annuals, since it is the only way they reproduce. It has been shown that seed production in annual grasses can be greatly reduced by clipping, especially late in the growth season. It is unlikely thought that grazing can reduce seed production below the amount needed for production. Ahmed (1976) mentioned that the carrying capacity in Gerih Elsarha scheme (western Sudan) in the year 76/77 increased for the reason of high rainfall and better rainfall distribution that led to better and more vigorous plant growth which increased the weight of plants and the scheme's carrying capacity. He also reported that in the period (77-84), although rainfall increased until it reached a maximum in season (79/80) yet the carrying capacity was decreasing. He attributed this phenomenon to overgrazing, uneven distribution of intensity of grazing due to the water points and the improper time of grazing that may occur in the wet season

Table 5: Carrying capacity A.U/ha/yr (2013, 2014).

Soil types	Season		Mean
	2013	2014	
sandy soil	0.222	0.19	0.208
clay soil	0.235	0.216	0.227
Significance			Ns

ns = not significant

CONCLUSION

The study concluded that the type of soil associated with rainfall parameters has an impact on range productivity and carrying capacity. Also the study concluded that, despite the two soils face the same challenges but the results showed that, the deterioration of productivity and the impacts on carrying capacity were highly in the sandy soil rather than the clay one.

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