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Comparison on allowable use of *Bromus tomentellus* in semi-steppe and mountainous rangelands of Alborz and Zagros

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Abstract

Current research was performed in selected sites of semi-steppe and mountainous rangelands of Alborz and Zagros. *Bromus tomentellus* is a key and palatable species which has a considerable portion in rangelands production. For this purpose, 40 similar species of *Bromus tomentellus* were selected in each site. Selected species were exposed to different harvesting intensities of 25, 50 and 75% and 0% as control group. Data were analyzed by SPSS and MSTATC, and Duncan's Multiple Range Test was used for mean comparisons. According to the results a significant difference ($P<0.01$) was found for the production among different years of study in semi-steppe vegetative region. At some sites, further damage was observed as a response to moderate harvesting compared to heavy harvesting. In general, it can be said that rainfall and temperature are considered as the first and second limiting factors for the growth of *Bromus tomentellus,* respectively. Consequently, a harvesting intensity of 50% was recommended as the best allowable use of *Bromus tomentellus* in semi-steppe vegetative region and other similar areas. According to the results of harvesting intensities in selected sites of mountainous rangelands of Alborz and Zagros, *Bromus tomentellus* showed no sensitivity toward different harvesting intensities, and increased rainfall during the growing season was identified as the main factor in increasing forage production. Therefore, a harvesting intensity of 75% was recommended as the best allowable use of *Bromus tomentellus* for this vegetative region and other similar areas.

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Introduction

Rangelands are one of the most important and most valuable national resources of Iran, forming a large part of the country (over 52%). Other services of the rangelands including pharmaceutical, industrial, and food products, soil conservation, control and increased groundwater storage, fresh air, the raise of relative humidity, regulation of the water cycle in nature, providing forage for livestock, preservation of plant and animal genetic resources as well as wildlife are important nationally (Fazilati *et al.*, 1965). It is noteworthy to state that providing forage for grazing livestock is the main use of rangelands, while forage quantity and quality are inadequate to provide the forage needed for livestock due to overutilization (Gharedaghi and Fazel Najafaabadi, 2000).

Despite the major role of determining allowable use of important species in the projects of improvement and restoration, soil erosion, calculation of available forage to livestock and also calculation of grazing capacity of rangeland and sustainability of desirable species, which result in economic prosperity, unfortunately, no systematic and adequate research has been done in this regard.

This research was aimed to determine the allowable use of *Bromus tomentellus* as a key range species in semi-steppe and mountainous rangelands of Alborz and Zagros. The main question of the study was to what extent of harvesting could be tolerated by this species.

Heavy grazing caused a reduction in forage production of *Bromus tomentellus* and after one year rest, the production loss was offset (Tavakoli *et al.*, 1993). Smith *et al.*, (2007) introduced range condition as one of the most important criteria in determining the level of range utilization, and stated that allowable use of the rangelands with poor condition would result in rangeland improvement. Also, allowable use should be considered higher in the rangelands with good condition while it should be lesser in poor rangelands. Arzani (2010) stated that the percentage of allowable use varied depending on plant species. If allowable use is calculated for desirable species, it can be used for all plant species. Reece *et al.*, (2001) developed a theory on allowable use, expressed as half harvesting and half remaining and according to it, livestock are permitted to graze a distinct percentage of available forage that its rate is typically 50%. Ghasriani *et al.*, (2013) determined the allowable use of *Stipa hohenackerian* in semi-steppe rangelands of Iran and concluded that a harvesting intensity of 25-50% is recommended as the best allowable use for this species in this vegetative region and other similar areas. Amiri (2008) estimated an allowable use between 20 to 40 percent in rangelands of Semirom of Isfahan. Also, Zhao and lin (2007) in studies of some range species, stated that a number of range species could not tolerate the pressure of forage harvesting and therefore are unable to offset declining production resulted from cutting shoots. Sharifi and Akbarzadeh (2010) studied the changes**Error! Reference source not found.** of vegetation under exclosure and grazing conditions in rangelands of Ardebil (Arshagh site), and reported that species of *Stipa hohenackeriana* showed a considerable growth during exclosure. (Ganskcopp, 1988) investigated the effect of harvesting intensities on changes of forage production of *Stipa thurberiana* at Range Research Station of Oregon and concluded that this species was sensitive to intense harvesting in vegetative stage and only in the case of light harvesting, it could be used multiple times during the growing season. Fulstone (2009), in his studies on grazing management of Missouri rangelands, reported the allowable use of key species of *Stipa californica* and Stipa *nevadensis*, to be 50 and 55%, respectively. In Iran, the allowable use is usually considered as 50% of annual growth which this value is reduced to 40% in the rangelands located in catchment areas to provide more canopy cover and protection of the watershed (Moghaddam, 1998). Increase of grazing intensity at Savijbolagh region caused a reduction of grasses and shrubs while herbaceous forbs, especially invasive and poisonous species, increased (Kohandel *et al.*, 2005).

As was mentioned, the determination of allowable use is dependent on the studies in place and its

percentage will vary depending on the species. Unfortunately, no systematic research has been done on determination of the allowable use of rangeland species. For this purpose, the project of determining the allowable use of *Bromus tomentellus* was carried out in reference sites of the semi steppe and mountainous rangelands of Alborz and Zagros for 5 years.

Materials and methods

Sampling

Characteristics of the selected sites of semi-steppe and mountainous regions are summarized in Table 1 and Table 2, respectively.

In each of the selected sites, *Bromus tomentellus* was evaluated as a key species. Therefore, 40 similar stands were selected at the beginning of the grazing season in each region and were marked by wooden labels. These lables remained stable and were protected from livestock grazing during four years. In this research, grazing simulation was performed in which different harvesting intensities of 25, 50, 75% and 0 (as control) were investigated as treatments with 10 replications for each treatment. Harvesting was done with clippers. Since forage harvesting was commenced from the begining to the end of livestock grazing, therefore, the number of days that species were normally grazed by livestock was calculated in each region and then it was divided by 30 to get the number of harvestsing. Residual forage and total forage of the control treatment were harvested when species were completely dry. Thereby, total yield was calculated in each year.

Statistical analysis

A split plot design in time with 10 replications was used, and data analysis was performed with SAS software. Mean comparisons were done by Duncan's Multiple Range Test. Interactions between treatments were tested by AMMI model, using IRRISTAT software. Other items, investigated in this study, included assessment of plant mortality, height, seed production and meteorological data.

Results

According to the results of analysis of variance during 2008-2010 (table 3), the effects of year, harvesting intensities and location and also their interaction effects on forage production of *Bromus tomentellus* were significant at 1% level of probability.

Table 1. Characteristics of the selected sites of semi-steppe region.

Row	Site	Altitude (a.s.l) (m)	Average annual precipitation (mm)
1	Gharebagh	1752	390
2	Firoozkooh	2880	274/5
3	Badamestan	2250	487
4	Ghavan- ban- hersin	2266	472
5	Ser	2315	348/5
6	Zaghe	1960	578/4
7	Alamot	2400	584/4
8	Ghorve	2300	328/3
9	Saral	2225	470
10	Jashloobar	2404	302
11	Kordan	1650	270
12	Enjedan	2000	327

Mean comparisons of forage production of *Bromus tomentellus* in years, locations and different harvesting intensities are presented in Table 4. According to the results, there was significant difference in terms of the mean comparison of the effects of year, harvesting intensities and location on forage production of *Bromus tomentellus* so that the

maximum and minimum forage production were obtained in 2009 and 2008, respectively.

Maximum forage production was obtained at 0% harvesting intensity (control group) and the minimum was obtained at 50 and 75% harvesting intensities, showing no significant difference. Also, a significant difference was found among the study sites so that the maximum and minimum forage production were recorded for Cheshmeh Anjir (43.01 g) and Sar Ali Abad (4.15 g), respectively.

Table 2. Characteristics of the selected sites of mountainous region.

Row	Site	Altitude (a.s.l) (m)	Average annual precipitation (mm)
1	Sahand	3000 - 3400	600
2	Polor	2944- 2361	561/8
3	Karsang	2590	567

Mean comparisons of interaction effects of location and different harvesting intensities performed by Duncan test are presented in Table 5.

Table 3. Analysis of variance of harvesting intensity, year and location on forage production of *Bromus tomentellus*.

Source of variations	Degrees of freedom	Mean squares
Location	15	**8132.53
Year	2	**4179.8
Location☐* Year	30	**567.8
Error(1)	387	29.82
Harvesting Intensities	3	**261.8
Location☐* Harvesting Intensities	44	**344.07
Year ☐ *Harveingst Intensities	6	123.8**
☐ Harvesting Intensities ☐* Site * Year	88	**69.23
Error(2)	1120	16831.4
cv		29.01

Table 4. mean comparisons of forage production of *Bromus tomentellus* in years, locations and different harvesting intensities.

Treatments	Forage Yield (g)
1387	c10.76
1388	a15.32
1389	b14.01
control	a14.73
%25	b13.4
%50	c12.73
%75	c12.71
Polor	a28.47
Karsang	b24.16
Ghavan- ban- hersin	c15.62
Kordan	d12.78
Sahand	ef12.23
Firoozkooh	ef11.98
Gharebagh	ef11.7
Saral	fg11.34
Ghorve	hg10.44
Zaghe	h10.02
Enjedan	i8.88
Badamestan	i 8.6
Alamot	j6.08
Jashloobar	j5.65
Ser	k4.15

Minimum production was obtained at 0 and 75% harvesting intensities at the sites of Jashloobar, Zagheh and Sar Ali Abad (3 g), having no significant difference with each other.

Discussion

Semi-steppe vegetative region

According to the results, there were statistically significant differences for the production of different years in the study sites. Results showed that precipitation and temperature were as the first and second growth limiting factors for *Bromus tomentellus*, respectively. On the other hand, in the treatments of control (0) , 25 and 50% harvesting, a high positive correlation was found between forage production and precipitation. In other words, even a harvesting intensity of 50% during the growing season did not cause much disturbance in the growth and production rates of *Bromus tomentellus*. Average

seed production in this species showed a decreasing trend from control group to 75% harvesting. The year * treatment interaction was significant for the number of flowering stem but there was no significant interaction in other morphological traits. Despite four years of successive harvesting in 2010, the height of all treatments was at a same level above the height of control group. It represents the offset of height and even the recovery of the height in years when rainfall is moderate to slightly above average. In fact, the harvesting of grasses in drought years may have significant effect on shoot production while this effect may be not significant in wet years. At some sites, moderate harvesting caused further damage to the plant's production compared to heavy harvesting. This damage is inversely related to the amount of annual rainfall.

Table 5. Mean comparison of interaction effects of location, different harvesting intensities and year on forage production of *Bromus tomentellus*.

Site	Harvesting Intensities	Forage Yield (g)	Duncan Grouping
Zaghe	control	32.33	ab
Polor	control	30.2	bc
Polor	75	28.69	e
Polor	25	27.77	ef
Polor	50	27.41	ef
Karsang	75	26.9	ef
Karsang	50	24.7	f
Karsang	control	24.11	fg
Karsang	25	20.85	g
Ghavan- ban- hersin	25	16.37	h
Sahand	75	16.22	h
Ghavan- ban- hersin	75	15.73	hi
Ghavan- ban- hersin	50	15.62	hi
Ghorve	25	14.92	hij
Ghavan- ban- hersin	control	14.77	hij
Kordan	control	14.3	hij
Kordan	50	13.91	hjki
Kordan	25	13.36	hjki
Saral	25	13.24	hjkim
Gharebagh	control	13.23	hjkim
Firoozkooh	50	12.85	hjkim
Gharebagh	25	12.49	hjkim
Firoozkooh	75	12.11	njkim
Gharebagh	50	11.94	njkimo
Firoozkooh	25	11.8	njkimo
Sahand	25	11.7	njkimo
Saral	75	11.6	njkmo
Ghorve	control	11.4	njkmo
Enjedan	control	11.27	njkmop
Firoozkooh	control	11.18	njkmop
Sahand	control	10.9	njkmopq
Badamestan	control	10.13	nrkmopq
Sahand	50	10.04	pkqnorm
Enjedan	25	9.93	pskqnorm
Kordan	75	9.58	pstqnorm
Gharebagh	75	9.15	pstqnorm
Saral	50	9.14	pstqnorm
Badamestan	25	8.33	pstqnorv
Enjedan	50	8.08	pstqnorv
Badamestan	50	8.06	pstqnorv
Ghorve	50	8.06	pstqnorv
Badamestan	75	7.89	pstqorv
Ghorve	75	7.31	pstqxrv
Jashloobar	75	7.1	stqxrv
Alamot	control	6.94	stqxrv

Zaghe	50	6.93	stqxrv
Enjedan	75	6.24	stxrv
Jashloobar	50	6.2	stxrv
Zaghe	25	6.15	stxrv
Alamot	50	6.06	stxrv
Alamot	25	5.86	stxv
Alamot	75	5.46	txv
Jashloobar	25	5.32	xv
Ser	control	4.62	xv
Ser	25	4.41	xv
Ser	50	4.26	xv
Jashloobar	control	3.95	x
Zaghe	75	3.61	x
Ser	75	3.32	x

But at some of the other sites, heavy harvesting was more effective. Also, at some sites, under light harvesting, the final height of the species was higher in all years compared to control. This result indicates that light harvesting compared to other harvesting intensities and even control treatment (no harvesting) would result in further height of reproductive stems of the species. The number of reproductive stems was affected by drought of 2008 and treatments of the last year more than any other feature. The overall result is that this species responds to climate change and drought and also to the intensity of harvesting. Generally, it can be concluded that light to moderate harvesting intensity (50%) would cause the increase of production of *Bromus tomentellus* in this vegetative region. This result is in agreement with the findings of Akbarinia *et al.,* (2003), Sanadghol and Moghaddam (2001) and Holechek *et al*., (2003). In contrast, the results of Gasriiani and Najibzade (2012) showed that the maximum amount of production of *Bromus tomentellus* was obtained at 75% harvesting intensity. Also, the increasing of grazing intensity has resulted in reduction of grasses and shrub species (Kohandel *et al.* 2005).

Mountainous vegetative region

The results of studies conducted at the sites of Alborz mountainous habitat (Sahand-East Azarbayejan and Ploor-Mazandaran) and Zagros (Karsanak-Chaharmahal and Bakhtiari) showed significant differences in terms of production among different years so that the highest production was recorded in 2009 and the lowest in 2008 due to the drought. It means that reduced rainfall decreased the amount of forage production. This result is consistent with results of Moghadam (1998), Ghaemi (2001) and Tavakoli *et al*., (1993). Kooc (2001) in studies on alpine rangelands of Turkey stated that spring and summer drought had no effect on production of legumes while the production of grasses declined under these conditions. Mean comparisons of the effects of different harvesting intensities on the amount of forage production of *Bromus tomentellus* showed no significant differences between harvesting intensities of 50 and 75%. There were also statistical significant differences among the study sites so that the maximum production was recorded for the control group (0% harvesting intensity) at Polour site, showing very small statistical difference at this site with 75% harvesting intensity. Minimum production was recorded for 0 and 50% harvesting intensities at Sahand site, showing no significant difference to each other. In general, it can be concluded that a harvesting intensity of 75% for *Bromus tomentellus* in this vegetative region and similar conditions would result in increased production of *Bromus tomentellus*. This result is consistent with the findings of Bedell (2002). According to his results, a harvesting intensity of 65 and 45% was obtained for *Agropyron cristatum*, and shrubs and forbs, respectively. However, this result was contradicted by the findings of Tavakoli *et al.,* (1993), and Kohandel *et al*., (2005) at Savojbelagh region.

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