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Impact of Management Practices on Ground Cover and Density of Herbaceous Plants in the Rangelands of South Kordofan, Sudan

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Abstract: The study was conducted at Tillow area in three sites, Kadugli locality of South Kordofan during three successive seasons (2005/2006, 2006/2007 and 2007/2008), to investigate the effect of four management practices on ground cover and density of herbaceous plants. A randomized complete block design (RCBD) with four treatments and three replicates was used. The treatments applied were: protection by fencing only, protection by fencing and removal of undesirable plants (protected plots), grazing, and grazing and burning (open plots). Measurement of ground cover was carried out using Parker loop (¾"), while 1m x 1m quadrate was used to obtain herbaceous plant density. The results indicated that protected plots had higher plant cover ($P< 0.05$) than open plots. On the other hand, the open plots had higher bare soil percentage than protected plots. The results indicated that protection only had the highest plant density in the third season. Protection only as well as protection and removal of undesirable plants increased herbaceous cover and reduced bare soil percentage. This suggested protection and protection with control of undesirable plants to be used as management practices for improving rangelands in the low rainfall savannah areas where desirable range species are abundant.

Key words: Management, ground cover, plant cover, rangelands, South Kordofan.

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INTRODUCTION

Sudan ranks at the top of the African and Arabian countries with regard to livestock population that depends almost entirely on natural range for feed. According to Abusuwar (2007), rangelands in Sudan are considered the main source of feed and they represent about 74% of total animal feed. Rangelands in South Kordofan are not grazed intensively by livestock until the dry season, when forage declines sharply in both quantity and nutritional value. Moreover, the risk of fires is high at this time of the year because of the large accumulation of combustible material resulting from insufficient wet season grazing (WSARP, 1982).

In the study area *Dichrostachys cinere*a (kadad) a shrub-tree legume causes a problem of bush encroachment by its thicket forming, resulting in a decrease in productivity of grass layer. Integrated weed management employs the planned, sequential use of multiple tactics (e.g. chemical, biological, cultural and mechanical control measures) to improve the ecosystem functions (energy flow and nutrient cycling) and maintain invasive plant damage below economic levels, and emphasizes managing rangeland ecosystem function to meet the objectives rather than emphasize a particular weed or control method (Masters and Sheley, 2001). There are numerous methods for improving rangelands. One of the simplest and least expensive is prescribed burning (Abdelaziz, 2012). Furthermore, current knowledge of response of natural rangelands to some management practices, such as protection by fencing,

controlled grazing/ browsing, prescribed burning and removal of undesirable plants under Sudan conditions are still lacking. Thus, the specific objective of present study was to investigate the effect of the different management practices on ground cover (plant cover%, bare soil% and litter%) and density of herbaceous plants.

MATERIALS AND METHODS

Study area

South Kordofan State, where this study was conducted, is located approximately between latitude 9˚00′ and 13˚00′N and longitude 27˚ 00′ to 32˚ 00′E. The study was conducted at Tillow area in Kadugli Locality for three successive years (2005/2006, 2006/2007, 2007/2008). The vegetation of Tillow area falls within the low rainfall savannah vegetation zone in special area which is dominated by tall coarse annual grasses such as Sorghum *purpureosericeu*m (Bejil) and *Hyparrhenia confinis* (Um racho) while the over story is dominated by *Dichrostachys cinere*a (L.) Wight & Arn.(Kadad). In South Kordofan, Annual rainfall ranges between 350 mm on the northern border to more than 800 mm on the southern border. The length of the rainy season varies from about 3 months in the north to about 5 month in the south. Rains occur between May – October with peak in August.

The average monthly maximum and minimum temperature range between 30ºC and 40ºC and from 17ºC to 20ºC respectively. April, May and June are the hottest months of the year, and December January and February are the coolest. Wind direction differs according to season, north-east in winter and south-west in summer. Soils in South Kordofan vary from sandy in the north to heavy cracking clay in the Nuba Mountains plain (Anon, 2004).

Treatments

The treatments used were: protection by fencing only, protection by fencing and removal of undesirable plants (protected plots), grazing, and grazing with burning" opened plots. Nine plots were selected at the three different range sites (A, B and C). The distance between sites was less than one kilometer. The first plot, in each site, was protected by fencing and divided into two equal sub-plots to minimize the cost of fencing; one of the sub-plots was managed by removal of undesirable plants manually using hand for herbaceous plants and traditional hand tools and big clippers for trees and shrubs, while the remaining sub-plot was unmanaged. The second plot in each site was freely grazed and browsed. The third plot in each site was freely grazed and browsed and subsequently burnt annually in early dry season. All trees and shrubs with height exceeding one meter were removed from each plot or sub-plot at the beginning of the study. The removal of trees and shrubs was done to minimize the differences between plots. Fire lines were opened around plots in each site annually. Plot size was (54m × 54 m). Two meters were left as margin in each of the four sides. The plot size became 50m × 50 m. Each plot or subplot was divided into two strata. In each stratum one permanent line transect (50 m long) was placed. A total of two line transects at each plot or sub-plot were placed. The statistical analysis was performed by using the JMP statistical package (1997) by SAS Corporation. According to Finney (1953), the data of ground cover were transformed from percentage to degrees. The trial was carried out in a randomized complete block design (RCBD) with four treatments (four management practices) and three replications (site A, B and C). Analysis of variance was done for data analysis. Least significant difference (LSD) was used for means separation.

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Measurement of ground cover

Line transects and Parker Loop (¾" diameter) were used to determine ground cover. Observation points were taken at one meter interval along the transect by using the loop. Hits were recorded for plant when any portion of it occurred within the circumference of the loop. Also, hits were recorded for bare soil, litter and rocks. According to WSARP (1985), Plant cover %, Grass cover, Forbs cover %, litter % and bare soil % were calculated as follows:-

$$\text{Plant cover \%} = \frac{\text{The total hits of plant}}{\text{The total number of hits}} \times 100\ \%$$

$$\text{Grass cover \%} = \frac{\text{The total hits of grass}}{\text{The total number of hits}} \times 100\ \%$$

$$\text{Forbs cover \%} = \frac{\text{The total hits of forb}}{\text{The total number of hits}} \times 100\ \%$$

$$\text{Litter \%} = \frac{\text{The total hits of litter}}{\text{The total number of hits}} \times 100\ \%$$

$$\text{Bare soil \%} = \frac{\text{The total hits of bare soil}}{\text{The total number of hits}} \times 100\ \%$$

Density of herbaceous plants

Two permanent (1m x 1m) quadrates were placed along each transect at 20 m intervals for counting the number of herbaceous plants. All herbaceous plant ground cover and density measurements were done annually in the late rainy season (early October).

RESULTS AND DISCUSSION

Effect of management practices on ground cover

The results in Table 1, show ground cover inside protected, protected and managed, grazed and grazed and burned plots at Tillow area in South kordofan for the three successive seasons (2005/2006, 2006/2007 and 2007/2008). In the first season (2005/2006), plant cover was significantly difference ($p < 0.05$) in grazed and burned plot compared to other treatments.

According to WSARP (1982), in South Kordofan the productivity of wetter southern ranges suffers primarily from extensive burning and under utilization rather than over grazing. In the study area *Dichrostaychys cinerea* (kadad) is dominant and it has the thicket formation.

The results indicated that light to moderate grazing coupled with burning probably increases herbaceous cover. Watanbe *etal*, (2002) reported that a positive effect of heating enhances seeds germination. Goat browsing in the study area reduced the competition of shrubs with grasses and consequently, enhanced grass cover. Moreover, the change in herbaceous cover by using management practices may be achieved gradually and might not be detected especially in the first season. Stoddart *etal*. (1975) reported that succession is usually gradual and involves a series of changes. Bare soil was significantly lower ($p < 0.05$) in grazed and burned plot compared to other practices Table1 ((2005/2006). The removal of undesirable plants inside protected and managed plot might have caused the increase in the bare soil percent especially in the first season. In addition, grazing can increase bare soil percentage due to the removal of vegetation cover.

The findings in Table1 in the second season (2006/2007) indicated that there was no significant difference in all ground cover attributes among the four management practices. The second season might be a transitional stage between first season and the third season and probably insufficient to detect significant variation among management practices.

The results in (Table 1, 2007/2008) are probably sufficient to detect the effect of protection and protection and management on herbaceous botanical composition according to the plant succession series. There was significant difference ($P < 0.05$) in grass cover between protected plot and other three plots. Furthermore, protected plots (protected, protected and managed

plots) had higher grass cover than open plots (grazed, grazed and burned). *Hyparrhenia confinis* and *Sorghum purpureosericeum* were dominant grass in the study area as mentioned before. The results also, indicated that protected plots had the least forbs cover than opened plots. Grazing, browsing and burning may be beneficial in enhancing herbaceous plants diversity whereas protection can increase grass cover and reduce forbs cover in the study area. There was a highly significant difference ($P<0.01$) in herbaceous cover between protected plots and open plots. Also, the results of bare soil indicated that there was a highly significant difference ($P<0.01$) between protected plots and grazed plots. The results indicated that protected plots had the higher herbaceous cover and the least bare soil, whereas the open plots had the least herbaceous cover and higher bare soil (Table1). The results of herbaceous cover support the finding of WSARP (1985) that herbaceous cover was generally higher inside enclosure than outside. In addition, the results showed that grass cover had the upward trend in protected plots from first season to the third season and grass cover increased gradually whereas forbs cover decreased sharply from the second season to the third season. Also, the results showed that bare soil in protected
plots had a downward trend (Table1).

Table 1. Effect of four management practices on ground cover at Tillow area in South Kordofan for the three late rainy seasons
(Data were transformed from percentage to degrees)

Season	Attribute	Protected	Protected and Managed	Grazed	Grazed and burned	LSD
2005/ 2006	Grasses	54.8 (66.6%)	53.3 (64.3%)	52.9 (63.3%)	58.0 (72.0%)	NS
	Forbs	22.5 (16.6%)	17.3 (11.3%)	21.4 (15.0%)	26.0 (21.6%)	NS
	Pant cover	67.8b (82.6%)	62.3b (75.6%)	66.9b (78.3%)	78.3a (93.6%)	7..3*
	Litter	4.6 (1%)	3.8 (0.0%)	0.0 (0.0%)	2.7 (3.3%)	NS
	Bare soil	21.2a (16.3)	26.2a (24.4%)	23.0a (21.6%)	10.6b (5.4%)	5.4*
2006/ 2007	Grasses	61.0 (72.6%)	12.2 (7.7%)	60.4 (75.0%)	57.6 (71.0%)	NS
	Forbs	22.7(21.4)	86.6a (99.0%)	20.9 (13.6)	25.6 (20.6%)	NS
	Pant cover	81.6 (94.0%)	3.3 (1.0%)	74.1 (88.6%)	76.2 (91.6%)	NS
	Litter	0.0 (0.0%)	0.0a (0.0%)	0.0 (0.0%)	1.9 (0.3%)	NS

Table2cont.

2006/ 2007	Bare soil	8.3 (6%)	16.4 (9.0%)	15.8 (11.3%)	13.4 (8.0%)	NS
2007/ 2008	Grasses	77.7a (95.0%)	74.4b (91.3%)	59.2c (73.3%)	61.6bc (78.3%)	3.1*
	Forbs	8.1(3.0%)	12.2 (7.7%)	22.6 (16.7%)	19.9 (11.9%)	NS
	Pant cover	83.3a (98.0%)	86.6a (99.0%)	72.4b (90.0%)	73.3b (90.2%)	5.8**
	Litter	0.0 (0.0%)	3.3 (1.0%)	0.0 (0.0%)	7.7 (3.3%)	NS
	Bare soil	6.0ab (2.0%)	0.0a (0.0%)	17.5c (10.0%)	11.9bc (6.3%)	6.0**

* Significant at 0.05 level
* *Significant at 0.01 level
Within a row values with the same letters are not significantly different
NS = No Significant difference

Effect of management practices on density of herbaceous plants

The results of grasses, forbs and herbaceous densities for the four management practices in the late rainy seasons (2005/2006, 2006/2007 and 2007/2008) are presented in Table 2. In season (2005/2006), grass density was significantly difference ($p < 0.05$) in grazed and burned plot compared to other treatments The results indicated that grazed and burned plot had the highest grass density (179.1) followed by protected plot (129.4), grazed plot (113.5) whereas protected and managed plot had the least grass density (97.2) in (2005/2006).

The density of grasses is a reflection of many factors such past management. Holechek *et al*. (2004) reported that plant density is commonly used to determine the plant survival in response to grazing and drought and plant establishment. Grazing, browsing and burning can interact positively and may increase grass density. According to Tyler (1995) direct heating on the soil and the seed bank may affect seed germination by breaking seed dormancy. Also, trampling may create condition in which seeds retain greater viability in the soil and can increase grass density. Trabaud (1987) reported that the effect of fire on seed depends on seed properties and characteristics of fire such as intensity, rate of spread, energy release and residence time. More research is needed to investigate when, and how grazing, browsing and burning can interact positively and hence increase grass density.

Protection probably increase grass density. This may be due to the absence of grazing. The removal of undesirable plants in protected and managed plots may decrease grass density especially in the first season. This may be attributed to the fact that while undesirable plants were removed by traditional hand tools, some plants were removed. In season (2005/2006), forbs density was highly significantly difference ($p < 0.01$) in protected plots compared to open plots. The result indicated that forbs density was higher in the protected plots than open plots in (2005/2006). This finding may be because forbs were dominant in the protected plots in the first season but in the second and third season the grasses became dominant. Also, the

results in Table 2, (2005/2006) showed that protected plot had the highest total density (249.7) followed by grazed and burned plot (203.9), protected and managed plot (195.3) whereas grazed plot had the least total density (142.2). The findings in Table2 in the second season (2006/2007) indicated that there was no significant difference in density of herbaceous plants among the four management practices. The results showed that protected plots had higher grass density than grazed and burned plot (Table 2, (2006/2007). The results in Table2, (2006/2007) indicated that protected plot had the highest forbs density (78.2) followed by grazed (30.7) whereas protected and managed plot and grazed and burned plot had the least forbs density (9.8) and (8.2) respectively. These results indicated that although, protected plot had the highest forbs density in the second season there was a decrease in forbs density when a comparison between the first season (2005/2006) and the second season (2006/2007) was made. The decrease in forbs density in protected plots may be attributed to the dominance of grasses due to inability of forbs to compete with tall grasses. In season (2007/2008), forbs density was highly significantly difference ($p < 0.01$) in protected plots compared to open plots. The result indicated that forbs density was higher in the open plots than protected plots. In season (2007/2008), total density was significantly difference ($p < 0.05$) in protected and grazed and burned plots compared to other two plots. Also, data in Table2 (2007/2008) indicated that protected plot had the highest total density (159.8) whereas grazed plot had the least density. The findings show that protection can increase total herbaceous density and cause tall annual grasses to be dominant in the study area. This may be due to fact that tall grass had high competition ability for light and water as mentioned before. Consequently, protection only in the study area may decrease species diversity and lead to dominant of tall coarse annual grasses which are less desirable range species. Moreover, the results showed that forbs density in protected plots had a downward trend.

Table 2. Effect of four management practices on density of herbaceous plants (Plant/m²) at Tillow area in South Kordofan for three late rainy seasons

Season	Taxon	Protected	Protected and managed	Grazed	Grazed and burned	LSD
2005/2006	Species groups					
	Grasses	129.4 b	97.2 b	113.5 b	179.1 a	36.4*
	Forbs	120.3a	98.1a	28.9 b	24.8b	27.4**
	Totals	249.7	195.3	142.4	203.9	NS
2006/2007	Grasses	100.3	126.3	115.5	57.5	NS
	Forbs	78.2	9.8	30.7	8.2	NS
	Totals	178.5	136.1	146.2	65.7	NS
2007/2008	Grasses	154.1	111.5	81.2	137.9	NS
	forbs	5.7a	3.5a	14.6b	11.3b	4.6**
	Totals	159.8a	115.0b	95.8b	149.2a	14.3*

* Significant at 0.05 level
* *Significant at 0.01 level
Within a row values with the same letters are not significantly different
NS =No Significant difference

CONCLUSIONS AND RECOMMENDATION

Protection only as well as protection and removal of undesirable plants increased herbaceous and grass cover besides reduced bare soil, cover and density of forbs. To improve rangelands in the low rainfall savannah areas where desirable plant species are abundant, protection or protection with removal of undesirable plant species are recommended as management Practices.

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أثر ممارسات الادارة على التغطية الأرضية و كثاثة النباتات العشبية في المراعي بولاية جنوب كردفان– السودان

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مستخلص البحث:

أجريت الدراسة في ثلاثة مواقع بمنطقة تلو، محلية كادقلي، ولاية جنوب كردفان ولمدة ثلاثة مواسم متتالية (2006/2005م، 2007/2006م/2008/2007م)، للتحقق من تأثير أربع ممارسات إدارة على التغطية الأرضية وكثافة النباتات العشبية. تم استخدام تصميم القطاعات العشوائية الكاملة بأربع معاملات وثلاثة مكررات. المعاملات التي تم تطبيقها هي: الحماية بالتسوير فقط، الحماية بالتسوير وإزالة النباتات غير المرغوبة (المواقع المحمية)، والرعي فقط والرعي والحرق (المواقع المفتوحة). تم استخدام حلقة باركر (¾ بوصة) والقاطعات الخطية لقياس التغطية الأرضية بينما استخدم البرواز (1 متر × 1 متر) لقياس الكثافة للنباتات العشبية. دلت النتائج أن المواقع المحمية لها غطاء نباتي أعلى مقارنة بالمواقع المفتوحة وبمتسوى معنوية ($P < 0.05$)، ومن ناحية أخرى، المواقع المفتوحة لها نسبة تربة عارية أعلى مقارنة بالمواقع المحمية. دلت النتائج أن الموقع المحمي فقط سجل أعلى كثافة نباتية في الموسم الثالث. الحماية فقط بالاضافة إلى الحماية وإزالة النباتات غير المرغوبة تزيد من الغطاء النباتي العشبي وتقلل من التربة العارية، تقترح الدراسة باستخدامها في تحسين المراعي في مناطق السافنا الفقيرة والتي تتواجد فيها النباتات الرعوية المرغوبة.

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