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Determining the allowable use for *Astragalus effusus* Bunge in the mountainous and semi-steppe rangelands of Iran

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Abstract

Current research was performed in selected sites of mountain and semi-steppe rangelands of Iran. The vegetative region included Karsanak (Chaharmahal and Bakhtiari) and Jashlobar (Semnan). *Astragalus effuses* Bunge is a key and palatable species, having a considerable portion in rangelands production of the mentioned flora. For this purpose, 40 similar stands of *Astragalus effusus* were selected in each site. Selected species were exposed to different harvesting intensities of 25%, 50%, 75% and zero as control group. Data were analyzed by SPSS and MSTATC and Duncan's Multiple Range Test was used for mean comparisons. Our results clearly showed that a harvesting intensity of 25% is recommended as the best allowable use for *Astragalus effusus* in this vegetative region and other similar areas.

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Introduction

Rangelands are one of the most important and most valuable national resources in 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 the allowable use of important species in improvement and restoration projects, soil erosion, calculation of available forage to livestock, and calculation of grazing capacity of rangelands and sustainability of desirable species, resulted in economic prosperity, unfortunately, no systematic and adequate research has been done in this regard.

The main purpose of this study was to determine the allowable use of a key range species i.e. *Astragalus effuses* Bunge in semi-steppe and mountain rangelands of the country. The main question of the study is that to what extent of harvesting can be tolerated by this species. Smith (2007) and 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. In addition, the 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 allowable use percentage varied depending on plant species. If the allowable use is calculated for desirable species, it can be used for all plant species. Reece *et al.*, (2001) have developed a theory on allowable use, which is expressed as half harvesting and half remaining and according to it, the livestock are permitted to graze a distinct percentage of available forage whose rate is typically 50%. Amiri (2008) estimated an allowable use between 20 to 40 percent in rangelands of Semirom of Isfahan. Also, Zhao *et al.*, (2007) in studies of some range species stated that a number of range species cannot tolerate the pressure of forage harvesting and therefore are unable to offset declining production resulted from cutting shoots. Sharifi *et al.*, (2009) studied the changes of vegetation under exclosure and grazing conditions in rangelands of Ardebil (Arshagh site) and reported that the species *Stipa hohenackeriana* showed a considerable growth. Ganskcopp (1988) investigated the effect of harvesting intensities on the changes of forage production of *Stipa thurberiana* at the Range Research Station of Oregon and concluded that this species was sensitive to intense harvesting at vegetative stage and only in the case of light harvest it can 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*, as 50 and 55%, respectively. Gasriiani *et al.*, (2013) showed that the maximum amount of production of *Bromus tomentellus* in semi-steppe and mountain rangelands of Iran was obtained at 75% harvesting intensity and for *Festuca ovina*, *Stipa hohenackeriana* it was calculated to be 25-50% harvesting intensity. As was mentioned, determining the allowable use is dependent on the studies in place and its percentage will vary depending on the species.

For this purpose, the project of determining the allowable use of *Astragalus effusus* in reference sites of the mountain and semi steppe region was carried out for four years.

Materials and methods

The characteristics of the selected sites of mountain and semi-steppe region are summarized in Table 1. In each of the selected sites, *Astragalus effusus* 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 labels 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 beginning 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 harvesting. The residual forage and total forage of the control treatment were harvested when species were completely dry. Thereby, the 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 SPSS and MSTACT 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 the assessment of plant mortality, height, seed production and meteorological data.

Results

According to the results of analysis of variance during 2006-2009 (table 2), the effects of year, harvesting intensities and location on forage production of *Astragalus effusus* were significant at 1% level of probability. The interaction effect of year and location and also the interaction effect of harvesting intensity and location were also significant.

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

Average annual precipitation (mm)	Altitude (a.s.l) (m)	Region	Site	Row
567	2590	Chaharmahal and Bakhtiari	Karsanak	1
302	2404	Semnan	Jashlobar	2

Mean comparisons of forage yield of the selected individuals related to each year, harvesting intensity and location were performed by Duncan's Multiple Range Test (Table 3).

Results of mean comparisons showed that the effects of year, different harvesting intensities, and location on forage yield of *Astragalus effusus* were significant at 1% level of probability. Results of mean comparison of the effect of year on forage yield showed that maximum forage yield was recorded for 2008 and no significant differences were found between 2006 and 2007.

Table 2. Analysis of variance of harvesting intensity, year and location on forage production of *Astragalus effusus*.

Source of variations	Degrees of freedom	Mean squares
Location	*1*	*414.18***
Year	*3*	*14.9***
Location* Year	*3*	*20.2***
Error(1)	*72*	*2.1*
Harvesting Intensities	*3*	*1.72***
Location* Harvesting Intensities	*3*	*7.6***
Year *Harvesting Intensities	*9*	*0.92ns*
Year* Location* Harvesting Intensities	*9*	*0.82ns*
Error(2)	*216*	*.055*
cv		*24.42*

Results of mean comparisons of the effect of different harvesting intensities on forage yield showed that maximum forage yield was obtained at 25% harvesting intensity, and minimum forage yield was recorded for 50% and 75% harvesting intensities.

In addition, there were significant differences among the studied sites statistically so that maximum yield was recorded for the site of Karsanak (4.18 g).

Mean comparisons of interaction effects of location and different harvesting intensities performed by Duncan test are presented in Table 4.

According to the results, the maximum yield obtained in the Karsanak site showed no significant difference among the study treatments and all were placed in the same statistical group (a). In the Jashlobar site, all treatments except 25% harvesting intensity were in the same statistical group (c).

Table 3. Mean comparisons of forage production of *Astragalus effusus* in years, locations and different harvesting intensities.

Treatments	Forage Yield (g)
2006	2.71c
2007	2.65c
2008	3.53a
2009	3.28b
Control	3.09ab
25 %	3.23a
50 %	2.93b
75 %	2.92b
Karsanak	4.18a
Jashlobar	1.9b

Discussion

According to the obtained results during the study period, the lowest and highest yield value of *Astragalus effusus* were recorded in 2007 and 2008, respectively. The yield decline in 2007 could be attributed to the reduced rainfall during 2006-2007. In addition, the lowest and highest yield values were obtained at harvesting intensities of 75% and 25%, respectively. The forage yield obtained at 25% harvesting intensity was higher as compared with the harvesting intensities of 75% and 50%. This increased yield could be related to the higher average height of this treatment than the two other treatments. On the other hand, the root length indicating the vigor and vitality recorded for this treatment was higher than the two other treatments that could be considered as another reason explaining the differences. The average values of height and seed yield in control treatment were higher as compared with other treatments. The average seed yield in the study species showed a decreasing trend from control treatment to the 75% harvesting intensity.

Therefore, given the ecological conditions, a harvesting intensity of 25% could be recommended for *Astragalus effusus*. This result is in agreement with the findings reported by Ayala (2001), who investigated the effects of grazing on a few forbs in New Zealand. He also showed that heavy grazing caused to reduced yield, composition, root biomass, canopy cover, and branch density as well as reduced root carbohydrates reserves. As well, many other researchers concluded that heavy grazing led to the reduced cover, yield, and vitality. Loeser *et al* (2007) studied the Arizona mountainous semi-arid rangelands for eight years, and concluded that heavy grazing significantly reduced the cover, vitality, and diversity of perennial legumes and increased the cover of annual grasses. In terms of interaction effects, it is noteworthy to state that since the variations of shrubs are the same in the years and different harvesting intensities, therefore, there is no interaction effect between year and harvesting intensity.

Table 4. Mean comparison of interaction effects of location, different harvesting intensities and year on forage production of *Astragalus effuses*.

Site	Harvesting Intensities	Forage Yield (g)	Duncan Grouping
Karsanak	Control	4.5	a
Karsanak	25 %	4.2	a
Karsanak	50 %	3.97	a
Karsanak	75%	3.97	a
Jashlobar	25 %	2.48	b
Jashlobar	50 %	1.89	c
Jashlobar	Control	1.69	c
Jashlobar	75 %	1.55	c

However, due to the rainfall differences in the two study areas, resulted in forage yield differences as well, the interaction effect of location and harvesting intensity becomes significant. Our results clearly showed that the vigor and yield of *Astragalus effusus* were higher where rainfall was higher.

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