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Full Length Article:

Effects of Seed Scarification on Vegetation Parameters in Some *Astragalus* Species under Field Conditions (Case Study: Homand Absard, Damavand, Iran)

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Abstract. This research aims to evaluate the effects of seed scarification on five perennial *Astragalus* species including *A. effusus*, *A. vegetus*, *A. subsecundus*, *A. brevidens* and *A. cyclophyllon* in the field conditions. Seeds were sown after scarification with sandpaper by hand in the field of Homand Absard Rangeland Research Station, Damavand, Iran in autumn in 2008. The seeds were sown using split plot design based on the completely randomized block design with three replications. In each plot, seeds of each accession were sown on two parallel lines (scarified and control) with 2 m length and 75 cm along with the distance of 50 cm for each accession. Vegetation indices including forage production, canopy cover area, plant height, number of flowering stems and seed yield were studied over three years. Data were analyzed using split plot for specific years in sub plots and mean comparisons were done by Duncan method. Results indicated significant differences between treatments, species and years for all the traits. Interactions between species and year were significant for all the traits except plant height. Seed scarification caused an increase in forage production, canopy cover area and number of flowering stems. According to the results, mechanical seed scarification has been recommended to be done before planting herbaceous *Astragalus*. The species *A. vegetus* (accession Kurdistan) and *A. effusus* (accession Urmia) were recommended for range revegetaion and rehabilitation in semi dry lands with the annual precipitation more than 300 mm.

Key words: *Astragalus*, Scarification, Forage yield, Homand Absard rangeland research station

Introduction

In recent years, due to rapid population growth, mining, long-term excessive deforestation, intensification of cultivation and other unreasonable land uses, the area has suffered from severe degradation of resources (Liu *et al*., 2004). It has resulted in a decline in crop and herbage productions and ecological quality of the environment leading to sparse vegetation, loss of species, broken terrains, etc. Restoration of degraded ecosystems has become a critical subject for regional ecological reconstruction. To prevent further environment deterioration and soil erosion, some critical measures such as returning degraded farmlands to grasslands, reseeding and planting of trees, shrubs and grass have been adopted (Wang and Wang, 2013). Therefore, the restoration of natural resources using desirable and compatible species is very important. Forage legumes are considered as desirable species playing an important role in animal nutrition. These species are rich in protein which is widely used in different husbandry systems due to high forage quality. On the other hand, they can increase the soil fertility by nitrogen fixation. Astragalus with 804 species is one of the numerous genera of Papilionaceae family in Iran of which 527 species are endemic (Masoumi, 2006). Among different species of this genus, more than 300 species are forbs of which a lot of species are perennial grazed by livestock. Successful establishment of seedling in rangeland is the most important step in vegetation establishment and preservation. Direct sowing of seeds of the rangeland species is one of the effective ways to restore the rangelands (Jankju, 2009). Therefore, it is important to evaluate the germination of these kinds of seeds and their stability in natural environmental conditions (Khavari, 2010). Despite the great importance and characteristics, the establishment of forage legumes is difficult. Seeds of legumes such as Astragalus species have one of the types of dormancy which guarantees their survival for long years but for the cultivation and propagation of these species, overcoming the dormancy in seeds seems to be necessary. One of the major constraints in successful establishment of *Astragalus* is hard seed content. High hard seed content in a seed lot can cause the delayed or decreased seedling emergence. As a result, stands become thin, sporadic and less competitive with weeds or undesirable species. Such legume stands reduce not only N fixation but also yield and quality. Therefore, the reduction of hard seed content in a seed lot of forage legumes is important before planting (Kimura and Islam, 2012; Jankju *et al.,* 2013). Mechanical scarification is a technique to physically create scars on seed surface to increase water imbibitions of the seed (Olisa *et al.,* 2010). Patanè and Gresta (2006) studied the seed germination of A. hamosus and showed that scarification using sand paper was the best method to overcome seed dormancy. They also showed that hot water could remove seed dormancy but a temperature of 80°C increased the seed damage up to 97.9%. Kožuharova *et al.* (2010) tested the seed germination process and seedling development of Astragalus alopecurus and Astragalus dasyanthus which are rare and threatened species. Mature seeds of the tested plants germinated well within several days if the seed coat was scarified with sandpaper.

Moderate mechanical scarification is the best method for germination of Cicer milkvetch. Scarification is recommended immediately (within 1 week) prior to planting because viability declines steadily after scarification (Townsend and McGinnies, 1972; Acharya *et al.*, 2006).

Arbabian *et al.* (2009) stated that scarification with sand paper, scarification with 10-day chilling and scarification with 15-day chilling were identified as the best treatments for seed dormancy breaking of *A. fridae*. Similarly, Zarekia *et al.* (2013) examined six species of *Astragalus* in laboratory and concluded that scarification resulted in a higher germination than that for chilling and control.

This research aims to study the effects of seed scarification on five perennial *Astragalus* species in the field conditions.

Materials and Methods

Geographical location and climatic conditions of the study area

Homand Absard rangeland research station is located at 70 km east of Tehran between 52°15' E and 35°4' N with an altitude of 1960 m above sea level. It has mean annual rainfall of 339 mm and average temperature of 12°C. Also, absolute maximum and minimum temperatures are 36°C and -22°C, respectively. According to the 30-year Embrothermic diagram, the study area has a high moisture status from November to April as the length of the wet and dry seasons is 7 and 5 months, respectively (Fig. 1). In this period only in March, rainfall reached less than 10 mm. The length of wet and dry seasons during 2010-2011 was similar to the previous year. Accumulative rainfall and average temperature were 285 mm and 12°C. But during 2011-2012, moisture status was high in December to April and the length of wet and dry seasons was 5 and 7 months, respectively. An accumulative rainfall of 341 mm and an average temperature of 12°C were recorded. November rainfall was remarkable but there was little rainfall in the other wet months. Therefore, the intensity of wet period was not significant during this period. However, an accumulative rainfall of 370 mm and an average temperature of 10.5 °C were recorded.

Homand Absard rangeland research station has a cold semi-steppe climate. In Damavand, summers are short and temperate in contrast to long and cold winters. The length of freezing periods is up to 120 days and the dry period lasts for about four months.

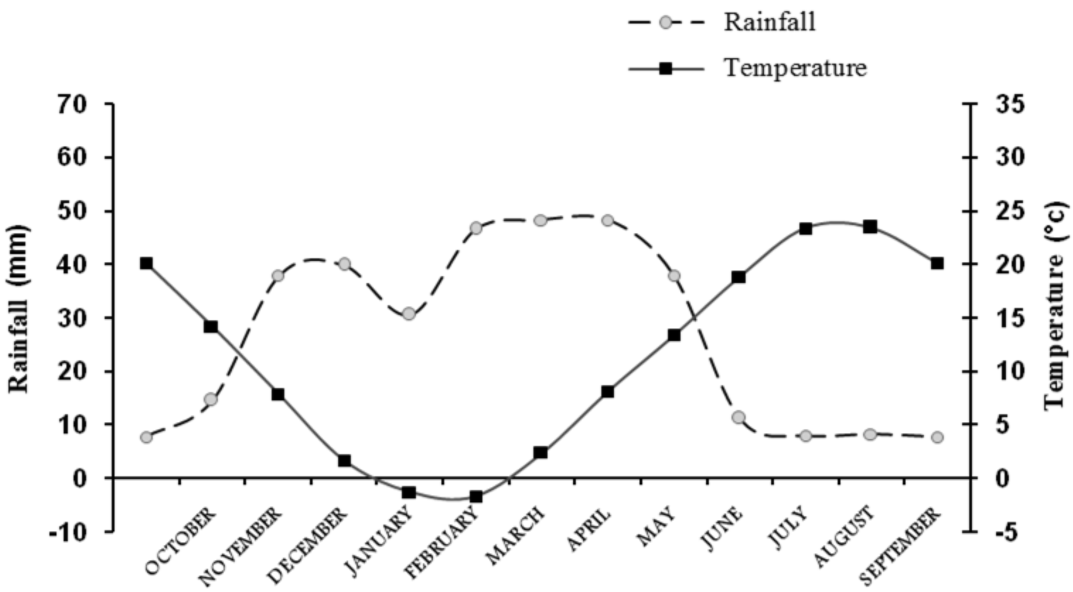

Fig. 1. The lines of two axes chart of Embrothermic curve for Homand Absard rangeland research station

Experimental design and sampling method

In this research, seeds of five perennial Astragalus species including *A. effusus*, *A. vegetus*, *A. subsecundus*, *A. brevidens* and *A. cyclophyllon* scarified by sand paper and were sown in the field of Homand Absard rangeland research station and then, compared with control treatment. Seeds were sown in the field using split plot design based on the completely randomized block design with three replications in autumn in 2008. In each plot, seeds of each accession were sown on two parallel lines (scarified and control) with 2 m length, row spacing of 75 cm and the spaced plant distance of 50 cm for each accession. No irrigation was made. Weeds were controlled mechanically. Herbage and grain yield were estimated at maturity stage. At harvest, plants were cut at ground level and at the same time, the following traits were measured

1. Plant height (cm): Five plants of each plot were selected and their heights were measured and then their averages were taken.
2. Stem number: Average number of stems for a 50 cm planting row of each plot was recorded by counting.
3. Canopy cover area (cm^2): Five plants of each plot were selected and their canopy's short and long diameters were measured and then, their averages were taken.
4. Forage yield or dry matter yield ($ton.ha^{-1}$): At the time of maturity, each plot was harvested, plant material was air-dried and dry weight measured. Thus, this represents the above-ground biological yield.
5. Seed yield (g/plant): At the time of maturity, plants were cut, dried, trashed and cleaned, and the average seed yield was calculated for each plant.

Data were analyzed by analysis of variance (ANOVA) using split plot during a year for sub plot and mean comparisons were performed by Duncan's Multiple Range Test. In the case that data did not have a normal distribution, data transformation was used but it had no effects on the results. Statistical analysis was performed using SAS 9 software.

Results

Results of analysis of variance (ANOVA) showed significant differences between treatments, species and years for almost all the traits. Interactions between species and year were also significant for all the traits except plant height (Table 1). Results showed that seed scarification increased the forage yield, canopy cover area and number of stems; the values of all vegetation parameters for the scarified treats were higher than those for control treatment (Table 2). Higher forage yield (640 $Kg.ha^{-1}$), canopy cover area (2915 cm^2) and number of stems (36) were recorded in scarification treatment (Table 2).

Table 1. Summary of ANOVA for all vegetation parameters

Source	DF	Forage Yield ($kg.ha^{-1}$)	Plant Height (cm)	Canopy Cover Area (cm^2)	Stem Number	Seed Yield (g/ Plant)
Scarification	1	80122 **	68.71	1022.7 **	2236 **	429.91
Species	6	286221 **	5170 **	5401.1 **	14999 **	12133**
Scarification x Species	6	18712	54.40	161.32	371.56	568.38
Error 1	6	25846	648161	6997	244.89	280.81
Year	2	297249 **	4300.6 **	19050 **	37115 **	4580.3**
Scarification x Year	2	23055	110.81	142.3	433.82	418.61
Species x Year	12	30869 **	167.41	1223.5 **	2789 **	6921**
Scarification x species x year	12	5532	54.62	64.2	134.15	908.33
Error 2	70	10284	115.9	295.9	481.79	783.84

**: Significant at 1% level of probability

Table 2. Mean comparison of vegetation parameters in scarified and control treatments averaged over years and species

Treatment	Forage Yield (kg/ha)	Plant Height (cm)	Canopy Cover area (cm^2)	Stem Number	Seed Yield (g/ Plant)
Scarification	640.0 a	32.97 a	2915 a	36.26 a	38.49 a
Control	442.8 b	31.33 a	2382 a	29.06 b	32.23 a

The means of treatments with same letters were not significantly different based on DMRT method P<0.05

Results of mean comparisons of species are presented in Tables 3 and 4. According to the results, the maximum values of all parameters were recorded for *A. vegetus* (Kurdistan). The maximum and minimum forage yields were obtained for *A. vegetus* (Kurdistan, 1384 $Kg.ha^{-1}$) and *A. subsecundus* (Damavand, 11.0 $Kg.ha^{-1}$), respectively. No significant difference was found among species in terms of plant height. Highest canopy cover area was recorded for *A. vegetus* (Kurdistan) and *A. brevidens* (both accessions). Number of stems and seed yield of *A. effusus* (Urmia) was almost similar to *A. vegetus* (Kurdistan). *A. subsecundus* (Damavand) and *A. cyclophyllon* (Esfahan) were not established well, and they did not show a considerable growth.

Overall means of all the accessions for all the traits in the first year were relatively lower than those for the second and third years indicating that all parameters were increased significantly over times (Tables 3 and 4). Minimum and maximum values of all vegetation parameters were recorded in 2010 and 2012, respectively.

Table 3. Means of forage yield, plant height of studied species in three years

Species	Origin	Forage Yield (kg/ha)				Plant Height (cm)			
		2010	2011	2012	Mean	2010	2011	2012	Mean
A. vegetus	Kurdistan	566	1731	1860	1385 a	35.2	48.3	56.8	46.7 a
A. brevidens	Tandure	163	638	1028	609 c	28.0	40.8	59.7	42.8 a
A. brevidens	Torogh	93.0	490	766	450 cd	29.5	38.5	61.0	43.0 a
A. effusus	Urmia	428	870	1748	1015 b	35.5	44.0	59.4	46.3 a
A. effusus	Semnan	44.0	52.0	502	199 de	19.0	28.1	37.1	28.0 b
A. subsecundus	Damavand	0.00	20.0	14.0	11.3 e	0.0	7.0	10.3	8.7 d
A. cyclophyllon	Esfahan	45	166	194.0	134.0 e	8.1	13.6	22.0	14.5c
Mean		191 C	566 B	873 A		26 C	31 B	44 A	

The means of column (species) with the same small letters were not significantly different based on DMRT method P<0.05
The total means of the years with the same capital letters were not significantly different based on DMRT method P<0.05

Table 4. Means of canopy cover stems number and seed yield of studied species in three years

Species	Origin	Canopy cover (cm^2)				Flowering stem No.				Seed yield (g/Plant)			
		2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean
A. vegetus	Kurdistan	1266	4329	8485	4694a	20	74	110	68 a	12.8	41.2	157.2	71 a
A. brevidens	Tandure	764	3246	7051	3687ab	6.0	37	73	38 b	5.2	19.2	85.1	36.5b
A. brevidens	Torogh	1022	3562	7513	4032 b	10	29	62	34 b	16.1	26.0	73.0	38.7b
A. effusus	Urmia	1243	2514	6710	3499ab	15	71	125	67 a	11.5	35.4	193	80 a
A. effusus	Semnan	402	1468	3348	1740 c	6.0	12	35	17 c	0.0	7.3	11.8	6.4 c
A. subsecundus	Damavand	0.00	30.0	77.0	36.0 d	-	-	-	Na*	-	-	-	Na*
A. cyclophyllon	Esfahan	366	870	1650	962 cd	-	1.0	3.0	2.0 d	0.5	0.0	1.9	0.8 c
Mean		723B	2288B	4976A		8.0C	32B	58A		6.6B	18.4B	74.6A	

Means of column (species) with the same small letters were not significantly different based on DMRT method P<0.05
Total means of the years with the same capital letters were not significantly different based on DMRT method P<0.05
*=data was not available

Discussion and Conclusion

Seeds of studied *Astragalus* species were hard and small having a length of 1-3 mm on average. These seeds had a dormancy period that must be broken. Seed coat is covered with a thick layer. This layer contains pectin and provides resistance against water penetration. Seed hardness needs to be broken by a treatment such as scarification before planting (Wang, 2009). Waxy-coated seed will not imbibe water quickly and can remain in the soil for a prolonged period without germination resulting in an uneven weed infested stand and poor biomass production (Acharya *et al.*, 2006). Seed coats of *Astragalus* species respond well to mechanical or chemical scarification which facilitates air and water imbibitions and allows the germination. Researches indicated that seed scarification could increase the seed germination percentage of Astragalus species (Isivand *et al.*, 2006; Yang *et al.*, 2006; Zarekia *et al.*, 2013). This result supports the reports of Ekpong and Sukprakran (2008) that soaking of *Eryngium* seeds increase the germination.

Results of this research showed that seed scarification caused an increase for all vegetation parameters in the studied species. Therefore, Scarification-seeded stands have produced substantial amounts of yield and stem number in the establishment years (Table 2).

Seed scarification is vital to enhanced seed germination, and consequently to improved stand establishment and crop yield (Ashraf and Foolad, 2005). In comparison, before planting Astragalus species with goal of forage providing in rangelands, seed scarification could be recommended.

Among the studied species, maximum values for all traits were recorded in *A. vegetus* (accession Kurdistan). This species also showed higher values concerning different germination factors (Zarekia *et al.*, 2013). According to the results, perennial forage of *Astragalus*, particularly *A. vegetus* with high yield can play a significant role in livestock systems in the semiarid region.

Total rainfall in 2010, 2011 and 2012 was 285, 341 and 370 mm, respectively. As results have shown, maximum forage yield and other parameters were in the third year of the study (2012). The increase of these parameters could be explained by two main factors including plant behavior and soil-stored moisture in the growing season. This success could be due to the absorption of deep soil moisture (Mirhaji, 2009). It is common knowledge that the distribution and abundance of most vegetation are controlled in part by climate conditions. Changes in climate, especially precipitation may be expected to result in the changes of structure and function of the vegetation (Zhao *et al.*, 2011). Therefore, the production of dry matter is directly related to the precipitation and the fluctuations in precipitation can alter the growth of *Astragalus* species.

According to these results, seed scarification with sandpaper is recommended before planting herbaceous Astragalus. *A. vegetus* (Kurdistan) and *A. effusus* (Urmia) are recommended for range improvement and development as well as the abandoned dry lands with a rainfall more than 300 mm and average temperature of 11°C.

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بررسی اثر خراش دهی بذر بر پارامترهای پوشش گیاهی در چند گونه گون علفی در شرایط مزرعه (مطالعه موردی: همند آبسرد، دماوند، ایران)

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چکیده. ارزیابی اثر خراش‌دهی بذر بر پارامترهای پوشش گیاهی ۵ گونه گون چندساله علفی شامل ***Astragalus effusus*** **،*Astragalus vegetus*** **،*Astragalus brevidens*** **،*Astragalus subsecundus*** **،*Astragalus cyclophyllon*** در شرایط مزرعه انجام گردید. بذور خراش داده شده با کاغذ سنباده و بوسیله دست با تیمار شاهد (بدون خراش) در مزرعه کشت و مورد مقایسه قرار گرفتند. کشت در قالب طرح کرت‌های خرد شده بر پایه بلوک کامل تصادفی در سه تکرار در پاییز ۱۳۸۷و در ایستگاه تحقیقات مرتع همند آبسرد دماوند انجام گردید. اکسشن‌ها روی دو خط ۲ متری (یک خط بذور خراش داده شده و خط دوم بذور شاهد) طوری کشت شدند که فاصله بین بوته‌ها روی ردیف ۰/۵ متر و فاصله خطوط مربوط به اکسشن‌های مختلف ۰/۷۵ متر از یکدیگر بود. داده‌های تولید علوفه، پوشش تاجی، قطر تاج پوشش، ارتفاع گیاه، عملکرد بذر، تعداد ساقه‌های گلدار در طی ۳ سال جمع‌آوری گردید. داده‌ها با استفاده از طرح اسپلیت پلات در زمان آنالیز و مقایسه میانگین تیمارها بوسیله آزمون چند دامنه‌ای دانکن انجام گردید. نتایج نشان داد که بین تیمارها، گونه‌ها و سال‌ها اختلاف معنی‌دار برای تمام پارامترها وجود دارد. اثر متقابل گونه و سال نیز برای تمام پارامترها به جز ارتفاع دارای اختلاف معنی‌دار بوده است. خراش بذر باعث افزایش میزان تولید، درصد پوشش تاجی و تعداد ساقه‌های گل دهنده شد. به طورکلی خراش مکانیکی بذر قبل از کشت گون‌های علفی پیشنهاد می‌شود. اکسشن‌های ***A. vegetus*** (کردستان) و ***A. effusus*** (ارومیه) برای توسعه و اصلاح مراتع بخصوص دیمزارهای رها شده در شرایط آب و هوایی مشابه با بارندگی ۳۰۰ میلی‌متر توصیه شدند.

کلمات کلیدی: ***Astragalus*** ،خراش‌دهی، تولید علوفه، ایستگاه تحقیقات مرتع همند آبسرد