Effect of burning on vegetation and range carrying capacity in clay and sandy soils in north Kordofan State, Sudan

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ABSTRACT: This study was conducted in Northern Kordofan State, Sudan during the seasons 2004/2005 and 2005/2006 to investigate the effects of burning on vegetation performance and range carrying capacity in clay and sandy soils. Four sites were selected in the study area; burned in clay soil, unburned in clay soil, burned in sandy soil and unburned in sandy soil. Vegetation cover, species composition, forage productivity and range carrying capacity were measured in each site. The results showed that plant cover was higher than the other types of cover in burned area in clay soil and in unburned area in sandy soil. Cover of litter was higher in unburned area in both soils. In sandy soil, bare soil was higher in burned site, while in clay soil there was slight increase in bare soil in unburned site. Rock cover was observed only in sandy soil. The plant *Oryza longistaminata* was dominant in clay soil with higher percentage in burned site associated with *Cyperus rotundus* and *Lippia multiflora* with higher percentage in unburned area. The sandy soil was dominated by *Aristida mutabilis*, *Cenchrus biflorus, Eragrostis tremula, Zornia gluchidiata* and *Fimbristylis dichotomo* with 5% or more. The plants *Zornia gluchidiata* and *Fimbristylis dichotomo* were higher in unburned site in the two seasons, while the effect of burning on *Aristida mutabilis*, *Cenchrus biflorus* was not consistent in the two seasons. Forage productivity and carrying capacity were higher in the unburned sites and the clay soil.

Keywords*: Fire, plant cover, species composition, plant productivity*.

INTRODUCTION:

Fire can be a friend or foe depending on whether it is under control or out of control. Fire is a common source of temporal and spatial change in plant species composition [1,2]; especially in dry regions' plant communities. Therefore it is used as a tool on certain kinds of rangeland to remove unwanted vegetation, promote growth of desirable plants, reduce bush cover, influence changes in species composition, improve quality of forage to animals and reduce disease-causing pests [3]. The changes in vegetation can directly be caused by fire or in conjunction with other factors like herbivory, climate, and soils [1]. In Africa 25-80% of rangelands are burned every year often to induce new plant growth palatable for livestock. This has implication for short–term productivity but possibly long–term land degradation. Disturbance by fire can cause mortality of aerial or soil-stored seed, but it can also stimulate germination [4]. In Sudan, where rangelands are the source of about 80% of the total animal feed, accidental fire is considered one of their main threats. In different parts of Sudan, uncontrolled burning removes annually about 10-30% of the standing dry forage, a network of fire-breaks of more than 35000 km are established annually to check the spread of these fires and protect dry grass [5]. This annual burning in the short term deprives pastoralists of fodder and in the longer term causes

degradation to rangeland by favoring tree and grass species unpalatable to livestock [6]. Since burning occurs, intentionally or unintentionally, in semi-arid and savannah rangelands it is inevitable, and its impact on vegetation needs to be investigated. The overall goal of this study was to investigate the role of fire in rangelands in the savannah region of Sudan as a management tool to improve the deteriorated rangeland. The specific objectives of the study were to investigate the effects of burning on vegetation cover, species composition, forage productivity and carrying capacity in the clay and sandy soils of Northern Kordofan State.

MATERIALS and METHODS

Site description

The study was conducted in Northern Kordofan State during the seasons 2004/2005 and 2005/2006. The area lies between latitudes 12º 00 and 16º 10" N, longitudes 26º 15" and 30º 30" E, with mean elevation of the area is about 750 meters above sea level. The topography is characterized by being flat with small seasonal water courses. The climate of the area is semi-arid with low erratic rainfall ranging between 300-350 mm per annum. The mean maximum temperature of the hottest month (May) is 35 - 40˚C and the coolest month (January) is 18-22˚C. Relative humidity is 80% in August and 20% in March-May. The soil in the area varies from sandy, sandy clay and clay soils. The vegetation in the area consists of 81.6% annual grasses 14.7% annual forbs, 2.8% perennial grasses and 0.9% shrubs. Banu (*Eragrostis tremula*) and Haskaneit (*Cenchrus biflorus*) were the most dominant and constitute 74% of the total vegetation.

Four sites were selected as an experimental area. Two of the sites were on clay soils (burned and unburned) and the other two were on sandy soils (burned and burned). The burned sites, in the two soils, were already burned at the beginning of the dry season of 2003. The four sites were used as variables for soil and burning were i) burned in clay soil, ii) unburned in clay soil, iii) burned in sandy soil and iv) unburned in sandy soil.

Vegetation measurements:

In each site, plants cover, species composition, and forage productivity were measured. Carrying capacity was also calculated using forage productivity.

Cover: Cover as the vertical projection of the above ground parts on the ground was measured using the step-point method [7]. A mark on the tip of the shoe was used as a sampling point. In each site, the observer made 200 steps (points). In each step, the observer recorded the hits of the mark on vegetation (species), litter and bare soil. Cover is normally expressed as percentage from the total number of hits using the following formula:

$$Cover = \frac{No.\ of\ hits\ on\ plants}{Total\ No.\ of\ hits} \ x\ 100$$

Species composition:

Using the data for cover, the points in which a certain species was hit by the mark were recorded. Species composition is determined by dividing number of hits of certain species by the total number of hits on vegetation. The percentage of a certain species was determined using the following formula:

$$Species\ composition = \frac{No.\ of\ \ hits\ on\ a\ certain\ species}{Total\ No.\ of\ hits\ on\ plants} \ x\ 100$$

Forage productivity:

In each site 40 quadrates of 1 m^2 were randomly laid. The plants inside the quadrates were clipped using scissors with 6 inch blade and the clipped plants

were placed in paper bags, subsequently dried and weighed to get the dry weight. The weight was converted to kg per ha.

Carrying capacity:

The forage productivity obtained was used in calculations of carrying capacity calculation. The calculation was based on :

- The proper use factor (PUF) determined as 50%, i.e 50% of the forage to be allowed for livestock consumption and 50% to be left for range sustainability (proper use).
- Daily animal unit (AU) consumption estimate which was 12 kg dry matter.

Carrying capacity in ha/AU/Year was calculated using the following formula:

$$Carrying\ capacity = \frac{Forage\ requirement\ \ per\ AU\ \ per\ Year}{Forage\ allowed\ to\ be\ consumed\ \ per\ ha}\ x\ 100$$

Descriptive statistic was used to analyze the data for cover and species composition using MS Excel spread sheet to get the means and draw graphs. Analysis of variance (ANOVA) was used to analyze the data for productivity and carrying capacity. Least significant difference (LSD) was used for mean separation for both experiments [8].

RESULTS and DISCUSSION

The effect of burning and soil type on vegetation cover, litter, bare soil and rock cover is shown in figures 1 and 2 for the first season and figures 3 and 4 for the second season, . In both seasons vegetation cover was generally higher than litter, bare soil and rock cover in burned and unburned sites. However, vegetation cover in both seasons was higher in the burned area in the clay soils and in the unburned area in the sandy soils. The higher vegetation cover in clay soil is due to the fact that the dominant plant species were mainly the grass *Oryza longistaminata,* the sedge *Cyprus rotundus* and the forb species *Lippia multiflora.* The first two possess rhizomes and corms, respectively. The re-growth of rhizomes and corms normally gives good cover under burning compared to plant species in sandy soils. The forb *L. multiflora* was stimulated by fire giving more re-growth compared to plants in the burned sandy soils which were negatively affected by fire. A reduction in vegetative cover in burned sandy soil was similarly reported [9]. Cover of litter in both soils in the two seasons was higher in the unburned area. In clay soil, the percent cover of litter in the burned area was more than 15%, while in sandy soil it was 10% or less in the first season. In the second season, litter on sandy soil increased up to 17%. This indicates that the effect of fire on litter was probably due to fire [10]. This reduction in fuel is due to the fact that fire consumed all the amount of the litter and reduced the density of standing

Forage plants. Bare soil percentage was generally higher in the burned site in sandy soil (> 20%) than in the unburned site. In clay soil bare soil was slightly higher in unburned (< 15%) than in the burned site in the first year. This indicated that the plant species in sandy soil are more sensitive to fire than the species in clay soils. The results concerning litter (in both soils) and bare ground (in sandy soil) in this study are in line with the results of Turhintokh and Urgamal [9] and Laterra et al: [11] who reported that bare ground increased with burning while litter decreased. Rock cover was very small and was detected only in sandy soils. This may be due to the fact that in sandy soils more rocks and gravel are distributed over bare ground.

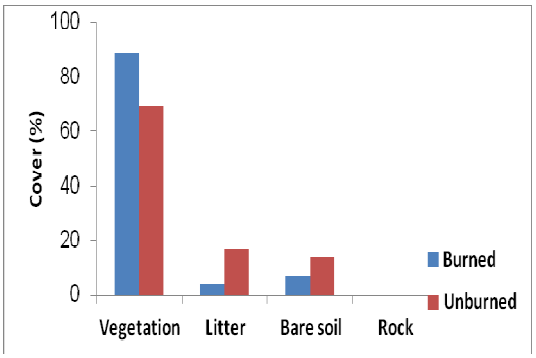

Fig.1: Vegetation cover, litter, bare soil and rocks on burned and unburned clay soil at Abu Kamdala area in 2004/2005

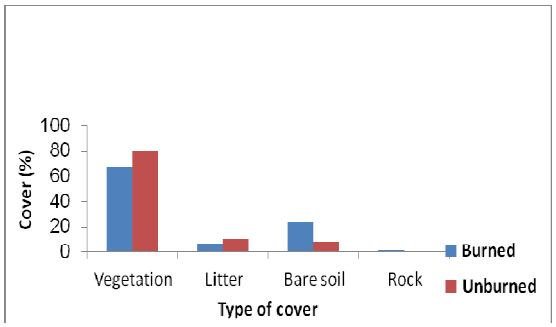

Fig.2: Vegetation cover, litter, bare soil and rocks on burned and unburned sandy soil at Um Khareen area in 2004/2005

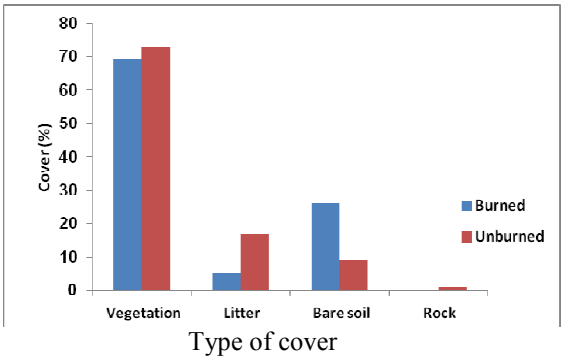

Fig.3: Vegetation cover, litter, bare soil and rocks on burned and unburned clay soil at Abu Kamdala area in 2005/2006

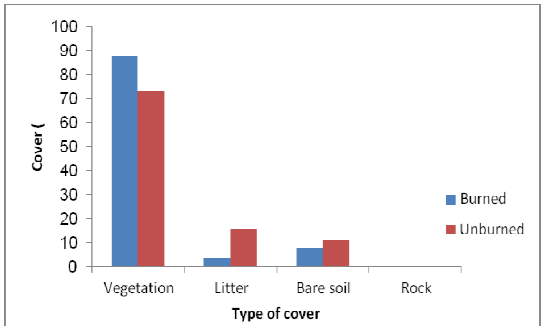

Fig.4: Vegetation cover, litter, bare soil and rocks on burned and unburned sandy soil at Um Khareen area in 2005/2006

Species composition:

The effect of burning on plant species composition in different soils is presented in table 1. The site with clay soil was dominated by the rhizomatous grass species *O. longistaminata* with 90 and 80% in the burned area and 64 and 74% in unburned area during the seasons respectively. The other associated species were the sedge, *C. rotundus* and the small shrub, *L. multiflora* that was present in higher percentage in the unburned than in the burned site. The dominance of *O.longistaminata* and, *C. rotundus* may be due to the fact that the two species possess sprouting rhizomes and corms which are fire tolerant, so they compete very well with other species. Moreover, clay soil in the study area was found in depressions where plants were subjected to water logging which is more suitable for these species. Due to high moisture, these species sprout immediately after fire and dominate the area. Moreover, *O. longistaminata* has very small seeds which could easily be buried in the cracks of soil, become protected from-fire and accordingly the species was abundant in the burned site than the other species. The presence of *L. multiform* with those competitive species in clay soils may be due to tolerance to fire and water logging. In sandy soil, the dominant species were *a .mutabilis*, *C.* b*iflorus*, *E .tremula*, *Z. gluchidiata,* and *F. dichotomy.* In the first season, *A. mutabilis* was higher in the unburned site, while in the second season it was higher in the burned site. This might be due to burning during the previous season before grazing when the vegetation density was high where high amount of fuel accumulated. Thus, the high fire intensity due to high fuel negatively affected the soil seed bank and consequently reduced the density of this species after burn. This result is in line with Laterra et al; [11] and those of Martinz et al; [12] who reported that burning reduces the amount of live seeds in the seed bank. *Cenchrus sp* was higher in the burned site in the first season and in the unburned site in the second season. This result indicates that *Cenchrus sp* is tolerant to fire as reported by Tix [13] *E. tremula* was higher in both burned and unburned sites in both seasons due to its tolerance to fire as reported by Daymba [14]. The two species, *Z. gluchidiata,* and *F. dichotomo,* were higher in unburned site than in burned site. This might be due to the fact that the two species produced comparatively large seeds that can be easily affected by burning than other species.

Generally, the seasonally inconsistent results for vegetation cover and species composition may be due to differences in fire intensity, seasonal rainfall variation and intensity of grazing after fire as repoted by Guevra et al [15] and Kraaij, et al[16] in semi-arid environment.

Forage productivity:

The effect of burning and soil type on forage productivity is presented in table 2. Forage productivity was significantly higher in unburned site than in the burned site in the two seasons. The result was expected since vegetation cover was higher in unburned site than in the burned site. The result is consistent with that reported by Turshinogtokh and Urgamal [9]. In clay soils forage productivity was significantly higher than in sandy soils in the two seasons.

Carrying capacity: The effect of burning and soil type on carrying capacity is presented in table 3. Carrying capacity was significantly higher in unburned site than in the burned site in the two

seasons. In the clay soils carrying capacity was significantly higher than in the sandy soils in the two seasons. Carrying capacity is strongly related to forage productivity.

Table. 1. Effects of burning on plant species composition on clay and sandy soil in Northern Kordofan State

Plant species/Season	Local name	2004				2005			
		Clay soil No: points		Sandy soil No: points		Clay soil No: points		Sandy soil No: points	
		Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned
Aristida mutabilis	Um shara	-	-	41	50	-	-	45	42
Cenchrus biflorus	Haskanit	-	-	22	15	-	-	13	23
Eragrostis tremula	Panu	-	-	12	5	-	-	16	11
Chrozophora brochiana	Erig alnal	-	-	4	-	-	-	7	-
Gegaria lata	Raihan	-	-	3	-	-	-	-	3
Zornia gluchidiata	Shilini	-	-	6	10	-	-	6	10
Fimbristylis dichotomo	Sisir	-	-	4	9	-	-	7	11
Sesamum alatum	Simsim	-	-	3	6	-	-	6	4
Euphorbia aegyptiaca	Um libana	-	-	4	-	-	-	-	-
Tephrosia spp	Um yakra	-	-	-	4	-	-	-	-
Oryza longistaminata	Ruze	90	64	-	-	80	74	-	-
Cyprus rotundus	Sieed	7	13	-	-	12	16	-	-
Lippia multiflora	Um rahan	3	23	-	-	8	10	-	-

Species percent cover as determined by using systematic step-point method (100 points per plot)

Table 2. Effects of burning and soil type on forage productivity (kg/ha) in north Kordofan state.

Treatments	season 2004/2005	Season 2005/2006
A Burning		
Unburned	1188.0 a	910.0 a
Burned	1032.0 b	833.0 b
LSD	105.3	62.7
B Soil type		
Clay	1814.0 a	1280.0 a
Sandy	407 0 b	463.0 b
LSD	105.3	62.7
CV (%)	30.3	18.7

Means with the same letter(s) within a column are not significantly different using Least Significant Difference at ($p \geq 0.05$).

Table 3. Effects of burning and soil type on carrying capacity (ha/AU/year) in north Kordofan state.

Treatments	season 2004/2005	season 2005/2006
A Burning		
Unburned	12.7 b	12.0 a
Burned	19.7 a	16.7 b
LSD	3.0	1.9
B Soil type		
Clay	5.2 a	7.1 a
Sandy	27.2 b	21.6 b
LSD	3.0	1.9
CV (%)	58.7	41.8

Means with the same letter(s) within a column are not significantly different using Least Significant Difference at ($p \geq 0.05$).

CONNLUION

Vegetation cover was higher in burned site with clay soil and in unburned site with sandy soil.

- *Accumulation of litter was higher in unburned site in both soils*
- *Percent of bare soil was higher in burned site with clay soil and in unburned site with sandy soil.*
- *In clay soil, in burned and unburned site, O. longistaminata*, *C. rotundus* and *L..multiflora were dominant.*
- *In sandy soil, the burned and unburned sites were dominated by A. mutabilis*, *C. biflorus, and E. tremula*
- In clay soils forage productivity was significantly higher than in the sandy soils in the two seasons
- *Percent of bare soil was higher in burned site with clay soil and in unburned site with sandy soil.*
- *In clay soil, in burned and unburned site, O. longistaminata*, *C. rotundus* and *L.multiflora were dominant.*
- *In sandy soil, the burned and unburned sites were dominated by A. mutabilis*, *C. biflorus, and E. tremula.*

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