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Impact of grazings on soil, vegetation and ewe production performances in a semi-arid rangeland

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Abstract: Controlled grazing is considered a good management strategy to maintain or increase the live weight of livestock and to reduce vegetation degradation of rangelands. The present study investigated soil characteristics, aboveground vegetation biomass dynamics and controlled grazing-induced changes in the live weight of local ewes in the semi-arid rangeland of Ahmadun, Ziarat, Balochistan province of Pakistan. An area of 115 ha was protected from livestock grazing in April 2014. In June 2015, soil characteristics within 0-30 cm depth i.e. soil organic matter (SOM), mineral nitrogen, pH and texture in controlled and uncontrolled grazing sites were assessed. Aboveground vegetation biomass measured in early (June) and late summer (August) in 2015 and 2016. The nutritional value i.e. crude protein, phosphorus (P), neutral detergent fiber (NDF), acid detergent fiber (ADF), calcium (Ca), magnesium (Mg) and potassium (K) of dominant plant species were assessed at the beginning of experiment in 2015. Vegetation cover of controlled and uncontrolled grazing sites was also measured during the two years of the study period using the VegMeasure software. From June to November in 2015 and 2016, controlled and uncontrolled livestock grazing sites were grazed on a daily basis by local ewes with a stocking rate of 2 and 1 head ha^{-1} respectively. Results reveal that the organic matter contents of coarse-textured, slightly alkaline soil of the study site were in the range of 9.4 - 17.6 g kg^{-1} soil and showed a strong positive correlation with aboveground vegetation biomass. The biomass of plants was 56.5% and 33% greater at controlled than uncontrolled grazing site in 2015 and 2016 respectively and plant cover was also higher at controlled than uncontrolled grazing site in both years. The nutrient contents were significantly ($P<0.05$) lower in grasses than shrubs. In both years, controlled grazing increased ~2 fold the weight gain of ewes as compared to uncontrolled grazing. The results indicate that controlled grazing improved the vegetation biomass production and small ruminant productivity.

Keywords: Grazing exclosure; Soil organic matter; Vegetation cover; VegMeasure

Introduction

According to most estimates, drylands cover more than 41% of the land surface of the world that accommodate around 30% - 35% of the total human population and 90% of this fraction live in developing countries (Davies et al. 2012). Around 65% of the human population depends on livestock for their livelihood (UN 2011), and rangelands accommodate approximately 50% of the world's livestock (van Oudenhoven et al. 2015). Livestock in arid and semi-arid regions of underdeveloped countries largely depends on rangelands for feed, where pastoralists feed their livestock freely on rangelands. Vegetative growth in arid and semi-arid rangelands is limited due to biotic and abiotic factors (Teague et al. 2011). Precipitation is the main limiting factor for plant growth and low rainfall limits vegetation regrowth after grazing that pose difficulties for pastoralists to manage and improve livestock production (Sanjari et al. 2008). Consequently, the biomass, distribution and diversity of palatable species undergo continuous reduction due to uncontrolled grazing, reducing overall rangeland productivity (Louhaichi et al. 2009; Ahmad and Islam 2011). In this situation rangeland protection is necessary to maintain vegetation biomass and ecosystem services provided by these rangelands (Gamoun et al. 2011).

Pakistan has an area of 87.98 million hectares (mha), out of which 45.2 mha is rangelands (Ahmad and Islam 2011). Balochistan has an area of 34.7 mha, of which rangelands cover 93% of the land area of this province (FAO 1983). Rangelands in Balochistan have traditionally been grazed by Baloch, Pushtoon, Brahvi, and Sindhi pastoralists as well as Afghan nomads. In Balochistan, anthropogenic factors, especially continuous grazing and persistent drought, have reduced the diversity of grasses, shrubs and herbs (Shah 2016). Due to an increasing population in the region since 1979, the demands on these rangelands as a source of forage and wood for fuel have been high.

In early 70's controlled grazing (closure for entire growing season) was in practice in the remote areas of Balochistan. Such management practices were called as Pegore or Rakh in local language. This traditional grazing management system has mostly vanished in Balochistan except in district Musakhail where it is still practiced. The uncontrolled grazing in Balochistan has severely affected rangelands (Ahmad and Islam 2011; Qasim et al. 2017). Controlled grazing that involves the timing of livestock grazing set by local pastoralists, based on apparent forage condition (Grigoli et al. 2012; Enri et al. 2017), is expected to maintain rangeland productivity in arid and semi-arid regions (Holechek 1991). Controlled grazing can be a good management practice to improve the productivity of rangelands of Balochistan. The objectives of this study were to 1) characterize the study area for soil quality (i.e. organic matter contents, texture, pH and concentration of mineral nitrogen), 2) nutritional quality of dominant plant species and 3) the influence of controlled grazing on aboveground vegetation biomass and cover and weight gain of local ewes.

1 Material and Methods

1.1 Study Site

The study site, "Ahmadun Tangian" is located in District Ziarat (30°37/N, 67°72/E). The elevation of study site from sea level ranges from 2287 m in the north to 2146 m in the south (Figure 1). The region receives summer and winter monsoon precipitation (Figure 2). The region is also characterized by cold winters and warm dry summers. Annual rainfall varies between 250 and 300 mm and is dominated by winter snowfall. The rainfall/precipitation during the study period (i.e. 2014 and 2015) was 227 and 221 mm (Figure 2) and was lower than the long-term average of over ten years precipitation (i.e. 300 mm). The mean maximum temperature in summer is 36 °C and the mean minimum temperature in winter is -1°C. The dominant vegetation in the community is characterized by *Seriphidium quettense* and the C4 grasses *Cymbopogan* and *Chrysopogan* spp. *Sophora griffithi, Convolvulus spinosus*, *Perwskia atriplicifolia* dominate the upper vegetation layer.

In April 2014, an area of 115 ha was demarked with white-painted stones and was protected from uncontrolled grazing after commitment with local farmers of the region. The protected site (hereafter called controlled) was further divided into 4 equal blocks A, B, C, and D in April 2015. Another adjacent area of similar size (115 ha) was used as uncontrolled grazing site (E) which was under free utilization by the livestock of local pastoralists and was further divided into four equal blocks for livestock grazing trial (Figure 1).

1.2 Physico-chemical analysis of soil

Soil sampling was carried out in April 2015. At controlled site, soil samples were collected from each block A, B, C and D from four random locations (four replicates per block and a total of sixteen replicates from controlled site). At site E, soil samples were collected from four random locations (a total of four replicates from uncontrolled E site). Soil samples were collected from three depths; 0-10 cm, 10-20 cm and 20-30 cm and were analyzed using the "weight loss on ignition method" described by Robertson (2011) and Craft et al. (1991). This method is commonly used to estimate organic matter contents of rangeland soils (e.g. Fallahzade and Hajabbassi 2011; Pacaldo et al. 2014). Moreover, this method is reported to be reliable for estimating soil organic matter if soil is burned at $\leqslant$ 360^{o}C as at this temperature, organic matter contents get burned while carbonates do not burn (Jia-Ping et al. 2013). Soil samples from the 0-10 cm depth were used for soil pH and texture estimation. Soil texture estimation was carried out using the method described by Estefan et al. (2013). Soil pH was analyzed with 1:1 w/v soil:water ratio as described in Estefan et al. (2013). Ammonium (NH_4^+) and nitrate (NO_3^-) for total mineral N estimation was analyzed for the pooled sample of soils collected from 0-10cm, 10-20cm and 20-30 cm depth. The protocol of Sims et al. (1995) was followed in this regard except that we used UV-visible spectrophotometer (Shimadzu UV-1700 Pharmaspec UV-Visible spectrophotometer) instead of microplate reader.

1.3 Aboveground vegetation biomass, nutritional status and vegetation cover assessment

The first sampling for vegetation characteristics was initiated in June 2015 using the line intercept method described by Herrick et al. (2015). Three transects of 100-meter length were stretched at three directions perpendicular to each other of each block and a 1 m^2 quadrate was used after each 10 m on alternate sides of the transect. Standing forage was clipped at 3-4 cm above ground level (to allow regeneration of plants) and then oven-drying at 60 °C for 48 hours. This was expressed as the dry weight of biomass per m^2 and converted in to kg ha^{-1}. Thirty quadrats were collected from each block, and the averages (of each sampled block) were used for data analysis. The same process was repeated in August 2015, April 2016 and in August 2016.

The oven-dried pooled samples of individual plant species collected from all study sites were used for chemical analysis. Plants were digested using the Kjeldahl method (Estefan et al. 2013). The digested aliquot was subjected to estimation of total nitrogen (N), phosphorous (P), potassium (K), calcium (Ca) and magnesium (Mg) in plant samples. For crude protein estimation, the concentration of total N in plant samples was multiplied by 6.25 (Estefan et al. 2013). Plant sample neutral detergent fiber (NDF), acid detergent fiber (ADF) were analyzed according to AOAC (1990) and i*n-vitro* organic matter digestibility (IVOMD) according to Catling et al. (1994).

The canopy cover of the Ahmadun rangeland vegetation in controlled and uncontrolled grazing sites was estimated using high-resolution Nikon digital camera 134, following the digital vegetation charting technique (DVCT) protocols (Louhaichi et al. 2017). The camera height was maintained at 1.5 m so that images were comparable. Captured Images were analyzed using VegMeasure software to estimate percent vegetation versus percent bare soil. VegMeasure® is a computerized vegetation measurement program developed by the Department of Rangeland Ecology and Management at Oregon State University (Louhaichi et al 2010; Tarhouni et al. 2016).

1.4 Controlled grazing

The controlled grazing experiment was designed based on the method described by Holechek et al. (2003). In both controlled and uncontrolled sites after calculating the carrying capacity, 2 animal units ha^{-1} (58 ewes in 28.8 ha plot) and 1 animal units-ha^{-1} (29 ewes in 28.8 ha plot) were allowed to graze on the land respectively, based on biomass production. The experimental ewes in controlled grazing scheme were allowed to graze in four blocks i.e.; A, B, C and D. After every 15- days, the flock was moved to the next block until block D, and the second round of rotation continued from block A. During both years (2015-2016), the ewes were allowed to graze 6-8 hrs daily for a period of 152 days from 02 June to November 01. In 2015, Shinwar sheep breed while in 2016, Harnai sheep breed were used for grazing experiment. All the experimental ewes were ear tagged and drenched anthelmintic (Nilzan Plus at 1 ml/kg boy weight) before the start of experiment. The live-weight gain data was collected on the first day followed by 15 days' interval until the end of the experiment.

1.5 Statistical analysis

The data were subjected to a normal distribution assessment using D'Agostino-Pearson K^2 test. The data for SOM contents were analyzed with non-parametric one way analysis of variance (ANOVA) using Kruskall-Wallis test. The data of chemical analysis of plant tissues were analyzed with one way ANOVA. The data of aboveground vegetation biomass was subjected to two way ANOVA with two factors i.e. years and sampling time. The differences between treatment means were analyzed with least significance difference (LSD) test. The difference in live weight gain of ewes between controlled and uncontrolled grazing treatments for a given experimental year was analyzed with student's t-test statistics. All the statistical analysis was carried out with CoStat software version 6.311 and Microsoft Excel.

2 Results

2.1 Physico-chemical properties of soil

The soil chemical property of study area is presented in Table 1. Soil organic matter (SOM) at 0-30 cm depth range from 14.7 g kg^{-1} to 11.6 g kg^{-1}. The pH of soil from 0-10 cm depth range from 7.8 to 8.3 (Table 1) and soil texture of 0-10 cm depth range from sandy silt loam to sandy loam. SOM contents were significantly different among sites ($P < 0.05$), while there were no differences in SOM contents between depths. Soil SOMs at site A and D were higher than those in other sites, and site E (open-for-grazing) had the least amount of SOM contents in all three depths (Table 1). Soil organic matter showed strong positive correlation with aboveground plant biomass (Table 1). Mineral N (ammonium (NH_4^+) + nitrate (NO_3^-)) contents were significantly higher for the soil taken from site A, site B and site D than site C and site E (Table 1; $P \leqslant 0.05$). Site E had the least concentration of mineral N in soil (Table 1; $P \leqslant 0.05$). SOM and mineral N contents of soil showed a strong positive correlation with aboveground vegetation biomass (Table 1; $P \leqslant 0.05$).

2.2 Aboveground vegetation biomass, nutritional status and vegetation cover

The dry vegetation biomass production, both in controlled and uncontrolled plots were significantly different in 2015 and 2016 ($P \leqslant 0.05$; Figure 3). The dry vegetation biomass was significantly higher for first sampling event for all sites as compared to other sampling events ($P \leqslant 0.05$; Figure 3). For instance, for the June 2015 sampling, dry biomass production was 1706, 1499, 1042, 1690 and 630 kg ha^{-1} for blocks A, B, C, D and E (uncontrolled grazing site) respectively, while in the June of second consecutive year (2016), dry biomass production was 746, 711, 597, 749 and 457 kg ha^{-1} in blocks A, B, C, D and E (uncontrolled grazing site) respectively (Figure 3). The dry biomass production at controlled grazing site was higher than uncontrolled grazing site across all sampling events ($P \leqslant 0.05$; Figure 3).

Crude protein concentrations varied greatly among species at the same sampling time and were significantly higher ($P < 0.05$) in shrubs (9.8% - 14.2 %) than in grasses (7.9% - 9.1%). The ADF, NDF, Ash and IVOMD concentrations fluctuated significantly during the growing season. Concentrations of P were significantly ($p < 0.05$) higher in grasses than in shrubs. Mg and K were significantly higher ($P < 0.05$) in the shrubs (Table 2) than in either of the grass life forms (annual or perennial).

In both years, in controlled plots, grasses contributed up to 30% in the total biomass production, which varied due to availability of soil moisture during whole season. In uncontrolled plots, after spring, the grass contribution was nearly 10% and in summer its contribution reduced up to 5% (Figure 4). The photographs taken in May 2015 and May 2016 from the same sites were used to assess the difference in percent cover of vegetation and bare soil (Figure 5). The plant cover was higher in controlled than uncontrolled grazing site in both years (Figure 5). Plant cover was 56.5% and 43.9% in the controlled grazing site during 2015 and 2016 respectively while it was 44.7% and 21.7% in the uncontrolled grazing site in 2015 and 2016 respectively (Figure 5).

2.3 Weight gain of ewes subjected to controlled grazing trial

The average final live-weight gain for ewes grazed on controlled grazing site during the 152 day period was almost double that of ewes grazed on uncontrolled grazing site during 2015 and 2016 (Table 3; $P \leqslant 0.05$). The experimental ewes that grazed on controlled rangelands showed significantly higher daily live-weight gain compared to ewes that grazed on uncontrolled site. The average live-weight gain (kg) per hectare also increased in a similar trend. The final live-weight (kg) gain of entire group of ewes per hectare showed a similar trend with higher gains on controlled grazing site than on uncontrolled grazing site during the two years.

3 Discussion

The amount of precipitation and the availability of soil water are the key factors in determining the rangeland productivity (Reeves et al. 2014). In Ahmadun, despite variation in rainfall pattern, our one year complete protection from grazing improves the rangeland productivity but previous heavy grazing in the area has a major impact on loss of species diversity and lack of opportunity for plant regeneration. Strong correlation of aboveground plant biomass with SOM and total mineral N contents indicate that aboveground plant biomass is an important indicator for SOM and nutrient contents in this rangeland, which has coarse-textured soil.

Many researchers have reported that grazing exclusion has a positive impact on rangeland conditions in that there is increased vegetation structure, improved composition of available flora and increased rangeland productivity (Bailey and Brown 2011; Briske et al. 2011; Gamoun and Hanchi 2014). In our experimental site, biomass varied between sites and was lowest in the uncontrolled livestock grazing site. Furthermore, total biomass production reduced significantly in response to grazing in all study sites in summer and the following year after the summer. Senescence of leaves and cessation of the growth of new shoots of dominant palatable plant species (i.e. *Haloxylon griffithii, Seriphidium quettense, Hertia intermedia, Lactuca orientalis*) in late spring (i.e. May) due to reduced rainfall-associated low water availability and grazing may explain reduced total vegetation biomass production in summer. The amount of precipitation in spring and early summer are the key factors that determine rangeland productivity (Reeves et al. 2014; Oomen et al. 2016). This aspect of Ahmadun rangeland may explain its productivity regarding livestock production since grasses in this region are mostly highly palatable.

Livestock production depends largely on the forage quality than the quantity (Bailey and Brown 2011), which is effected by precipitation (Trott et al. 2004; Reeves et al. 2014), or by grazing intensity (Kristensen 1988). In Ahmadun, it is observed that palatable grasses had higher fiber contents (NDF and ADF) and contributed towards higher dry matter intake by small ruminants. The forage quality of grasses may further drop later in the summer as the plants mature. At the time of sampling, all species had concentrations of nitrogen in foliage that were higher than 1% N (dry weight basis); which is the recommended minimum requirement for small ruminants by National Research Council (NRC) (2007). The concentrations of phosphorus and calcium were enough for grazing ruminants except in a few plant species. All shrub and grass species had higher concentrations of potassium than the rate of 0.5% - 0.8% recommended by the NRC (2007). Magnesium concentrations were also higher in all species. Our preliminary studies of plant nutrition of species in Ahmadun has provided basic information of nutritional quality of forage plants. Future studies are required to investigate the nutritional status of forage plant species at seasonal bases and as influenced by management practices.

For the first time in Pakistan, a nondestructive method was used to estimate vegetation cover of rangelands. Thus, the VegMeasureR software was successfully used to quantify vegetative ground cover in Balochistan rangelands. This measure is less labor exhaustive than traditional extractive methods and it is also easily accessible for monitoring rangeland productivity (Louhaichi et al. 2010). Our results demonstrate that VegMeasure allows a low cost and rapid measure of early vegetative cover in the field that could easily be incorporated into future rangeland programs for rangeland managers to develop their regular planning.

After evaluating the total available biomass production, light stocking rates were set at Ahmadun for sustainable productivity of both range and livestock (Holechek 2003). In controlled and uncontrolled grazing sites, the stocking rate was 2 animal units-ha-1 and 1animal units-ha-1 based on biomass production of the experimental site. In both years, the weight gain in controlled area was significantly higher 7 kg to 6 kg per head during 2015 and 2016 respectively in five months compared to -uncontrolled area where the weight gain was 3 kg per head. Results from this current study are helpful for range managers in evaluating the possible effects of changes in grazing pressure on the Ahmadun rangeland, although there is a need for more assessment of how small ruminants are managed (light or light/moderate grazing or greater levels of grazing) to maintain and improve the rangeland productivity in this particular area. In such degraded conditions, grazing management strategies should be developed not only with respect to the rangeland carrying capacity but also the rest period duration and the grazing frequency that allow for plant regeneration and growth (Ahmad et al. 2007, 2010). In this situation, grazing strategies should be developed to prevent the disappearance of palatable species beyond a threshold level that allows unpalatable species to attain dominance in the community.

4 Conclusions

Rangelands have a vital role in Balochistan due to numerous ecosystem services offered to the community including food, forage, medicine and wood. Based on the findings of this study, we can suggest that un-controlled livestock grazing has negatively affected the vegetation biomass and the plant species composition of the target study site. Protection from unmanaged livestock grazing in our study showed improved rangeland productivity. In order to reverse the trend of degradation there is a need first to improve the awareness of the local herders and convince them about the importance of their fragile ecosystem. At a later stage, moderate grazing (low stocking rate) could be introduced to maintain rangeland productivity. Grazing management should take into account vegetation physiological stage and avoid early grazing and overgrazing. Any grazing scheme should be implemented with full participation of the local communities to achieve sustainable rangeland-based livestock production system.

Furthermore, in order to withstand the harsh environment of Balochistan, characterized by huge rainfall variability and even larger fluctuation in primary productivity, during extreme droughts the Government of Balochistan may provide supplements to support the local herders for sustaining their livestock and their livelihood.

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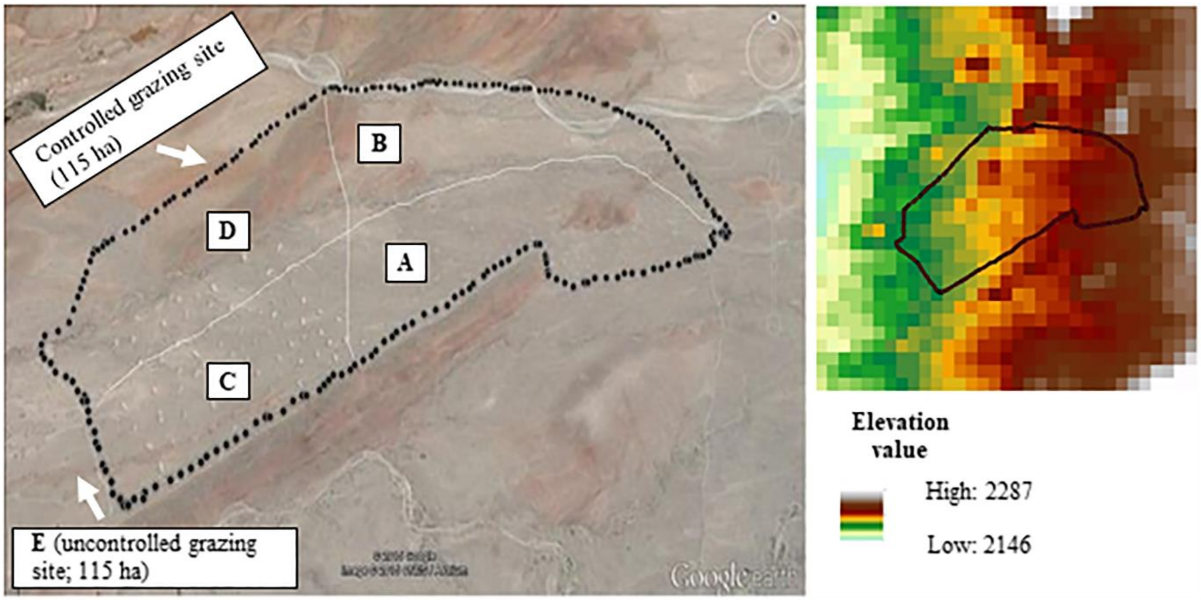

Figure 1 Site map of 4 - controlled blocks from grazing (A, B, C, D) and uncontrolled area (E).

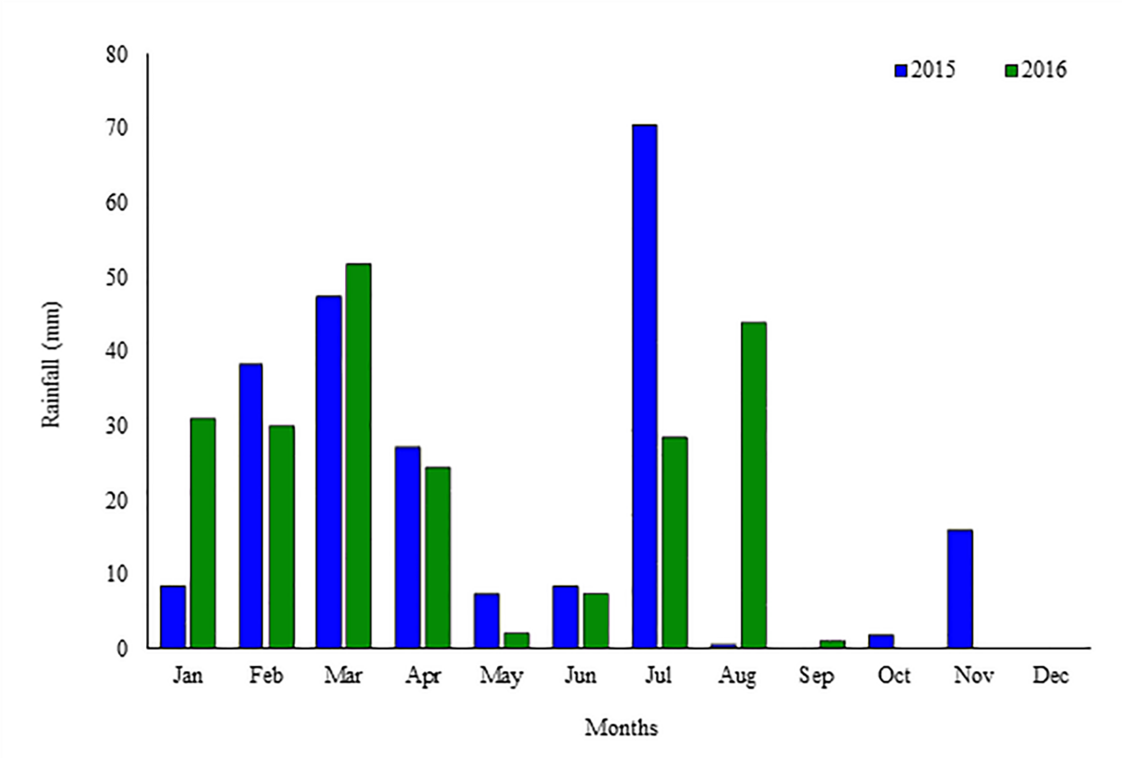

Figure 2 Rainfall distribution (mm) during 2015 and 2016 at Ahmadun Ziarat.

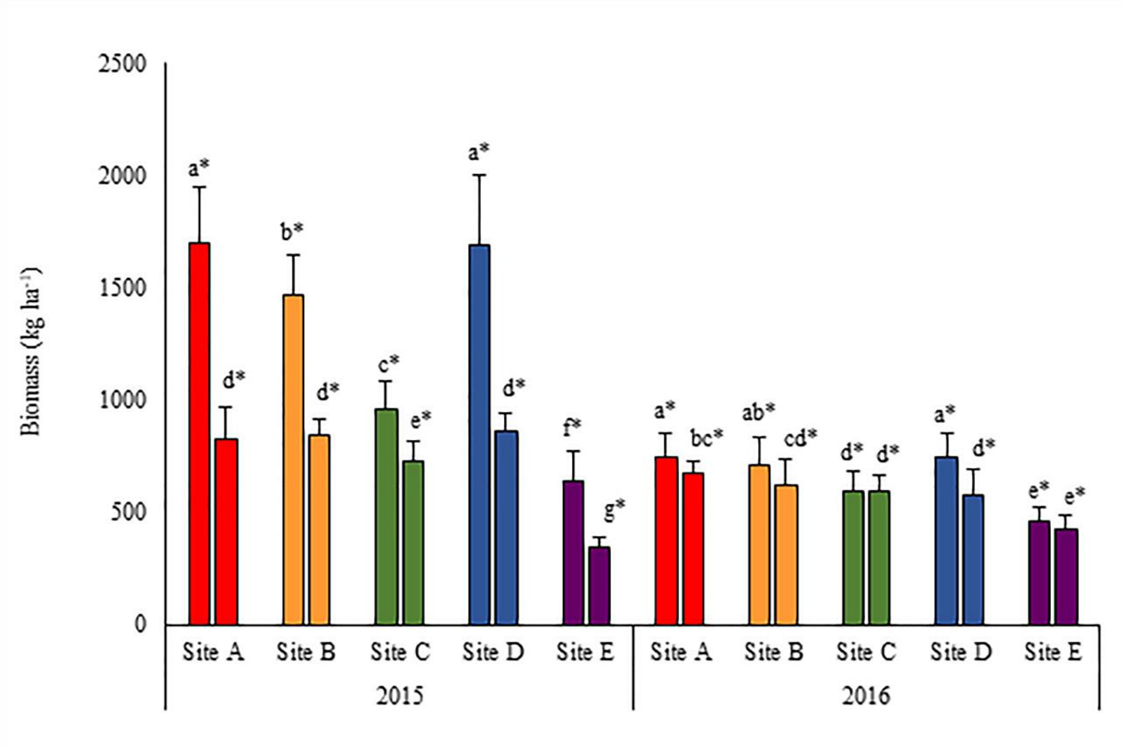

Figure 3 Aboveground plant biomass at sites A, B C, D and site E sampled in June and August during 2015 and 2016. Different letters represent significant difference (*P* aboveground plant biomass at sites A, B C, D and site E sampled in June and August during 2015 and 2016. Different letter<0.05) in aboveground vegetation biomass of sites between years.

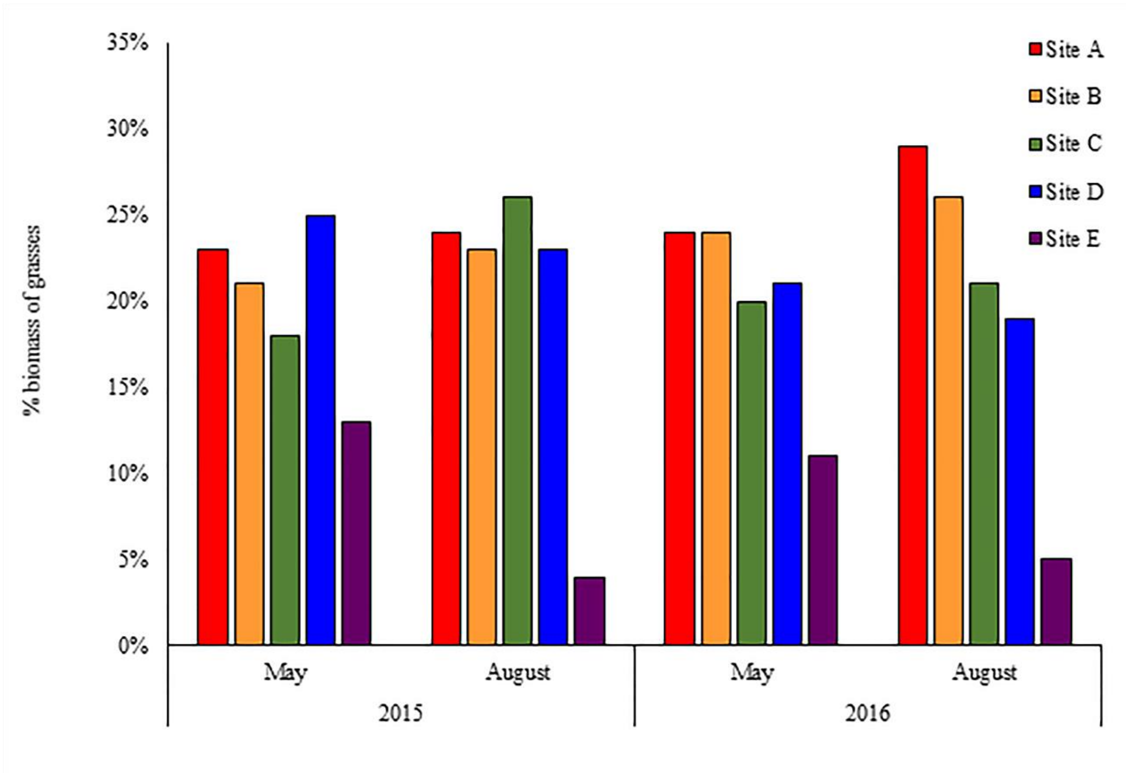

Figure 4 Contribution of grasses to the total biomass production during 2015 (May, August) and 2016 (May, August).

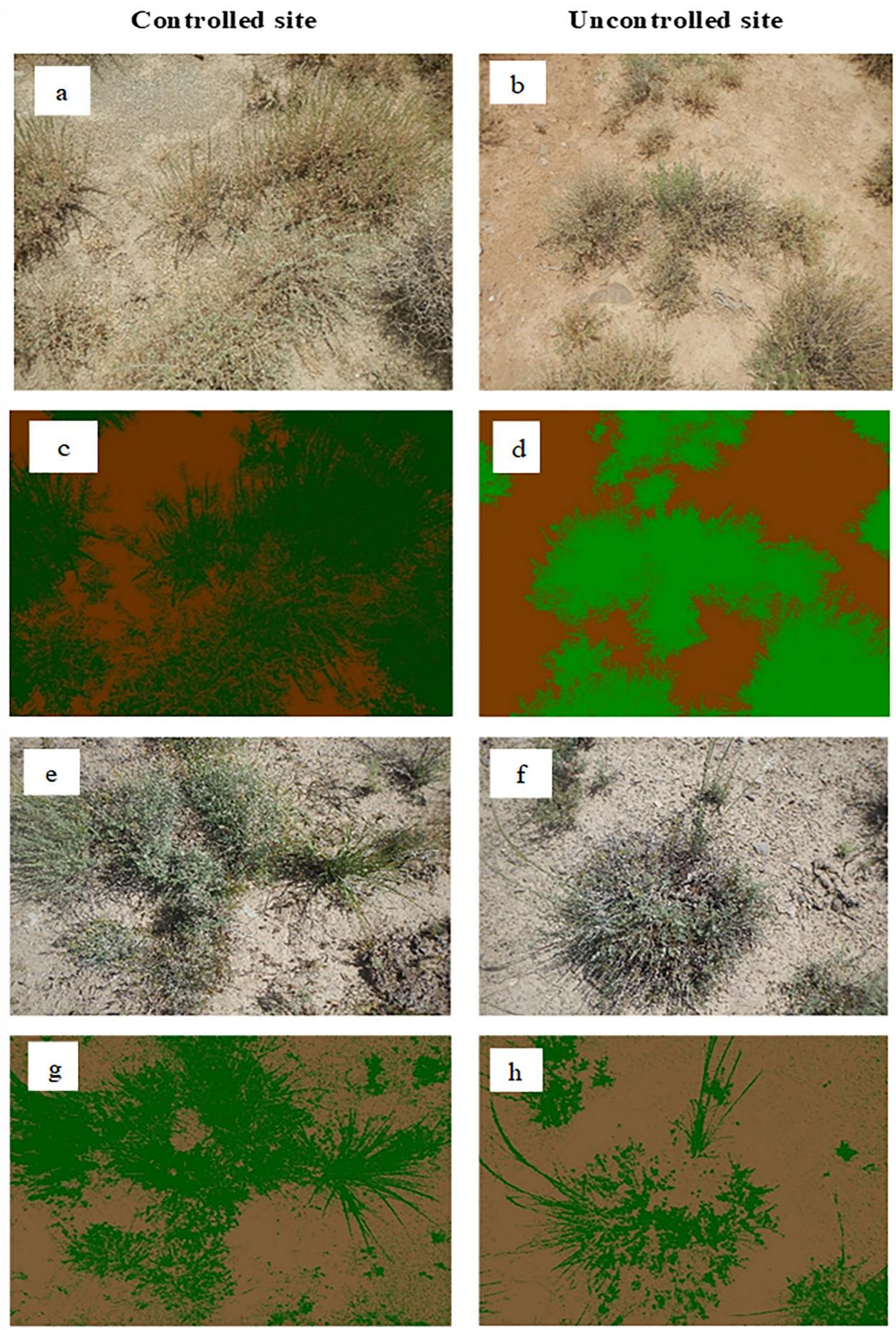

Figure 5 Original and processed digital images using VegMeasure software 2015 (a-d) and 2016 (e-h).

Table 1 Soil properties at controlled and uncontrolled sites.

SOM (g kg^{-1})	Site A	Site B	Site C	Site D	Correlations	
0-10 cm	14.44 ± 2.81	14.45 ± 1.02	11.71 ± 2.64	17.63 ± 3.52	SOM with plant biomass	
10-20 cm	14.94 ± 2.09	15.69 ± 1.48	12.98 ± 2.89	15.49 ± 2.62	0-10 cm	r^2 = 0.907*
20-30 cm	14.88 ± 2.67	14.49 ± 3.15	9.42 ± 3.41	14.76 ± 4.76	10-20 cm	r^2 = 0.945*
Soil texture					20-30 cm	r^2 = 0.828
Sand (%)	35	52.5	50	47.5	SOM with soil mineral N	r^2 = 0.759
Silt (%)	62.5	37.5	37.5	50	Soil mineral N with biomass	r^2 = 0.906*
Clay (%)	2.5	10	12.5	2.5		
Soil pH	7.7	7.8	8.0	7.8		
Soil mineral N contents (mg kg^{-1})	17.90 ± 1.17	20.40 ± 3.49	10.94 ± 5.09	16.37 ± 2.08		

Note: Non-parametric one way ANOVA Kruskall-Wallis test reveals significant differences for SOM contents between sites (P = 0.0311). Correlation values with * show significant relation at $P \leq 0.05$.

Table 2 Concentrations of CP, NDF, ADF, Ash IVDOMD, P, Ca, Mg and K (% oven dry weight) in the foliage growing at Ahmadun, District Ziarat.

Lifeform / Shrubs	CP	NDF	ADF	Ash	In Vitro DOMD	P	Ca	Mg	K
Haloxylon griffithii Boiss	13.2^{b}	39.1^{i}	23.6^{cd}	12.3^{e}	63.5^{b}	0.86^{l}	1.5^{f}	2.3^{d}	1.8^{ab}
Sophora mollis (Royle)	14.2^{a}	35.8^{k}	25.3^{bcd}	23.5^{a}	58.6^{c}	1.45^{f}	1.2^{h}	9.5^{a}	0.7^{b}
Peganum harmala Linn	12.4^{c}	32^{l}	27^{abcd}	8.6^{g}	55.7^{e}	0.9^{k}	1.8^{e}	4.6^{b}	1.4^{b}
Seriphidium quettense (Podlech)	13.4^{b}	44.5^{g}	33.6^{a}	12.3^{de}	53.5^{g}	1.87^{d}	1.5^{f}	2.3^{d}	0.7^{b}
Hertia intermedia (Boiss)	11.6^{d}	38.6^{ij}	22.5^{d}	11.5	47.6^{i}	0.98^{i}	1.9^{e}	2.9^{c}	2.1^{ab}
Lactuca orientalis (Boiss.)	10.9^{e}	46.2^{f}	21.3^{d}	13.5^{d}	55.4^{e}	1.12^{g}	1.3^{g}	2.1^{d}	1.7^{b}
Convolvulus arvensis Linn.	$11.3d^{e}$	38.4^{j}	30.8^{d}	22^{b}	49.6^{h}	1.55^{e}	1.2^{h}	1.3^{f}	0.6^{b}
Alhaji camolorium Fisch	9.8^{f}	42.3^{h}	34.7^{a}	18.4^{c}	45.7^{j}	0.95^{j}	1.1^{i}	1.6^{e}	0.9^{b}
Ephedra intermedia Schrenk	12.5^{c}	58.5^{a}	33.2^{a}	12.4^{e}	40.5^{k}	0.9^{k}	2.47^{a}	0.65^{gh}	1.1^{a}
Perovskia atriplicifolia Benth.	11.98^{d}	49^{e}	33^{a}	8.4^{gh}	55.6^{e}	1.1^{h}	1.98^{d}	0.87^{g}	1.3^{b}
Grasses									
Poa bulbosa Linn (annual)	9.1^{g}	56.3^{b}	31.3^{ab}	7.9^{h}	65.3^{a}	1.9^{c}	1.98^{d}	0.45^{hi}	0.9^{b}
Chrysopogon aucheri (Boiss) (perennial)	8.4^{h}	54.4^{c}	34.34^{a}	6.8^{i}	56.7^{d}	2.2^{a}	2.11^{c}	0.21^{ij}	0.45^{b}
Cymbopogon jwarancusa (Jones) (perennial)	7.9^{h}	52.7^{d}	30.23^{abc}	7.3^{i}	54.2^{f}	2.1^{b}	2.34^{b}	0.18^{j}	0.43^{b}
P Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Note: Values within column followed by different uppercase letters are significantly different at $P \leqslant$ values. Crude protein (CP); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); In Vitro Dry Organic Matter Digestibility (IVDOMD); Phosphorus (P); Calcium (Ca); Magnesium (Mg); Potassium (K).

Table 3 Animal production performances in controlled and uncontrolled livestock grazing sites.

	Parameters	2015	
		Controlled	Uncontrolled
a.	Total area (ha)	115	115
b.	Numbers of plots	4	4
c.	Hectares per plot *(a/b)*	28.8	28.8
e.	Stocking rate (head/ha)	2	1
f.	No of animals per plot	58	29
f.	Days grazing/plot	15	15
g.	Days rest period /plot	45	45
h.	Total days on pasture	152	152
j.	Mean initial weight (kg)/head	51.0	50.5
k.	Mean final weight (kg)/head	58.0	53.2
l.	Mean daily gain (gram)	46.1	17.7
m.	Weight gain (kg/head)	7	3