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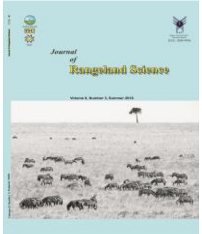

Research and Full Length Article:

Vegetation Dynamics in Relation to Grazing Management Practices in Semi-arid Grazing Lands of Makueni County, Kenya

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Abstract. Livestock grazing practices in rangelands are being recognized as management tool for environmental protection and increased livestock productivity. Continuous grazing has been largely reported to reduce pasture productivity and increase environmental degradation. Rotational grazing is an alternative to continuous grazing and is considered to reduce negative environmental effects and provide quality pastures and browse ensuring availability of quality feed for animals while conserving the environment. This study was conducted in a semi-arid grassland in the south eastern rangelands of Kenya which is primarily used for cattle production to establish how grazing management system affects herbaceous biomass yield, cover, plant species richness and diversity (in 2016). Quadrat method was used to collect vegetation samples. In each plot, a 100 m^2 sub- plot was demarcated and five 1×1m quadrats laid out. A quadrat was placed at each of the four corners of the 100m^2 plot and the 5th quadrant placed at the center of the plot. Herbaceous biomass production was significantly higher ($p \leq 0.05$) in rotationally grazed areas compared to both continually grazed and ungrazed areas with average values of 7037, 2478 and 2390 $Kgha^{-1}$ respectively. Similar trend was obtained for vegetation cover. Vegetation cover of herbaceous plants was significantly higher under rotationally grazed areas compared to both continually grazed and ungrazed areas with average values of 55, 37 and 27%, respectively. There was no significant difference for plant species richness and diversities and between the three sampling blocks. However, the highest values of both latter traits were obtained in rotationally grazed areas, followed by continually and ungrazed areas. Improved biomass yields and high species diversity in rotation grazed areas was largely attributed to the flexibility in the management in which grazing frequency, durations and the rest periods are efficiently controlled compared to continuous grazing areas. This study concludes that rotation grazing allows flexibility of animal utilization of pastures resulting to enhanced soil water retention, increased species diversity; richness and vegetation cover which increase biomass yields.

Key words: Biomass, Cover, Diversity, Richness, Grazing management

Introduction

Globally, properly managed grazing lands incorporates the most important land use practices (Liebig *et al.*, 2006) and covers about 25% of earth's land surface (Asner *et al.*, 2004; Einstein, 2010). The significant area of rangelands generally makes them a useful resource for grazing, biodiversity conservation and a source of livelihood, specifically for rural communities (Ericksen *et al*., 2009) Most of the global's rangelands are believed to be degraded as a result of excessive livestock grazing (Milton *et al.*, 1994). Livestock grazing influences the plant community structure and ecosystem functioning which is a key issue in the management of rangelands in order to maximize livestock production and sustainability (Jacobo *et al.*, 2006). Evidence exists that livestock grazing strongly influences the structure, richness, and composition of plants in rangelands (Huang *et al.*, 2015; Porqueddu *et al.*, 2016; Rutherford & Powrie, 2013), for instance, the short term effects of grazing has been reported to influence the structure of plant communities through defoliation and reduction of plant tissues while causing changes in botanical composition and species diversity in the long term through selective grazing (Jacobo *et al.*, 2006). Changes in plant species composition are mostly due to the substitution of palatable by unpalatable species with an increase in annual plants species following rangeland degradation (Tarhouni *et al.*, 2007). Previous studies on effects of grazing on rangeland vegetation showed that the substitution of palatable by unpalatable plants decreases not only plant species diversity but also the rangeland productivity (Cingolani *et al.*, 2005). When unpalatable species become dominant, it becomes difficult to reverse the effects hence lowering the rangeland productivity (Westoby *et al.*, 1989). Rotational grazing may be used as a useful management method to preserve species diversity and rangelands productivity (Gamoun, 2014). It is also a preferred practice for conserving biological soil crusts and the ecological services they provide in nitrogen fixation and soil stabilization (Liu *et al.*, 2009). Moreover, low to light grazing intensity can increase production compared to no grazing. However, the extent of grazing may affect the photosynthesis process which maximizes manufacturing of plant food and depends on the growing conditions of the harvesting stage within the seasons hence there is need to use a properties and hydrology, which may result to critical outcomes affecting plant growth proper grazing management strategy (Patton *et al.*, 2007). and productivity in the rangelands where water scarcity is a common phenomenon (Jeddi & Chaieb, 2010).

Rangelands in the tropics are highly dominated by Savanna grasslands with most grass species being highly tolerant to grazing, however, the common high grazing intensity grazing coupled with frequent droughts increasingly lead to shift in species composition and decline in soil fertility and biomass productivity (Van Auken, 2009). Poor grazing practices leads to overgrazing which negatively influence the botanical composition and species diversity. Continuous over grazing results to increase in more competitive and drought tolerant grass species but of low feed value to animals while selective grazing of palatable herbaceous vegetation by grazing animals encourages the establishment of annuals and unpalatable plant species (Fensham *et al.*, 2010). Rangeland vegetation does not always respond in a linear way to grazing intensity, partly because local environmental conditions such as high rainfall and soil fertility regulate the plants' ability to cope with grazing pressures. However, herbaceous biomass appears to be more responsive to differences in grazing intensities across grazing management systems. Well management rangelands usually exhibits a higher herbaceous biomass production with higher forage quality than the poorly managed grazing lands, which could be due to the higher grazing intensities of the latter compared with the former.

The concept of rangeland management in Kenya has become widely accepted and implemented. When natural vegetation becomes severely degraded, the management of this land with an aim of increasing productivity has proven unlikely. However, this situation can be remedied if restoration work is undertaken (Gamoun *et al.*, 2012). This is why rangelands protection is necessary to maintain sustainable management and resilience (Gamoun, 2014). Although a lot of studies have been done on the impact of grazing on vegetation dynamics, we did not find literature on studies comparing the impact of different grazing management systems on vegetation cover, biomass and diversity in the southern rangelands of Kenya. Therefore, we investigated the influence of two grazing systems (continual and rotational grazing systems) on herbaceous vegetation diversity, richness, cover and biomass production to an ungrazed area.

Materials and Methods

Study area

The study was conducted in Yaoni ranch located in Makueni County, approximately 125 km southeast of Nairobi, Kenya (Fig. 1). The county borders Kajiado to the West, Taita Taveta to the South, Kitui to the East and Machakos to the North. It lies between Latitude 1º35´ and 1°30′ South and Longitude 37º10´ and 38º 30´East. The area lies at an altitude of between 1200-1400 m above sea level and receives bimodal rainfall with long rains falling between the months of March to May and short rains in October to December. Total annual rainfall is between 400 and 600mm. In between the rainy seasons, the area experiences intervening dry spells in January/February as well as July to September.

The county is largely semi-arid and usually prone to frequent droughts. The study site falls under agro-ecological zone IV and V (Jaetzold *et al.*, 2006). In terms of agro-ecological potential, the study site is classified as a ranching zone naturally suited for extensive livestock production and wildlife.

The terrain is characterized by plains to the North and undulating hills to the South. The geology of the study area is characterized by relatively deep over-burden, with very few exposures of the underlying basement rock. The basement system are crystalline rocks of pre-cambrian age often occurring as fine–grained schists and course gneisses, that have been invaded by pink quartzo feldspathic pegmatites (Kurrent Technologies, 2011) The soils are highly varied, dominated by sandy soils punctuated with vertisols, acrisols and cambisols. The natural vegetation of the study area consists of *Themeda triandra*, a tufted perennial grass species that is preferred by grazers, and *Themeda–Balanites* or *Themeda–Acacia* wooded grassland (Kinyua *et al.*, 2000).

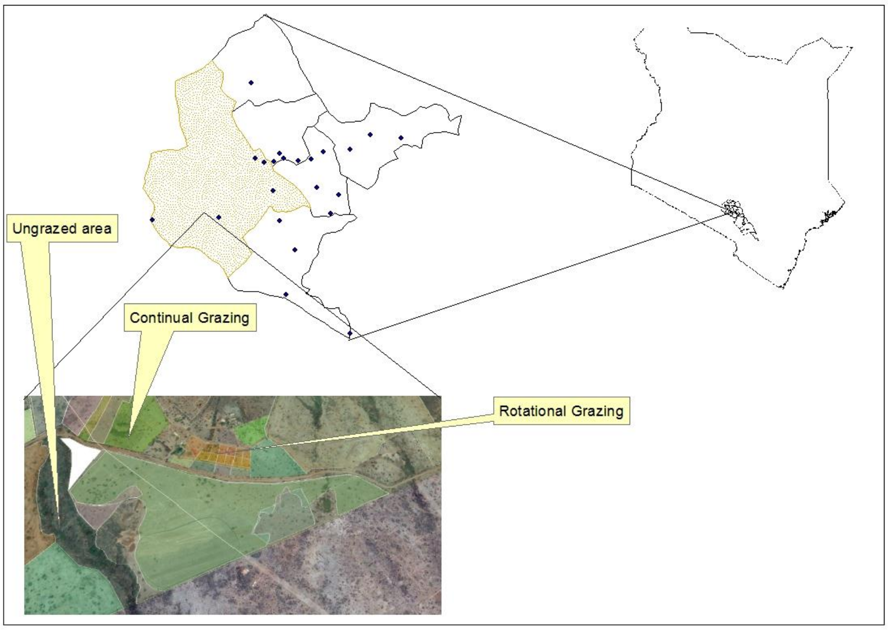

Fig. 1. Map of a study area in relation to map of Kenya

Experimental design

The experimental design was Completely Randomized Design (CRD) involving two grazing systems and ungrazed area: continuous grazing, rotational grazing and ungrazed area (control). This research site was on a commercial grazing ranch which is primarily used for cattle grazing with both systems having similar stocking rates. A section of it was converted from continuous grazing into rotational grazing for the last six years at the time the study was conducted. The second sampling block was a continuously grazed area for the last 30 years. Under rotational grazing, a large herd of livestock is moved between paddocks for short periods of time. These periods of grazing are considerably shorter than the rest durations.

The ungrazed area consist of an abandon for more than 30 years due to a deep gully which was formed due to gully erosion creating and isolated area inaccessible by livestock as shown in (Fig. 1)

Data collection

Quadrat method used to collect vegetation samples. In each plot, a 100 m^2 sub- plot was demarcated and five 1×1m quadrats laid out. A 10×10m plot was demarcated along a 200m transect at an interval of 20m. Quadrat was placed at each of the four corners of the 100m^2 plot and the 5th quadrant placed at the center of the plot. Vegetation samples were collected late May of 2016, when the biomass had reached its maximum height. There were a total of 135 quadrats used for the three grazing systems, each grazing system having 45 quadrats. Plant functional types were identified either as Annuals, Perennials, forbs, and trees; and their taxonomy done at the National Museums of Kenya. They were then clipped, weighed and put in their respective sample bags for biomass determination. The herbaceous vegetation cover was estimated by visual method for each quadrat with the help of Taxonomist from the University of Nairobi. Biomass was determined by weighing the oven dried vegetation sample. Species diversity and richness were determined using Shannon Weiner's diversity index (1963) as described by (Krebs, 1989). Species richness was calculated as the total number of species per quadrat (Polley *et al.*, 2005).

Shannon-Weiner's Diversity index (H') (Equation 1);

$$H' = -\sum[\left(\frac{n_1}{N}\right) \times \ln\left(\frac{n_1}{N}\right)]$$

(Equation 1)

Where;

n_1= number of individuals of each species,

N= Total number of individuals (or amount) for the site,

Ln= the natural log of the number.

Statistical analysis

Data collected on vegetation attributes was subjected to analysis of variance (ANOVA) using GenStat Discovery 15th edition statistical software. Tukey's HSD post hoc was used to comparison of treatment means.

Results

Table 1 below shows the species dominating the functional groups across the different grazing management systems in our study area. The higher frequency was found in rotational grazing.

Results for herbaceous plant species richness and diversity are presented in Figs. 2 and 3 respectively. There was no significant difference in plant species richness between the three sampling blocks. However, plant species richness was higher in rotationally grazed areas, followed by continually and ungrazed areas with mean species numbers of, 13.4, 11.9 and 9.67, respectively (Fig. 2). The difference in diversities among the grazing systems was not statistically significant. However, the rotationally grazed site had higher species diversity followed by continual and ungrazed area with mean values as follows 3.08, 2.88 and 2.43, respectively (Fig. 3).

The herbaceous biomass production and percentage cover results are presented in Figs 4 and 5, respectively. The study demonstrated that the above-ground herbaceous biomass production was significantly ($P \leq 0.05$) different in rotationally grazed site than both continually grazed and ungrazed sites with mean values of 7037, 2478 and 2390 $Kgha^{-1}$, respectively (Fig. 4), with the rotational grazed site having the highest herbaceous biomass. The herbaceous vegetation cover was significantly different across the management systems (Fig. 5) with the rotationally grazed site having the highest percent herbaceous cover, followed by continual and ungrazed sites. The mean percentage values of vegetation cover under rotational, continual grazing and ungrazed site were 55.7, 37.26 and 27.6%, respectively.

Table 1. Species dominating herbaceous functional groups in the study area, Species in each functional group are listed in order of abundance

Groups	Rotational	Continual	Ungrazed
Perennials	*Cynodon dactylon*	*Cynodon dactylon*	*Cynodon plectostachyus*
	Cyperus spp.	*Digitaria macroblephera*	*Digitaria macroblephera*
	Panicum maximum	*Cyperus rotundus*	*Eragrostis superba*
	Eragrostis superba	*Cyperus spp.*	*Panicum maximum*
	Sporobolus fimbriatus	*Hybernia litonia*	*Cynodon dactylon*
	Cynodon plectostachyus	*Eragrostis superba*	*Themeda triandra*
	Cyperus rotundus	*Chloris roxburghiana*	*Enteropogon macrostachyus*
	Pennisetum incunum	*Pennisetum mensianum*	*Cyperus rotundus*
	Digitaria macroblephera	*Sporobolus fimbriatus*	*Centrus ciliaris*
	Pennisetum mensianum	*Sporobolus pyramidalis*	*Cymbopogon excavatus*
	Chloris roxburghiana	*Centrus ciliaris*	*Chloris roxburghiana*
	Bothriochloa insculpta	*Bothriochloa insculpta*	*Digitaria macroblephera*
	Sporobolus pyramidalis	*Eragrostis tenuifolia*	
	Cymbopogon excavatus	*Hyparrhenia rufa*	
	Centrus ciliaris	*Microchloa kunthii*	
	Hibernia lithonia	*Digitaria scalarum*	
Forbs	*Comelina benghalensis*	*Comelina benghalensis*	*Justicia ancelina*
	Indigofera spicata	*Ocimum basilicum*	*Comelina benghalensis*
	Solanum incanum	*Indigofera spicata*	*Chlorophylum spp.*
	Tephrosia pumila	*Sita ovada*	*Ruellia batula*
	Sita ovada	*Tribulus terrestris*	*Ocimum basilicum*
	Vilentus mandela spata	*Solanum incanum*	*Achyranthes aspera*
	Ocimum basilicum	*Commelina latifolia*	*Leucas martinicensis*
	Erucastrum arabica	*Aster spp.*	*Calinum salisofolia*
	Ipomea mombasana		
	Oxygonum sinuatum		
	Setaria pallitefusica		
	Achyranthes aspera		
	Leucas martinicensis		
	Schcuria binata		
	Tagetes minuta		
	Sonchus aspa		
	Polly halus spinethera		
Annuals	*Digitaria velutina*	*Dactyloctenium aegyptium*	*Digitaria velutina*
	Brachiaria reptans		

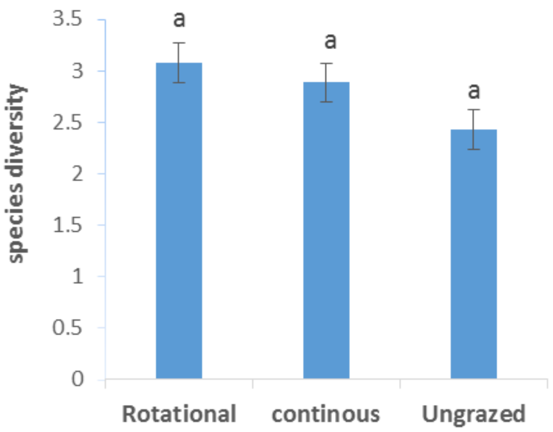

Fig. 3. Herbaceous species diversity under different grazing management systems

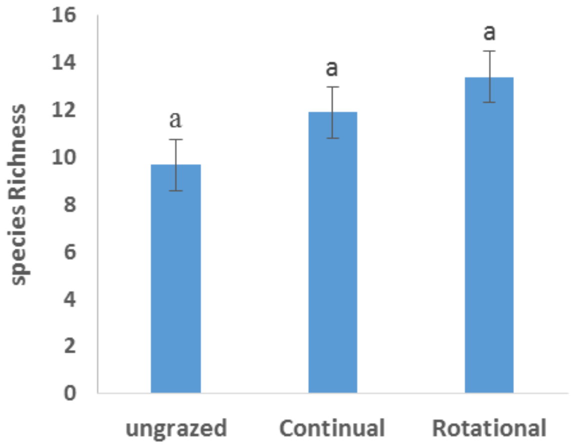

Fig. 2. Herbaceous plant species richness across different grazing management systems

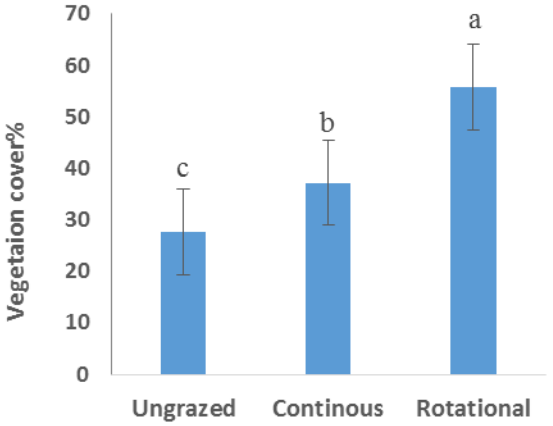

Fig. 5. Herbaceous vegetation cover percentages under different grazing management systems

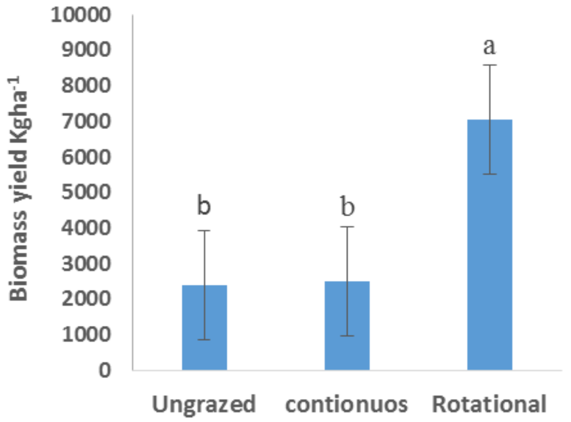

Fig. 4. Herbaceous biomass yield ($Kgha^{-1}$) across different grazing management systems

Different letters indicate significant difference(P≤0.05)

Discussion

Diversity and Richness

The observed low plant species diversity in ungrazed areas can be attributable to the presence of a few dominant tree stands that tap the largest share of the habitat resources (nutrients and light). Belsky (1992) reported that plant species favoured by lack of livestock disturbance through grazing always tend to outcompete plants with smaller statures, an argument that was also supported by (Pekin *et al.*, 2015). On the other hand, we recorded lower herbaceous plant species diversity and richness in the continuously grazed areas compared to the rotationally grazed areas. This implies that the high livestock grazing pressure in the continually grazed areas led to decreased herbaceous species diversity and richness in this semi-arid rangeland.

The high herbaceous plant species diversity in rotationally grazed areas can be attributed to the effects of livestock grazing that results in opening up of the canopy, hence giving chance for regeneration of gap opportunistic plant species (Pekin *et al.*, 2014). The observed high plant species diversity and richness can be attributed to livestock grazing which may have reduced competition among plant species through selective grazing on palatable competitors as well as trampling of both unpalatable and palatable plants during grazing (Rooney & Waller, 2003). Our results are in agreement with the intermediate disturbance hypothesis proposed by Connell (Connell, 1978) whereby the models and metadata analysis have indicated that species richness and the Shannon Wiener diversity index are strong predictors of the intermediate disturbance hypothesis (Svensson *et al.*, 2012). The mechanism underlying the intermediate disturbance hypothesis is centred on a complex interplay between life history, biotic interaction and historical disturbance regime (Catford *et al.*, 2012). The increased availability of plant requirements, such as light, following disturbances through livestock grazing explains why high diversities were observed in rotationally grazed areas. According to Roberts & Gilliam (2003), intermediate disturbance causes changes in local microclimates by opening up space in the canopy, resulting in the release of resources such as sun light, that would otherwise not be accessible to understory plants. Physical disturbances prevent competitively dominant species from excluding other species from the community (Mackey & Currie, 2001). This brings about a trade-off between plant species ability to compete and tolerate various forms of disturbance. Species diversity is low at extremely low levels of disturbance because only the best competitors dominate and persist within community (Connell, 1978). This concept is in agreement with the findings from this study, in which sampling site under the ungrazed area where disturbance was low displayed low plant species diversity. However, in the severely and the highly disturbed areas only a few species persisted or repeatedly colonised after every similar regime of disturbance, thus resulting in low species diversities. This concept also applies to the findings from this study in which continually grazed areas had lower species diversities than rotationally grazed areas which could be probably due to the difference in disturbance from grazing livestock, where by the continually grazed area experienced high grazing pressure which was evident by the fact that it was dominated by unpalatable plant species. Therefore, the balance between competitive exclusion and the loss of competitive dominants through disturbance is attained at intermediate disturbances (Mackey & Currie, 2001)) which in our study, we can put rotationally grazed site under this category due to minimal disturbance with respect rest periods from grazing.

Biomass production and vegetation cover

The enhanced biomass production and herbaceous cover in rotational grazed sites could be attributed to higher forage recovery time under rotational grazing management. These results are similar to those observed by (Alphayo, 2015) while studying the influence of holistic grazing management on biomass production. The low herbaceous cover and biomass yield in ungrazed site was associated to canopy effects by the dense wooded species which affects the growth of herbaceous vegetation through the shedding effects, whereby the herbaceous plants experiences limited light availability as a result of canopy cover leading to low photosynthetic rates hence their low growth.

Under continuous grazing management, livestock graze continuously until forage becomes insufficient to sustain them. This exposes plants to frequent defoliation, which can be detrimental to plant productivity (Kamau, 2003; Kioko *et al.*, 2012; Lemus & Rivera, 2011; Metera *et al.*, 2010). Furthermore, the increased biomass production in the rotationally grazed area can be due the combination of both the frequency and intensity of forage use in the growing season with sufficient recovery time after grazing period (Alphayo, 2015; Oba *et al.*, 2001). This is in contrast to continual grazing system where the land is always continuously being grazed, thus resulting to reduction in herbaceous biomass and cover. The deterioration of the overgrazed areas is evident with respect to the observed low aboveground biomass and cover in continual grazing sites. The low biomass observed in continual grazing sites was partly due to individual plants being subjected to multiple, severe defoliations without enough time for regrowth and flowering. The high frequency of livestock grazing invariably led to a decline in the plant's productivity, root biomass and vigour (Kamau, 2003). The difference in biomass and cover between the two grazing system can also be attributed to the influence of livestock grazing on the composition and structure of the community primarily by modifying the competitive interactions via selective feeding of livestock between plants. The plant species under the rotational grazing have the similar competitive advantage due to less selectivity by grazing livestock, these leads to the high growth rate of the palatable plant species which usually have high biomass compared with the unpalatable plant species found under continual grazing as a result of selective grazing (Kamau, 2003). Similar results were reported by (Gebremeskel, 2006) who found more biomass production under moderate grazing regimes that are well utilized by the grazing animals than areas that had been severely and continuously been grazed in the semi-arid lands of Ethiopia. Our results were also in agreement to those of (Jacobo *et al.*, 2006) who reported that in time-controlled grazing systems, the frequency and duration of grazing and the rest periods is of importance to plant species since it gives amble time to recover from defoliation and gain vigor again for their survival thus resulting in more biomass yield. Both (Radford *et al.*, 2008; Steffens *et al.*, 2008) reported similar results whereby in the well-structured grazing system they found high biomass which they attributed it to the to the adequate recovery time allowed for grazed plants after defoliation than in the continuous grazing that is always subjected to high grazing pressure on continual basis without rest.

The high herbaceous biomass production and vegetation cover under rotational grazing can be attributed to the good soil conditions due to the herbaceous standing biomass which promotes soil and water conservation. The more herbaceous aboveground standing biomass in rotationally grazed sites promotes soil and water conservation hence improved ability to control erosion therefore, soils in the rotationally grazed area allow water to penetrate into the cracks of the soil, which are formed by the plant roots, hence allowing sufficient water infiltration and aeration that are prerequisite conditions for the growth and development of plants (Bilotta *et al.*, 2007).

The low herbaceous biomass under continual grazing site can be due to high utilization of pasture in the continually grazed areas is an indication of high grazing pressure, and it effects on vegetation production by removing bunch grasses hence exposing the soil to higher erosion, low water infiltration thus resulting in minimal moisture and soil fertility (Alphayo, 2015). The low biomass production and vegetation cover under the continual grazing system can also be attributed to the, reduced plant leaf area by grazing animals and with insufficient or no time to recover which affects negatively the absorption of active radiation for photosynthesis. This is evidenced by the low biomass production which is as a result of reduced plant's ability to convert light energy into chemical energy for production of biomass. The functioning, growth and development of plant is normally affected by limited conversion of energy (Li *et al.*, 2013). The root system is also greatly affected by high grazing pressure because the energy to support the root biomass and new root production is reduced hence affecting the longevity of the roots as well. When plants are subjected to high grazing pressure, their ability to access the required water and nutrients for their survival is undermined (Holechek, 2001) leading to low plant biomass as was observed in the continually grazed sites.

In his study on savanna dynamics in relation to rangeland management systems and environmental conditions in semi-arid rangelands of Botswana, (Kgosikoma, 2012) observed that grazing intensity is the major factor determining the influence of grazing on the ecosystem, and that continuous grazing leads to overuse of forage resources, which affects the ability of plants to regrow after defoliation hence low aboveground herbaceous biomass and cover. In a study on the linkages between land use change, land degradation and biodiversity across East Africa by (Maitima *et al.*, 2009), grazing type and the grazing intensity were found to have profound impact on biodiversity and that to achieve better results in the production of forages resources, the two factors needs to be balanced.

Conclusions

Grazing management is considered the most important of all grazing management decisions. Arid rangelands are typically resilient and capable of regeneration even though the process of regeneration can be delayed by natural forces (droughts) or by the interference of overgrazing, time of grazing introduction, and heavier stocking rates. However, we confirm that rotational grazing on arid rangelands is an effective tool for their sustainable management. By controlling stoking rates, managers conserve biodiversity, increase primary productivity and vegetation ground cover while ensuring the continued productivity of forage.

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چکیده. اسپرس یکساله *Onobrychis crista-galli* L. سازگاری خوبی به مناطق معتدل و سرد ایران دارد و به صورت طبیعی در مراتع رویش دارد و از آن برای تولید علوفه و چرای دام استفاده می‌شود. به منظور بررسی تاثیر پرایمینگ بذر بر بهبود جوانه‌زنی و رشد گیاهچه در *O. crista-galli*، دو آزمایش فاکتوریل جداگانه در قالب طرح کاملا تصادفی با ۳ تکرار در سال ۱۳۹۴ در آزمایشگاه و گلخانه موسسه تحقیقات جنگل‌ها و مراتع، تهران، انجام گرفت. فاکتور A شامل ۵ روش نگهداری بذر ذخیره‌سازی میان مدت (دمای ۴ °C به مدت ۱۵ سال)، طولانی مدت (دمای ۱۸- °C مدت ۱۵ سال)، بذرهای احیاء شده (شاهد) و تیمار پیری زودرس با قرار دادن بذور در دمای ۴۱ °C و رطوبت ۱۰۰٪ در دو بازه زمانی ۴۸ و ۷۲ ساعت بودند. فاکتور B، پرایمینگ بذر در ۴ سطح شامل اسموپرایمینگ با پلی‌اتیلن گلایکول PEG6000 (۰/۴- و ۰/۸-مگاپاسکال)، هیدروپرایمینگ (خیساندن بذر به مدت ۲۴ ساعت در آب مقطر) و شاهد (بدون پرایم) بودند. بذرهای پرایم شده اسپرس و شاهد در آزمایشگاه و گلخانه کشت شدند و پس از ۲۱ روز رشد در ژرمیناتور و ۴۵ روز رشد در گلخانه صفات درصد جوانه زنی، شاخص بنیه بذر، طول ریشه‌چه، طول ساقچه، طول گیاهچه و وزن‌تر گیاهچه اندازه‌گیری شد. داده‌ها با استفاده از نرم افزار SAS_9 مورد تجزیه واریانس قرار گرفتند و میانگین اثرات اصلی و اثرات متقابل با روش دانکن مورد مقایسه قرار گرفتند. نتایج نشان داد که در آزمایشگاه، بیشترین میانگین صفات جوانه زنی بجز طول ریشه‌چه در حفاظت طولانی مدت (دمای°C ۱۸-) بدست آمد. در گلخانه بیشترین رشد رویشی گیاهچه با تیمار اسموپرایمینگ (۰/۴- مگاپاسکال) مشاهده شد. در هر دو محیط آزمایشی هیدروپرایمینگ نیز اثر معنی‌داری بر افزایش میانگین صفات جوانه زنی و رشد گیاهچه در هر دو سیستم حفاظت شده میان مدت و طولانی مدت داشت. در هر دو سیستم حفاظت بذر بیشترین طول ریشه‌چه از طریق اعمال اسموپرایمینگ (۰/۴- و ۰/۸-مگاپاسکال) بدست آمد. در تیمارهای پیری زودرس بیشترین میانگین صفات جوانه‌زنی و رشد گیاهچه از طریق اعمال اسموپرایمینگ (۰/۴- مگاپاسکال) بدست آمد. نتیجه‌گیری کلی نشان داد که اسموپرایمینگ روشی کارآمد در بازیافت بذور زوال یافته طبیعی و مصنوعی می‌باشد.

کلمات کلیدی: زیست توده، پوشش، تنوع، غنا، مدیریت چرای دام