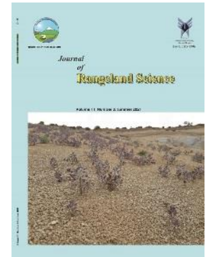
Contents available at ISC and SID

Journal homepage: www.rangeland.ir



Research and Full Length Article:

Effects of Seed Priming on Morph-physiological Traits of Three Ecotypes of *Astragalus squarrosus Bunge* Grown in Iran

Mahshid Souri[A*], Saeedeh Nateghi[B], Nadia Kamali[B], Mina Bayat[C]
[A] Assistant Professor, Rangeland Research Division, Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran *(Corresponding Author). Email: souri@rifr-ac.ir.
[B] Assistant Professor, Rangeland Research Division, Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran
[C] Senior Research Expert, Rangeland Research Division, Research Institute of Forests and Rangelands, Agricultural Research, Education and Extension Organization (AREEO), Tehran, Iran

Received on: 05/08/2020
Accepted on: 02/02/2021

Abstract. *Astragalus squarrosus* Bunge is one of the native and compatible range species in the dry lands of Iran. It is of great importance in terms of tolerance to specific ecological conditions as well as high nutritional value and soil conservation. In order to study the effects of seed priming on some morph-physiological traits, an experiment was conducted in form of split plots based on a completely randomized block design with five replications in Torud Research Farm in Semnan Province, Iran in 2017. Seed samples were collected from their natural habitats in Yazd, Kashan and Semnan in Iran. Seeds of three *A. squarrosus* ecotypes were treated by hydropriming (distilled water), hormonal priming (gibberellic acid: with concentrations of 125 and 250 ppm), (Salicylic acid: 100 and 200 mg/l), (Ascorbic acid: 100 and 200 mM) osmopriming (potassium nitrate: 0.3 and 0.2%) and control (without priming). The primed seeds and controls were sown in the field. No seeds were germinated for control and gibberellic acid (250 ppm). The results showed that the effect of priming was significant on leaf carbohydrate content, vegetation cover, dry matter (DM), yield and plant height ($p<0.01$). According to the results, the highest DM yield and plant height with average values of 82 (g/m^2) and 34 cm, respectively, were related to the ecotype of Yazd treated with salicylic acid 100 mg/l. The highest vegetation cover with an average value of 34.6% was observed in Kashan ecotype by applying salicylic acid 100 mg/l. For carbohydrate content, the highest value of 36 (g/100gFW) was obtained in Semnan ecotype using 100 mg/l salicylic acid. The highest rate of proline with a value of 3.39 (Mm/gFW) was obtained in Semnan ecotype using 125 ppm gibberellic acid. It was concluded that application of hormonal seed priming of *A. squarrosus* could be useful for direct seeding of this species for rehabilitation of degraded arid rangelands of Iran.

Key words: Seed, Vegetation Cover, Plant height, Proline, Carbohydrate, *Astragalus squarrosus*

Introduction

Nowadays, due to genetic erosion and loss of genetic diversity, especially in sensitive and fragile ecosystems of arid areas, the implementation of rangeland improvement projects with scientific methods is at a top priority. In order to make optimal use of rangeland resources, rehabilitation and improvement of winter rangelands in desert areas are inevitable. One of the methods for rangeland improvement is the seed sowing with native species as Astragalus species. The genuses Astragalus belongs to the Fabaceae family and are of great medicinal, forage and industrial values in Iran. Astragalus is the largest genus of vascular plants with about 3000 annual and perennial species classified in 205 sections (Lock and Simpson, 1991; Maassoumi, 1998; Podlech, 1998). *Astragalus squarrosus* Bunge is a desert perennial shrub. This plant has no thorns and is palatable plant in dry areas of central, south-east to north-east of Iran with wide distribution (Batoli, 2008).

The seeds of some species of the Fabaceae family are usually hard and impermeable to water and gases. Therefore, seeds generally have hard shell dormancy and this crust is affected by environmental conditions at the time of seed development (Nasiri, 1994). *A. squarrosus*, Syn. *Astragalus biabanesis* and *A. farsicus* Sirj & Rech. F., Persian name is "Netar, growing in the sands of desert areas of Iran. Its regeneration in the natural habitat is through seeds if the annual rainfall is favourable, especially in the middle of winter, the seeds will germinate and produce seedlings. Many of forage and medicinal species in Iran have wild growth type and as a result, they have seed dormancy (Alizadeh and Nasiri, 2012). The main problem in wild species is the lack of knowledge about how to break their seed dormancy and improve their germination. For several years, efforts have been made to use pretreatments to improve the percentage and speed of seed germination in the field (Bradford, 1986). Seed priming is known as a method which improves the seed germination performance (Araghi Shahri *et al*., 2014).

Seed priming is one of the practical methods of pre-sowing treatment to strengthen the seed vigor. The treatment is soaking the seeds in water, osmotic materials or germination stimulants (Jisha and Puthur, 2018). The basis of this method is to control the water uptake to a level that allows the seed to perform the initial metabolic stages of germination. But the root does not come out of the seed (Farooq *et al*., 2019). Research has shown that the use of seed priming increases the percentage and reduces the germination time (Kavandi *et al*., 2018; Muzaffar *et al*., 2019). There are several methods for seed priming including osmopriming, hydro priming, matrix priming, hormonal priming and biopriming (Alias *et al*., 2018). In the hormonal priming method, hormonal solutions such as gibberellic acid, salicylic acid and ascorbic acid are used as pretreatment to increase seedling growth and plant establishment rate (Nawaz *et al*., 2013). Plants face to different stress conditions at different stages of their life. In this regard, it was reported that seeds priming under stress conditions produce stronger and larger seedlings (Langeroodi and Noora, 2017; Michalska-Klimczak *et al*., 2018; Moreno and Seal, 2018). In another study on the germination indices of *Cynodon dactylon* under the influence of salicylic acid, gibberellic acid and potassium nitrate treatments, it was concluded that among the treatments used, pre-soaking treatment with different concentrations of salicylic acid had the most positive effect on the seed germination indices of *Cynodon dactylon* (Fakhireh and Shahriari, 2018). In another study, the effect of gibberellic acid treatments and wet cooling pretreatment on

Trifolium pratense was investigated. The results showed significant effect of seed priming on seedling length, root length, germination percent, seedling dry weight, and seedling vigor index ($p<0.01$) (Shirini and Moameri, 2018). Abbasi Khalaki *et al*., (2017) studied the effect of osmopriming and hormopriming treatments on germination and early growth of *Festuca ovina*. Their results showed that osmopriming had better performance than hormonal priming and control treatments. Also, the results of Kaur *et al.,* (2002 and 2005) showed that hydro priming and osmotic priming cause root and stems elongation, and increase dry and fresh weight of seedlings, number of flowers, number of branches, number of pods and number of seeds per chickpea plant, which ultimately leads to increased grain yield. Singh *et al.*, (2014) examined the effect of osmopriming on germination and growth of *Vigna unguiculata* in Nigeria, and their results showed that osmopriming by KNO3 showed better results compared to hydropriming. In contrast, Alvani *et al*., (2017) in a study of the effect of ascorbic acid priming on the physiological characteristics of *Taverniera cuneifolia* under drought stress found that the performances of *T. cuneifolia* physiological traits (photosynthesis rate, leaf surface temperature and water potential were significantly decreased compared to the control. Increasing the amount of soluble carbohydrates has an important role in reducing the osmotic potential and ultimately creating a suitable slope between the plant and the soil and increases water absorption. Because the accumulation of organic compounds such as carbohydrates and amino acids in the cytoplasm plays an important role as osmotic regulators and increase plant function. More carbohydrates make the species have higher resistance and DM yield (Javadi *et al*., 2004). Also, free proline accumulation is a common response to stress in excellent plants. There are several reports of a positive correlation between proline accumulation and adaptation to osmotic stress conditions. Proline affects the solubility of various proteins and enzymes. Proline prevents them from changing their nature (Nourzad *et al*., 2015).

Astragalus squarrosus is one of the native and compatible species in the desert areas of Iran, which is very important in terms of tolerance to special ecological conditions as well as high nutritional value and soil conservation. Establishing this species is difficult and needs seed priming technique for cultivation and domestication, so the present research was performed to determine the effect of seed priming on performance of *A. squarrosus* and finding the most suitable treatment to increase the performance of this species.

Materials and Methods

In order to evaluate the effect of seed priming on morph-physiological traits as plant height, DM yield, vegetation cover, proline content and carbohydrate content of three ecotypes of *Astragalus squarrosus*, a field study was conducted in 2017 at Trade Research Farm, Semnan Province. Torud is situated in the central district of Shahrud city, Semnan Province, Iran. Torud latitude is 36º22´01´´N, longitude is 55º54´0´´ E and altitude is 1325 m. The nearest meteorological station is Shahroud station. Average total annual precipitation of the area is 133.5 mm. Average annual temperature is 15.4˚C.

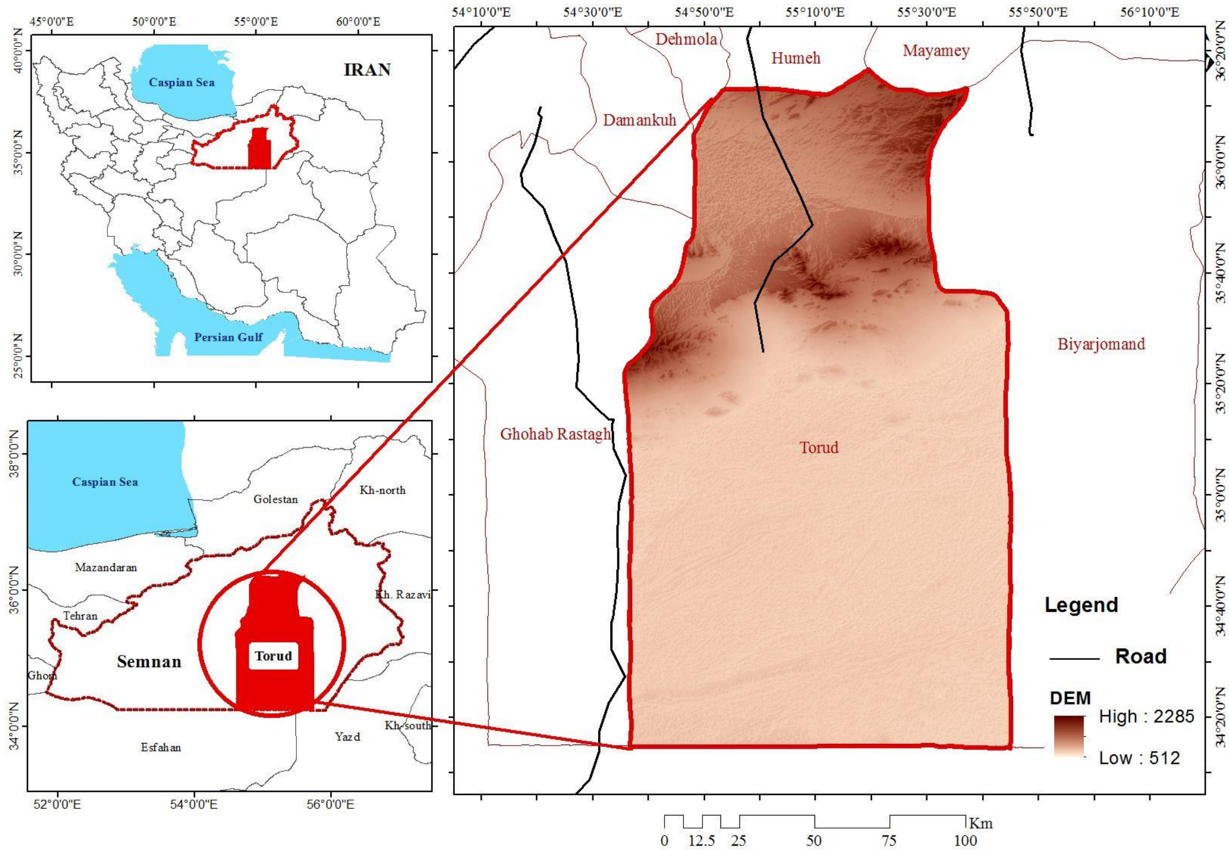


Fig. 1. Geographical location of Taroud city in Semnan province and Iran

This research was carried out as a split plot design based on a completely randomized block design with 5 replications. Thus, the main plot was related to three different *A. Squarrosus* ecotypes including Semnan, Yazd and Kashan and sub-plots related to priming treatments including: hydropriming (distilled water), priming hormone (gibberellin hormone: 125 and 250 ppm, salicylic hormone: 100 and 200 mg/l and ascorbic hormone: 100 and 200 mM) and osmopriming (potassium nitrate: 0.3 and 0.2%) and control (without priming). Information about seed sample habitat is presented in Table 1.

Table 1. Table of collecting habitat information

Province	Ecotype	Latitude	longitude	Altitude (m)
Semnan	Semnan	35º 10´ 15´´N	55º 03´ 00´´ E	1110
Yazd	Yazd	30º 20´ 19´´ N	54º 30´ 17´´ E	1210
Esfahan	Kashan	34º 18´58´´ N	51º 52´ 17´´ E	982

In order to cultivate primed seeds in the field, the seeds were primed for 8 hours, a day before sowing at normal room temperature (23˚C) with different treatments. After being placed on a cloth towel for 5 hours and removing surface moisture, the primed seeds and controls were sown immediately in the field (Musa *et al*., 2001; Rashid *et al*., 2004).

The field planting pattern was such that each sub-plot consisted of 5 planting lines with a length of 3 m and distance between individual plants on each planting line (30 cm) and the distance between lines in each plot 50 cm apart and the distance between sub-plots (1 m). The distance between the main plots was 5 m. Seeds were sown on March 16, 2017. The sowing pattern was sowing 10 seeds in each hole with 2 cm depth. At the end of the growing season, No control, seeds and gibberellic acid (250 ppm) seeds geminated. Data were collected for percentage of vegetation cover, plant height and DM yield. Then, the amount of free proline and soluble carbohydrates were determined in laboratory as follows:

To measure proline, several developed leaves were harvested from each plant in 5 replications. To extract proline, 0.5 g of leaf was crushed using a 5 ml of 95% ethanol in a porcelain mortar and the upper part of the solution was separated. Extraction was performed with 5 ml of 70% ethanol. The resulting solution was placed in a centrifuge (model chermlez 230A made in Germany) for 10 minutes at a speed of 3500 rpm. After separating the liquid phase from the solid, the liquid part was used to extract proline (Irigoyen *et al*., 1992). To determine the proline concentration, one ml of the above alcohol extract was diluted with 10 ml of distilled water and 5 ml of ninhydrin reagent was added to it. After adding 5 ml of glacial acetic acid to it and stirring for 45 minutes, it was placed in a boiling water bath. After removing the samples from the boiling water bath and cooling them, 10 ml of benzene was added and mixed with a mechanical stirrer to allow the proline to enter the benzene phase. The samples were left to stand for 30 minutes and then, the proline content was measured with a spectrophotometer at 515 nm (Paquin and Lechasseur, 1979; Nourzad *et al*., 2015).

To measure soluble carbohydrates, proline-like extraction was performed. 0.1 ml of alcoholic extract was mixed with 3 ml of freshly prepared antron (150 mg of antron + 100 ml of 72% sulfuric acid). The solution was placed in a boiling water bath for 10 minutes. Then, its adsorption rate was read by spectrophotometer at 625 nm and the amount of soluble carbohydrates was determined (Paquin and Lechasseur, 1979).

Cultivation was done with no irrigation and no fertilizer. DM yield refers to the amount of plant biomass in terms of g/m^2 of dry weight.

The obtained data were analyzed of variance using SPSS software and the means of treatments were compared by Duncan's multiple range test.

Results

Due to the fact that the control seeds and the seeds treated with gibberellic acid (250 ppm) were not established in the field, so they were removed from the statistical analysis. The results obtained from the analysis of variance of the studied traits showed that priming had a significant effect on all of the traits except proline content ($p<0.01$) (Table 2). The effect of ecotype was significant for DM yield ($p<0.05$) and proline content ($p<0.01$). There was also ecotype by priming interaction for proline content ($p<0.01$) (Table 2).

Table 2. Analysis of variance of study traits in three ecotypes of *Astragalus squarrosus* under the influence of 8 seed priming treatments

SOV	DF	MS				
		Plant Height	Forage DM yield	Vegetation Cover	Carbohydrate	Proline
Ecotype	2	245.5^{ns}	2166.4*	148.58^{ns}	66.91^{ns}	44.46**
Rep	4	176.4^{ns}	715.2^{ns}	96.22^{ns}	95.72^{ns}	0.05^{ns}
Error1	8	179.5	627.1	68.31	123.8	0.13
Priming	7	1030.3**	5691.7**	933.06**	830.67**	0.30^{ns}
Ecotype *Priming	14	7.80^{ns}	71^{ns}	19.73^{ns}	60.53^{ns}	2.09**
Error2	84	100.4	466.8	67.33	71.48	0.18
Total	119					

ns, * and **= non significance and significance at 5% and 1% probability levels respectively.

The results of means comparison of the studied traits of *A. squarrosus* under the influence of different priming treatment are presented in Figs. 2 to 6. The results showed that in all studied traits (cover percent, DM yield and plant height, except carbohydrates, proline), the highest value was related to seeds primed with salicylic acid at concentrations of 100 and 200 (mg/l) followed by hydro priming; all these traits ranked in class a. The lowest value was related to priming with gibberellic acid treatment ranked in class d. The results showed that the highest values of carbohydrates and proline were related to priming with gibberellic acid treatment ranked in class a.

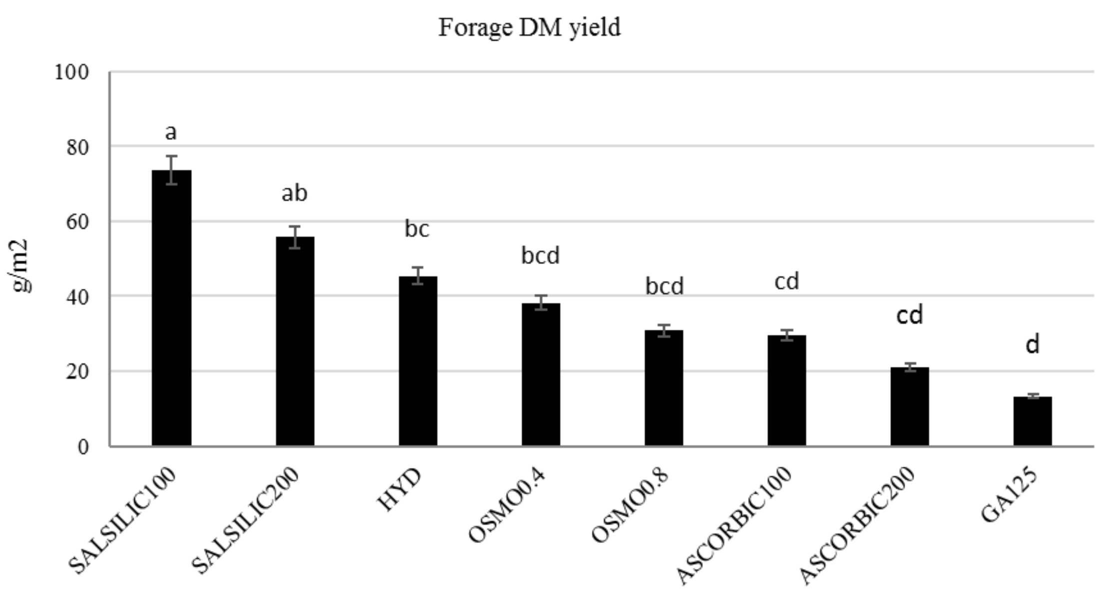


Fig. 2. Influence of seed priming treatments on forage DM yield of *Astragalus squarrosus* Means with the same letter are not significantly different at 5% probability level based on Duncan test

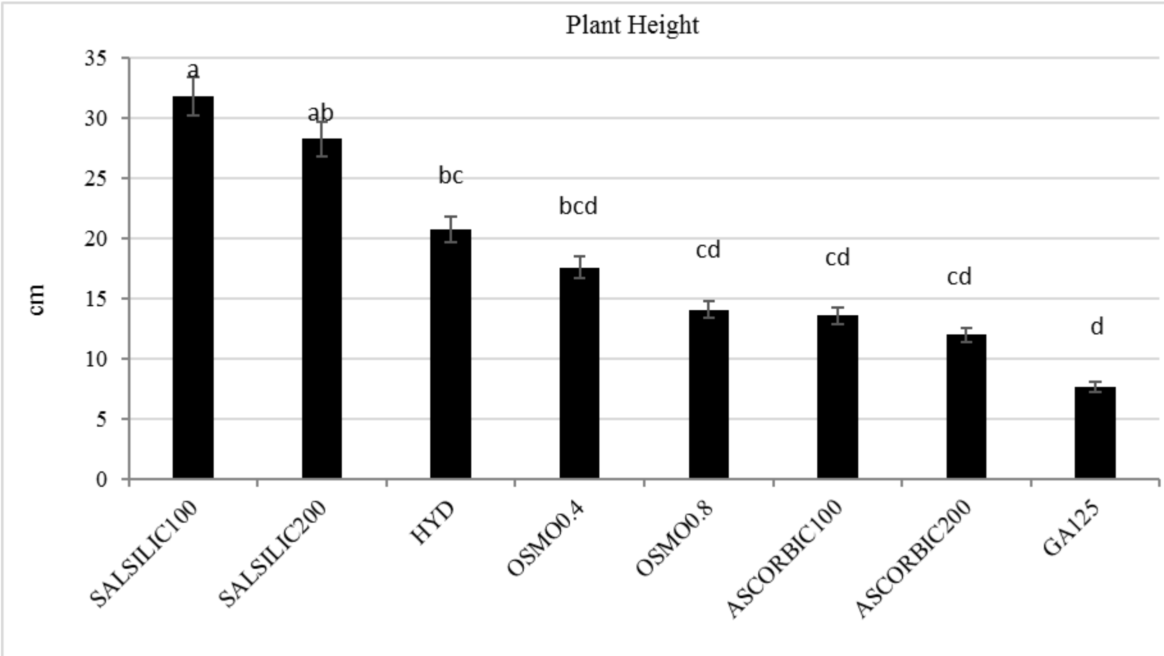


Fig. 3. Influence of seed priming treatments on plant height of *Astragalus squarrosus* Means with the same letter are not significantly different at 5% probability level based on Duncan test

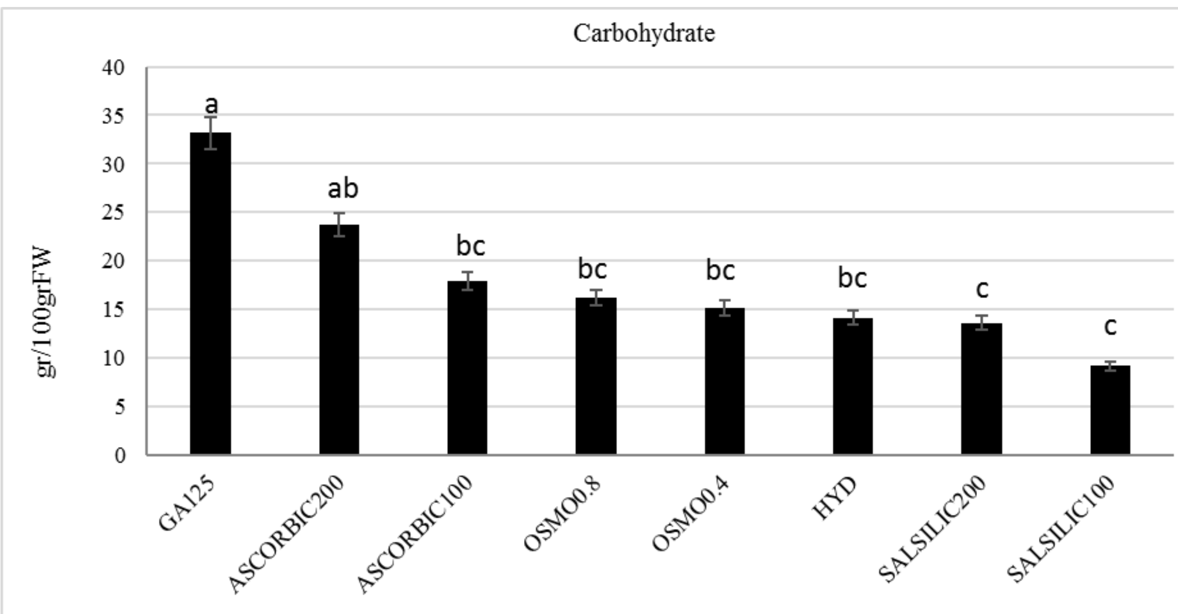


Fig. 4. Influence of seed priming treatments on carbohydrate content of *Astragalus squarrosus* Means with the same letter are not significantly different at 5% probability level based on Duncan test.

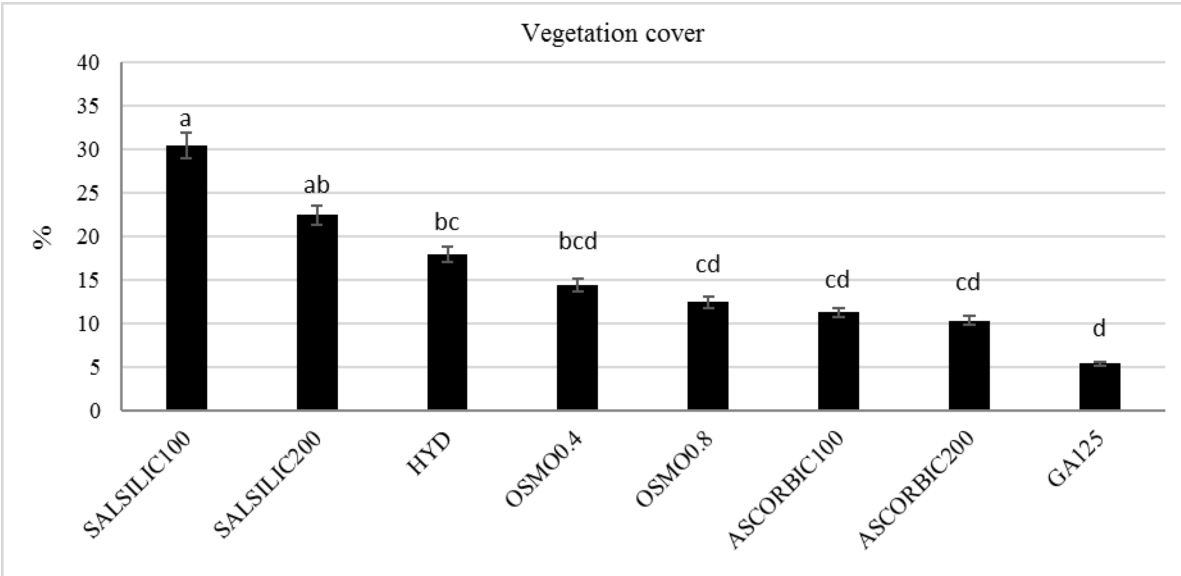


Fig. 5. Influence of seed priming treatments on vegetation cover of *Astragalus squarrosus* Means with the same letter are not significantly different at 5% probability level based on Duncan test.

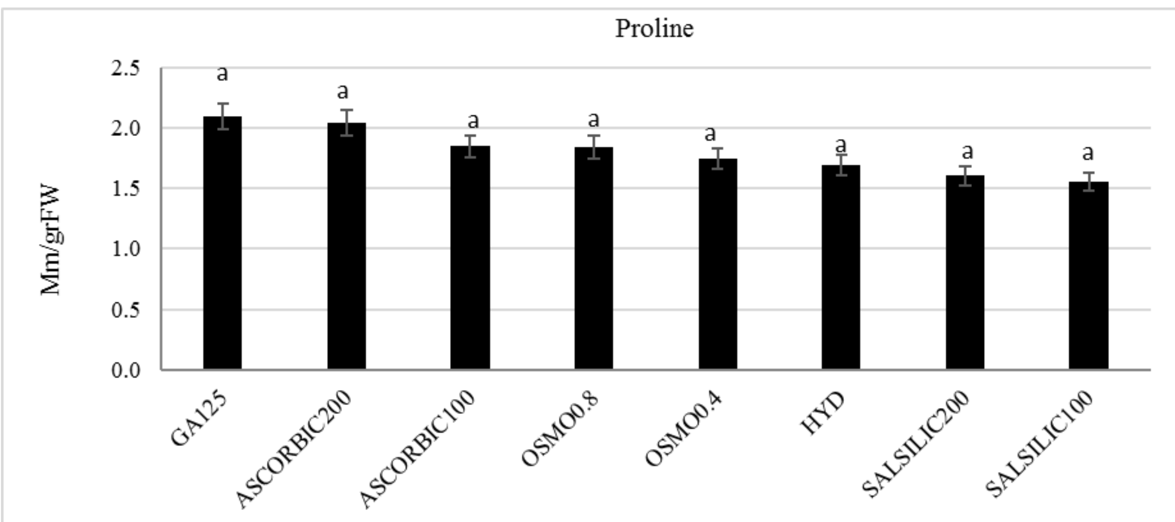


Fig. 6. Influence of seed priming treatments on proline content of *Astragalus squarrosus* Means with the same letter are not significantly different at 5% probability level based on Duncan test.

The results of means comparison between ecotypes showed that for DM yield, the highest and lowest values of 46.4 and 31.8 g/m^2 were obtained in Yazd and Semnan ecotype, respectively. In contrast, for proline content, the highest and lowest values of 2.95 and 0.79 Mm/gFW were obtained in Semnan and Yazd ecotype, respectively (Table 3). There were no significant differences between ecotypes for cover percent, plant height and carbohydrates; however, the highest yield was always obtained in Yazd ecotype.

There were no significant effects of priming by ecotype interaction for plant height, forage DM yield, vegetation cover and carbohydrate content, indicating the responses of treatment which were similar in all of ecotypes. According to the results obtained from Table 4, the highest DM yield and plant height with average values of 82 (g/m^2) and 34 cm, respectively, were related to the ecotype of Yazd with salicylic acid hormone 100 (mg/l). The highest percentage of cover with a value of 34.6% was reported in Kashan ecotype by applying salicylic acid 100 (mg/l). Regarding carbohydrate factor, the highest value of 36 (g/100gFW) was reported in Semnan ecotype with salicylic acid 100 (mg/l) (Table 5).

The priming by ecotype interaction effect was significant for proline content (p<0.01) (Table 2), indicating that responses of ecotypes to treatment were not similar and the highest rate of proline with value of 3.39 (Mm/gFW) was related to Semnan ecotype with gibberellic acid hormones 125 (ppm) (Table 5).

Table 3. Comparisons of mean ecotypes on the studied characteristics of *Astragalus squarrosus*

Ecotypes	Plant height (cm)	DM yield (g/m2)	Vegetation cover (%)	Carbohydrate (g/100gFW)	Proline (Mm/gFW)
Yazd	20.35a	46.40 a	17.3 a	18.9 a	0.79c
Kashan	18.80a	37.20 a	15.8a	18.2 a	2.01b
Semnan	15.50a	31.85b	13.4a	17.4 a	2.59a

Means of column with the same letter are not significantly different at 5% probability level based on Duncan test.

Table 4. Mean ± standard error of plant height, forage DM yield and vegetation cover in three ecotypes of *Astragalus squarrosus* under the influence of 8 seed priming treatments

Treatments	Plant height (cm)			DM yield (g/m²)			Vegetation cover (%)		
	Yazd	Kashan	Semnan	Yazd	Kashan	Semnan	Yazd	Kashan	Semnan
SALSILIC100	34.2±0.8	32.6±0.8	28.6±0.4	82.8±1.8	72.4±3.5	65.8±3.3	28.4±0.8	34.6±1.44	28.2±1.32
SALSILIC200	27.6±1.1	28.4±0.8	28.8±1.1	58.2±3.7	53.6±3.3	55.4±3.3	22.6±1.3	22.4±1.24	22.2±1.13
HYD	22.8±0.9	21.6±1.1	17.8±10	54.2±3.7	49±3.3	33.0±3.3	21.0±1.1	16.8±1.1	15.8±1.05
OSMO0.4	20.2±0.8	18.2±0.9	14.4±0.8	45.0±3.4	37±3.1	32.6±2.9	16.8±1.1	13.8±1.05	12.4±0.94
OSMO0.8	16.8±0.7	14.6±0.8	10.8±0.7	42.8±3.2	29.4±2.7	23.0±2.6	16.6±0.8	11.8±0.83	9.4±0.72
ASCORBIC100	16.2±0.7	14.2±0.6	10.4±0.5	37.4±3.1	28.4±2.7	20.4±2.5	14.2±0.79	11.6±0.75	8.8±0.64
ASCORBIC200	14.6±0.6	12.6±0.6	8.8±0.5	31.4±1.8	15.4±1.5	16.4±1.4	11.8±0.73	10±0.69	7.4±0.58
GA125	10.4±0.3	8.2±0.6	4.4±0.3	19.4±0.4	12.4±0.3	8.2±0.4	7.0±0.52	5.4±0.40	3.6±0.37

Table 5. Mean ± standard error of carbohydrate and proline content in three ecotypes of *Astragalus squarrosus* under the influence of 8 seed priming treatments

Treatments	Carbohydrate (g/100gFW)			Proline (Mm/gFW)		
	Yazd	Kashan	Semnan	Yazd	Kashan	Semnan
SALSILIC100	27.4±0.69	36.0±1.07	36.2±0.49	1.63±0.26	2.29±0.27	2.34±0.26
SALSILIC200	21.6±1.10	24.2±1.00	25.2±0.44	1.42±0.31	2.01±0.27	1.78±0.26
HYD	17.8±1.06	19.2±0.98	16.8±0.40	0.91±0.29	2.45±0.27	2.76±0.25
OSMO0.4	17.8±1.00	14.8±0.94	15.8±0.43	0.62±0.28	2.38±0.27	2.06±0.24
OSMO0.8	17.6±0.99	16.4±0.90	11.4±0.40	0.49±0.28	2.54±0.26	2.50±0.25
ASCORBIC100	18.4±0.94	13.0±0.85	11.0±0.41	0.45±0.28	1.66±0.26	2.70±0.26
ASCORBIC200	15.2±0.90	14.8±0.81	10.8±0.42	0.44±0.27	1.84±0.26	3.23±0.25
GA125	15.6±0.86	7.6±0.77	4.2±0.40	0.35±0.20	0.91±0.26	3.39±0.24

Discussion

The results showed that the effect of different treatments on qualitative and quantitative traits of *Astragalus squarrosus* was different in three ecotypes of Yazd, Kashan and Semnan. The interaction between priming treatments and different ecotypes was not significant except proline. Among the treatments, salicylic acid 100 and 200 (mg/l) had a higher effect on quantitative and qualitative traits in all three eotypes except proline and carbohydrate.

In this regard, Salicylic acid activates many protective enzymes such as catalase, superoxide dismutase and ascorbate peroxidase. Also, this acid causes cell elongation and cell division, which is done in cooperation with other regulators, including auxin, and regulates cell proliferation, division and death, and increases the total weight of the plant (Shakirova and Sahabutdinova, 2003). Salicylic acid is a plant hormone known to reduce the harmful effects of many stresses. Salicylic acid and its derivatives are among the new compounds that act as phytohormones in some plants (Chen *et al*., 2019). Salicylic acid is a prophetic and an inductive molecule in plant defense and thus increases plant resistance to pathogens (Fakhireh and Shahriari, 2018). Researchers have shown that salicylic acid has improved a number of abiotic stresses such as heat stress and reduced freezing damage in various plants (Tasgin *et al*., 2003; Kang and Saltveit, 2002) and increased resistance to heavy metal stress in plants (Metwally *et al*., 2003). Salicylic acid is effective in bud growth, membrane permeability, mitochondrial respiration, stomata closure, photosynthetic material transfer, and ion uptake rate (El-tayeb, 2005).

Analysis of variance of plant height showed that the effect of seed priming treatments on plant height was significant ($P<0.01$). According to the means comparison, it was observed that Yazd and Semnan ecotypes had the highest and lowest plant height, respectively. In terms of priming treatments, the highest and lowest plant heights were related to salicylic acid and gibberellic acid (125 ppm), respectively. The results showed that forage DM yield was influenced by the seed priming treatments ($P<0.01$). According to the means comparison, it was observed that Yazd and Semnan ecotypes had the highest and lowest DM yield. Regarding priming treatments, it was observed that the highest DM yield was related to priming treatment with salicylic acid 100, 200 (mg/l) and hydropriming and the lowest DM yield was related to gibberellic acid 125 (ppm). Shoghian and Roozbehani, (2017) reported that salicylic acid had a positive effect on morphological and physiological traits, DM yield, plant height, improving total chlorophyll and grain yield components in *Phaseolus vulgaris*. Salicylic acid causes cell elongation and cell division, which is done in cooperation with other regulators including auxin and regulates cell proliferation, cell division and increases the total weight of the plant (Shakirova and Sahabutdinova, 2003). Based on the research of Alamri *et al*., (2018), it was found that salicylic acid by increasing proline and carbohydrates concentration in wheat seeds increases the germination traits and plant height, which is consistent with the findings of the present study. Mir-Mahmoodi *et al*., (2014) stated that priming with salicylic acid has a significant positive effect on various characteristics of *Brassica napus* L., which is consistent with the results of this study. Various physiological and biochemical effects of salicylic acid have been observed on plant biological activity including the increased ion uptake, membrane permeability, mitochondrial respiration, stomata closure, material transfer, growth rate, and photosynthesis rate (Senaratna, 2003). Researchers have found that the use of salicylic acid improves photosynthesis, reduces the content of sodium, chlorine and increases nitrogen, phosphorus, potassium and calcium stored in plant tissue, thereby improving DM yield (Torrens-Spence *et al*., 2019).

In terms of priming treatments, it was observed that the highest vegetation cover was related to priming treatment with salicylic acid 100 (mg/l) followed by salicylic acid 200 (mg/l) in the next rank and the lowest plant vegetation cover related to gibberellic acid 125 ppm. Moravcová *et al*., (2018) in a study that examined the effect of salicylic acid on corn seed germination stated that salicylic acid has a significant effect on increasing metabolic activity and seed germination as well as corn root development. Salicylic acid plays a central role in regulating various physiological processes such as growth, plant evolution, ion uptake, photosynthesis and germination depending on the concentration used in the plant and environmental conditions. The exact mechanism of action of salicylic acid is not yet known, but salicylic acid like auxin may be involved in the regulation, elongation, and cell division (Torrens-Spence *et al*., 2019).

The results showed that the amount of carbohydrates of plants under the influence of priming treatments had a significant difference ($p<0.01$). Soluble carbohydrates not only play an important role in increasing forage quality but also have a significant effect on cold resistance and grazing resistance of livestock, hence, they are considered as the most important quality trait after digestibility. These compounds also play an important role in energy transfer and storage as well as plant body maintenance. The nutritional value of forage plants is directly related to the amount of soluble protein and carbohydrates because the amount of plant protein and carbohydrates is against cellulose and fiber. Also, carbohydrates play an important role in plant palatability (Ghasriani *et al*., 2017). Increasing the amount of soluble carbohydrates has an important role in reducing the osmotic potential and ultimately creating a suitable slope between the plant and the soil and increases water absorption. Because the accumulation of organic compounds such as carbohydrates and amino acids in the cytoplasm plays an important role as osmotic regulators and increases plant function. More carbohydrates make the species have higher resistance under drought stress and have a higher DM yield (Javadi *et al*., 2004).

Based on the results of this study, regarding factors examined, hydropriming as well as hormone priming led to the best result in field of DM yield and plant height of *Astragalus squarrosus*. The reason for the improvement of the studied characteristics of *A. squarrosus* species in this study under hydropriming can be explained by the fact that the seeds spend a considerable amount of time absorbing water during sowing. By reducing this time to a minimum, seed hydropriming can speed up its germination and seedling emergence. Another benefit of seed hydropriming is the reduction of the germination base temperature, which increases plant DM yield (Jisha and Puthur, 2018; Muzaffar *et al*., 2019; Alias *et al*., 2018).

Conclusion

In general, based on the results of this study, regarding factors examined, Yazd ecotype had higher plant height, vegetation cover, carbohydrate and DM yield than other studied ecotypes. Despite the fact that the Semnan ecotype is native, the Yazd ecotype, which is non-native, was superior to the Semnan ecotype and this fact shows that to select the elite ecotype, assessments have to make on ecotypes with different origins.

Hydropriming as well as hormone priming was introduced as the best treatments to improve the performance of *A. squarrosus*. So, this issue can be considered in improving the DM yield and performance of this valuable endemic species in Iran. Hydropriming has been reported to be an economical, simple and safe technique for increasing the capacity of seeds for the osmotic adjustment and enhancing the seedling establishment and germination performance and emergence in the seeds of many crops and small seeded grasses. Also, since hydropriming is cheaper and more ordinary than hormone priming by salicylic acid. Therefore, in applying priming for ecotypes of *A. squarrosus*, this issue should be considered by beneficiaries. The information generated in this research is useful for both researchers and producers. It was concluded that application of hormonal seed priming of *A. squarrosus* could be useful for direct seeding of this species for rehabilitation of degraded arid rangelands of Iran.

References

Abbasi Khalaki, M., Ghorbani, A. and Samadi Khanghah, S., 2017. The effect of osmopriming and hormo priyming on germination and early growth of Festuca ovina under drought stress (in vitro). Journal of Range and Watershed Management, 70(4):909-913. (In Persian).

Alamri, S. A., Siddiqui, M. H., Al-Khaishani, M.Y. and Ali, H. M., 2018. Response of salicylic acid on seed germination and physio-biochemical changes of wheat under salt stress. Journal of Acta Scientific Agriculture, 2(5): 36-42.

Alias, N.S.B., Billa, L., Muhammad, A. and Singh, A., 2018. Priming and temperature effects on germination and early seedling growth of some *Brassica* sp. Journal of Acta Hortic, 1225: 407-414.

Alizadeh, M. A. and Nasiri, M., 2012. Seed technology with emphasis on rangeland plant species. Seed and Plant Registration and Certification Institute Publication, Karaj, Iran, P. 197. (In Persian).

Alvani, F., Dianati Tilaki, G. H. and Sadati, E., 2017. The effects of priming with acid ascorbic on physiological traits of *Taverniera cuneifolia* seeds under drought stress. Journal of Rangeland, 11(3):294-305. (In Persian)

Araghi Shahri, S.M., Dianati Tilaki, G.A., Behtari, B. and Alizadeh, A., 2014. Comparative effects of hydropriming and halopriming on germination performance of *Secale montanum* Guss, under salinity stress. Journal of Rangeland Science, 4(3):216-223. (In Persian)

Batoli, H., 2008. Ecological study of *Astragalus squarrosus* Bunge in Kashan sand dunes, Journal of Research and Construction, 21(3):8 - 17.

Bradford, K. J., 1986. Manipulation of seed, water relations via osmotic priming to improve germination under stress conditions. Journal of HortScience, 21 (5): 1105-1111.

Chen, L., Wang, W. S., Wang, T., Meng, X. F., Chen, T. T. and Huang, X. X., 2019. Methyl salicylate glucosylation regulates plant defense signaling and systemic acquired resistance. Journal of plant physiology, 180: 2167–2181.

El-tayeb, M. A., 2005. Response of barley grains to the interactive effect of salinity and salicylic acid. Journal of Plant Growth Regulation, 45: 215-224.

Fakhireh, S. and Shahriari, A., 2018. Analysis of seed germination characteristics of *Cynodon dactylon* affected by treatments of salicylic acid, gibberellic acid and potassium nitrate treatments. Journal of Plant Research, 31(1):166-174. (In Persian).

Farooq, M., Hussain, M., Imran, M., Ahmad, I., Atif, M. and Alghamdi, S. S., 2019. Improving the productivity and profitability of late sown chickpea by seed priming. International Journal Plant Production, 13: 129–139.

Ghasriani, F., Bayat, M., Abolghasemi, M., Abarsaji, G.H., Akbarpour, H., Azami, A., bagheri, H., Bani Asadi, M., Hasan zadeh, M., khodagholi, M., Dehghani Tafti, M A., Rahmani, G.H., Zarekia, S., Zare,M T., zadbar, M., Sharifi Yazdi, M., sharifi, J., Farmahini Farahani, A. and Mohammadpour, M., 2017. Allowable use of the dominant species in steppe and desert rangelands of Iran. Research Institute of Forests and Rangelands publication, Tehran, Iran (In Persian).

Irigoyen, J.J., Emerich, D.W., Sanchez-Diaz, M., 1992. Water stress induces changes in concentration of proline and total soluble sugar in nodulated alfalfa (*Medicgo sativa*) plants. Journal of Physiologia Plantarum, 84:55-60.

Javadi, T., Arzani, K. and Ebrahimizadeh, H., 2004. The amount of soluble carbohydrates and proline in nine ecotypes of (*Pyrus serotina*) under drought stress. Journal of Biology, 17 (4): 369-387. (In Persian).

Jisha, K.C. and Puthur, J.T., 2018. Seed hydropriming enhances osmotic stress tolerance potential in *Vigna radiata*. Journal of Agricultural Research, 7:145–151.

Kang, H. M. and Saltveit, M. E., 2002. Chilling tolerance of maize, cucumber and rice seed ling's leaves and roots are differently affected by salicylic acid. Journal of Plantarum, 115: 571-576.

Kaur, S., Gupta, A. K. and Kaur, N., 2002. Effect of osmo and hydropriming of chickpea seeds on the performance of crop in the field. Chickpea Pigeonpea News, 9: 15-17.

Kaur, S., Gupta, A. K. and Kaur, N., 2005. Seed priming increases crop yield possibly by modulating enzymes of sucrose metabolism in chickpea. Journal of Agronomy, Crop Science, 91:81-87.

Kavandi, A., Jafari, A A. and Jafarzadeh, M., 2018. Effect of seed priming on enhancement of seed germination and seedling growth of annual sainfoin (*Onobrychis crista*-galli (L.) Lam.) in medium and long-term collections of Gene Bank. Journal of Rangeland Science, 8(2): 117-128. (In Persian)

Langeroodi, A.R.S. and Noora, R., 2017. Seed priming improves the germination and field performance of soybean under drought stress. Journal of Animal and Plant Sciences, 27(5):1611–1620.

Lock, J.M. and Simpson, K., 1991. Legumes of west Asia, a checklist. Royal Botanic Gardens, Kew. Chicago Press book.

Maassoumi, A. A., 1998. *Astragalus* in the old world. Check list. Research Inistitute of Forests and Rangelands, Tehran.

Metwally, A., Finkmemeier, I., Georgi, M. and Dietz, K.J., 2003. Salicylicacid alleviates the cadmium Toxicity in barley seedlings. Journal of Plant physiology, 132: 272-281.

Michalska-Klimczak, B., Wyszy ́nski, Z., Paˇcuta, V., Rašovský, M. and Ró˙za ́nska, A., 2018. The effect of seed priming on field emergence and root yield of sugar beet. Journal of Plant, Soil Environment, 64:227–232.

Mir-Mahmoodi, T., Karbalaye Golizadeh, S., Khaliliqhdam, N. and Yazdanseta, S., 2014. The effect of salicylic acid on rate germination and seedling establishment on rapeseed (*Brassica napus* L.). International Journal of Agriculture Innovations and Research, 2(6): 2319-1473.

Moravcová, Š., Tůma, J., Dučaiová, Z.K, Waligórski, P., Kula, M., Saja, D., Słomka, A., Bąba, W. and Libik-Konieczny, M., 2018. Influence of salicylic acid pretreatment on seeds germination and some defence mechanisms of *Zea mays* plants under copper stress. Journal of Plant Physiology and Biochemistry, 122:19-30.

Moreno, C. and Seal, C. E., 2018. Papenbrock, J., Seed priming improves germination in saline conditions for Chenopodium quinoa and Amaranthus caudatus. Journal of Agronomy and Crop Science, 204: 40–48.

Musa, A. M., Johansen, J. and Kumar, J., 2001. Short duration chickpea to replace fallow after Aman Rice: the role of on-farm seed priming in the high Briand Tract of Bangladesh. Experimental Agriculture, 37: 509-521.

Muzaffar, W.; Ahmad, R.; Hussain, M.; Farooq, M. and Wakeel, A., 2019. Influence of seed priming and sowing methods on growth and productivity of wheat cultivars differing in seed size in rice-wheat cropping system of Punjab, Pakistan. International Journal of Agriculture and Biology, 21:803–809.

Nasiri, M., 1994. Factor affecting dormancy, germination and seed development. Research Institute of Forests and Rangelands press, pp.63. (In Persian)

Nawaz, J., Hussain, M., Jabbar, A., Nadeem, G. A., Sajid, M., Subtain, M. and Shabbir, I., 2013. Seed priming a technique. International Journal of Agriculture and Crop Sciences, 6(20): 1373-1381.

Nourzad, S., Ahmadian, A. and Moghadam, M., 2015. Evaluation of proline chlorophyll carbohydrate index and nutrient uptake in coriander under drought stress and fertilizer treatment. Journal of Crop Research, 13(1): 131-135.

Paquin, R. and Lechasseur, P., 1979. Observations sur une methode dosage de la proline libre dans les extraits de plantes. Canadian Journal of Botany, 57:1851-1854.

Podlech, D., 1998. Phylogeny and progression of characters in Old World Astragali (Leguminosae)., In: Zhang A.,Wu S. (Eds.) Floristic characteristics and Diversity of East Asian Plants., China higher Education Press., Beijing., Pp: 405-407.

Rashid, A., Harris, D., Hollington, P. A. and Rafiq, M., 2004. Improving the yield of mungbean (*vigna radiata*) in the North West frontier province of Pakistan using on-farm seed priming. Experimental Agriculture Journal, 40: 233-244.

Senaratna, T., 2003. Acetyl salicylicacid (Aspirin) and salicylic acid induced multiplestres tolerance in bean and tomato plant. Plant Growth Regulation, 30:157-161.

Shakirova, F. M. and Sahabutdinova, D. R., 2003. Changes in the hormonal status of wheat seed lings induced by salicylic acid and salinity. Journal of Plant science, 164: 317-322.

Shirini, R and Moameri, M., 2018. Effect of gibberellic acid treatments and wet cooling pretreatment on *Trifolium pretense.* 7th National Conference on Rangeland and Rangeland Management of Iran. Tehran, Iran.

Shoghian, S.H. and Roozbehani, A., 2017. Effect of salicylic acid foliar application on morphological and physiological traits of yield and yield components of *phaseolus vulgaris* under drought stress, Journal of Crop Physiology, 34(9): 131-146. (In Persian)

Singh, R., Dahiru, Musa, M. and Sani Haliru, B., 2014. Effect of osmopriming duration on germination, emergence, and early growth of Cowpea (*Vigna unguiculata* (L.) Walp.) in the Sudan Savanna of Nigeria. International Journal of Agronomy. P: 1-4. https://doi.org/10.1155/2014/841238.

Tasgin, E., Atic, O. and Nalbantoglu, B., 2003. Effect of salicylic acid on freezing tolerance in winter wheat leaves. Plant Growth Regul, 41: 231-236.

Torrens-Spence, M. P., Bobokalonova, A., Carballo, V., Glinkerman, C. M., Pluskal, T. and Shen, A., 2019. PBS3 and EPS1 complete salicylic acid biosynthesis from isochorismate in Arabidopsis. Mol. Plant 12:1577–1586.

اثرات هیدروپرایمینگ، اسموپرایمینگ و هورمون پرایمینگ بر تغییر برخی از صفات فیزیولوژیکی سه جمعیت مختلف گونه ***Astragalus squarrosus*** **Bunge** در ایران

مهشید سوری[الف]، سعیده ناطقی[ب] ، نادیا کمالی[ب] ، مینا بیات[ج]

[الف]استادیار پژوهشی، بخش تحقیقات مرتع، موسسه تحقیقات جنگلها و مراتع کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، تهران، ایران (نگارنده مسئول) پست الکترونیک: souri@rifr-ac.ir

[ب] استادیار پژوهشی، بخش تحقیقات مرتع، موسسه تحقیقات جنگلها و مراتع کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، تهران، ایران

[ج] کارشناس ارشد پژوهشی، بخش تحقیقات مرتع، موسسه تحقیقات جنگلها و مراتع کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، تهران، ایران

چکیده. گون‌ها از نظر دارویی، علوفه‌ای و اقتصادی در ایران دارای اهمیت فراوانی هستند. تخریب قلمرو گسترش گون‌ها و تشدید فرسایش، نابودی این منبع را تهدید می‌کند. گونه نتر *Astragalus squarrosus* یکی از گونه‌های بومی و سازگار در شنزارهای ایران است که به لحاظ تحمل شرایط خاص اکولوژیکی و نیز ارزش تغذیه‌ای و حفاظت خاک بالا از اهمیت زیادی برخوردار است، بنابراین این پژوهش به منظور تعیین تأثیر تیمارهای پرایمینگ بر شاخص‌های رشد و عملکرد گونه *A.squarrosus* انجام گرفت. در این تحقیق اثر هیدروپرایمینگ، اسموپرایمینگ و هورمون پرایمینگ بر فاکتورهای ارتفاع، درصد پوشش، تولید، میزان پرولین و کربوهیدرات گونه نتر مورد بررسی قرار گرفت. بذرهای سه اکوتیپ یزد، کاشان و سمنان تحت تیمارهای مختلف شامل هیدروپرایمینگ (آب مقطر)، هورمون پرایمینگ (اسید جیبرلیک: ۱۲۵ و ۲۵۰ ppm، اسید سالسیلیک: ۱۰۰ و ۲۰۰ mg/l و اسید اسکوربیک: ۱۰۰ و ۲۰۰ mM) و اسموپرایمینگ (نیترات پتاسیم: ۰/۳ و ۰/۲ درصد) به صورت جداگانه پرایم شدند. آزمایش به صورت کرت‌های خرد شده بر پایه طرح بلوک‌های کامل تصادفی در پنج تکرار در مزرعه تحقیقاتی طرود استان سمنان در سال ۱۳۹۷ اجرا شد. بررسی نتایج گویای معنی‌دار بودن اثر پرایمینگ بر میزان کربوهیدرات، پوشش، تولید و ارتفاع گونه *A. squarrosus* در سطح خطای یک درصد بود. ویژگی‌های مورد بررسی بذرهایی که در معرض انواع پرایمینگ قرار گرفته بودند در مقایسه با بذرهای شاهد اختلاف معنی‌داری با یکدیگر داشتند. بر اساس نتایج تحقیق حاضر، بیشترین ارتفاع گیاه با (۳۴ سانتی متر) و تولید علوفه (۸۲ گرم بر متر مربع) در جمعیت یزد با استفاده از تیمار اسید سالسیلیک۱۰۰ (mg/l) گزارش شد. بیشترین میزان کربوهیدرات ۳۶ (g/100g FW) و پرولین و ۳/۳۹ (Mm/g FW) در جمعیت سمنان به ترتیب با استفاده از تیمار اسید سالسیلیک۱۰۰ (mg/l) و اسید جیبرلیک: ۱۲۵ ppm به دست آمد. بیشترین میزان درصد پوشش (۳۴/۶ درصد) در جمعیت کاشان با اعمال تیمار اسید سالسیلیک۱۰۰ (mg/l) گزارش گردید. اطلاعات بدست آمده از این تحقیق، برای بذرکاری مستقیم گونه *A. squarrosus* برای احیا مراتع خشک تخریب شده ایران مفید می باشد.

کلمات کلیدی: بذر، درصد پوشش، ارتفاع، پرولین، کربوهیدرات، *Astragalus squarrosus*