



Investigation of Different Root Cutting Treatments on Gum Yield and Survival of *Dorema ammoniacum* D.Don in South of Sabzevar City

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Abstract

Dorema ammoniacum D.Don (Apiaceae) is a monocarpic species with bulky root and stem height by 1-2 meters, which its gum resin flows in phloem issues. Gum resin has pharmaceutical and industrial properties. In traditional medicine, it has been described as a sputum (expectorant), anticonvulsant, anti-cough, antispasmodic and gastrointestinal drug. In order to compare the different root cutting methods for gum extraction, a factorial experiment was carried out based on randomized complete block design with four replications on 4-year-old *Dorema* plants in south of Sabzevar city, Iran, in 2016. Treatments consisted of cutting methods (surface and concave), number of root cutting (1 to 4 times) and stopping time after root cutting (2 to 10 days). The results showed that the gum yield in concave method (14.73 gr plant⁻¹) was 56% more than the surface method (9.41 g / plant). In addition, in the surface method, by increasing the number of root cutting from 1 to 4, the amount of gum increased from 6 to 11.8 g per plant. Whereas in the concave method this value was increased from 10.2 to 18 g per plant ($p < 0.05$). The interaction between number of cutting and stopping time after root cutting showed that two times of cutting with 6 days stopping caused 16 g gum per plant. In terms of survival, 85% of plants (95 bushes) with more than 2 times cutting or 8 to 10 days stopping after root cutting died in the next year.

Keywords: *Dorema ammoniacum*, Gum, Root cutting, Surface, Concave

Introduction

Dorema plant (*Dorema ammoniacum* D.Don) from the Apiaceae family [1], which is also known as Oshak and Kandel, is a herbaceous, perennial, and monocarpic species with rosette leaves, yellow flowers, schizocarp fruit, with a large root and 1-2 m high stems, which there are latex tubes containing milky gum throughout the interior space of its petiole, stem and root [2]. This gum, which can leak out of the stem due to sand particles hitting the stem or insect bites, serves as an antispasmodic, expectorant, anticancer [3], carminative, poultice, mild diuretic, diaphoretic [4], stimulant, spleen, antimicrobial, liver tonic [5], vasodilator [6], and it has an industrial application too [7]. So far, 16 species worldwide and 6 species from Iran have been reported for genus *Dorema* [8], the most important of which is *D. ammoniacum*. Since the

habitat distribution of *D.ammoniacum* is only in arid and semi-arid regions of Iran [9] and some neighboring countries such as Afghanistan, Pakistan [10,11], and north of India [12], then it can be considered as a rare and valuable species [13]. The gum of *D.ammoniacum* has medicinal and industrial properties and it has been considered in treatment of spastic pains, intestinal parasitic infections, skin inflammations in traditional medicine [14,15,16]. It is also used in the treatment of gastrointestinal and sciatica diseases [17]. The ammoniac gum in addition to improving many chronic diseases it is used in the glue and cosmetics industries too [18]. Several studies have been conducted in relation to identification of chemical compounds of the gum and volatile oil of different parts of *D.ammoniacum* such as flower, stem, leaf, and root [19,20]. The molecular structure of essential oil major chemical compounds of *D. ammoniacum* consists of Limonene, Neophytadiene, -Caryophyllene,

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Phytol, and Neryl acetone that is widely used in the process of manufacturing and production of various cosmetic products [21]. Some studies indicate that, the leaves of this plant contain 34 hydrocarbon compounds with -himachalene (9.3%), -chamigrene (8.7%), and its root contains 35 hydrocarbon compounds with -bisabolene (15.1%), -hexadecanal (13.2%). There is a strong antioxidant and antibacterial activity in essential oil of ammoniac gum too [12]. Other researchers reported that, 37 and 26 organic compounds, consisting of a variety of fatty acids, enzymes, and alcohols are respectively obtained from the stem and seed essence of *D. ammoniacum* [22]. Another report states that essential oils of ammoniac gum have been used for thousands of years in various cultures for medicinal and health purposes and it has a widespread range of application from aromatherapy, household cleaning products, personal beauty care and natural medicine treatments [23]. Reviews conducted by the authors of this article indicate that, due to the exclusivity of the *D. ammoniacum* habitat, there has been no similar foreign research on the proper root cutting methods and there have been only few studies in Iran. In this regard, Gholami and Faravani conducted a study in Mohammad Abad region of Qain city in order to find the best root cutting method for *D. ammoniacum* root, in which three root cutting methods such as traditional, concave, and staircase methods were examined at different time intervals and they reported that staircase and concave method provide the best results for gum harvesting with 3 to 4 days stopping time after cutting [24]. They also stated that, 4-times root cutting with more than 6 days stopping time after

each cutting, as well as the traditional method, resulted in elimination of the vegetative bud and death of *D. ammoniacum* [24]. In another study related to two different root cutting methods for the *Ferula assa-foetida*, from Apiaceae family that carried out by Pirmoradi, the two-way cutting method was cited as an appropriate method, but the root cutting more than 9 times, which results in reduced gum content and death of plant, as well as the traditional method in which the vegetative bud is eliminated, were rejected [25]. Since *D. ammoniacum* is considered to be a rare plant [26] and it has been referred to as a species undergoing extinction in the Red Data Book [10], it is necessary to conduct studies related to harvesting of its gum. There are currently no specific methods for root cutting by plant scientists to extract gum from *D.ammoniacum* root and due to different climatic and economic conditions in ecological areas of *D.ammoniacum* species, each region needs a study for finding the right method exploiting the root. This study was conducted to introduce a suitable method for exploitation of *D.ammoniacum* root and to investigate its survival in southern region of Sabzevar city.

Material and Methods

For investigating the effect of different root cutting treatments of *Dorema ammoniacum* on its root gum yield quantity, we carried out a factorial experiment based on randomized complete block design with four replications on 4-year-old *Dorema* plants in one of its natural habitats in the south of Sabzevar city, Iran, in 2016.

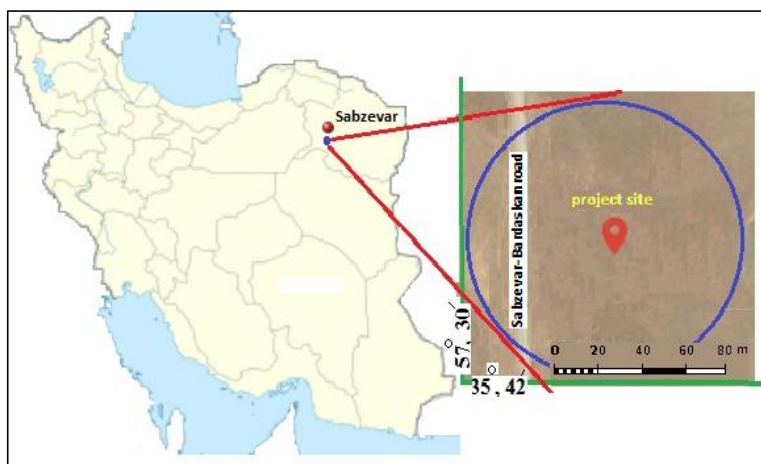


Fig. 1 Location of the study area on the map (Google earth, 2016)

To do this, we first selected a habitat from *D. ammoniacum* species in 75 km south of Sabzevar city with geographical coordinates of 57 °, 30' E (Longitude) and 35°, 42' N (Latitude) in 2016 (Fig. 1). Then we enclosed an area (1 hectare) in the natural habitat of the *D. ammoniacum*. In the next step, we randomly chose and marked 160 4-year old *D. ammoniacum* bushes. In this study bushes less than 4 years old due to weak roots and bushes older than 4 years were not selected for the experiment. Treatments included two root cutting methods (surface and concave), number of cutting (1 to 4 times) and stopping time (time duration) after root cutting (2 to 10 days) (Fig. 2 and 3).



Fig. 2 Root cutting surface method



Fig. 3 Root cutting concave method

After marking the selected bushes and drying the rosette leaves, the root cutting of *D. ammoniacum* was performed from the middle of August in 2016. For this purpose, to facilitate access to the root of the

plant, pits were dug at the depth of 20 cm under the bushes and backward to the sun. Then, using a special knife, the root of *D. ammoniacum* was cut. To harvest the gum yield from root in surface cutting method, we cut a circular thin layer of root tissue with 5 cm in diameter and 3 mm in depth, and in the concave cutting method, a similar layer, but at 45-degree angle towards the root, was cut, such that the depth of the cut from the circumference of the circle to its center is gradually increased and reached 1 centimeter in the middle of the circle. After each cutting, the gum leaked from the wound site was collected and weighed according to defined treatments. The soil around the root was returned to the pits after finishing the experiment in order to prevent the contamination of root. The collected data were analyzed with SAS software. In addition, in order to investigate the effect of root cutting on survival of all the bushes examined, we counted the number of *Dorema* bushes that grew or died after root cutting in the following year (in the spring of 2017).

Results

Results showed that root cutting methods, root cutting repetition time duration after root cutting, and their interactions have a significant effect on gum yield ($p < 0.05$) (Table 1).

The outcomes of evaluations and comparisons showed that extraction of gum using concave cutting method on *Dorema ammoniacum* root with an average production of 14.73 g / plant was 56% more than surface cutting method (9.41 g / plant) and their difference was significant at 5% level (Fig. 4).

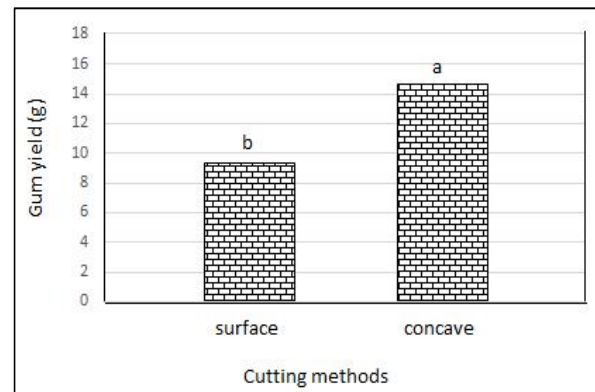


Fig. 4 Comparison of gum extracted from roots of *D. ammoniacum* in surface and concave cutting methods

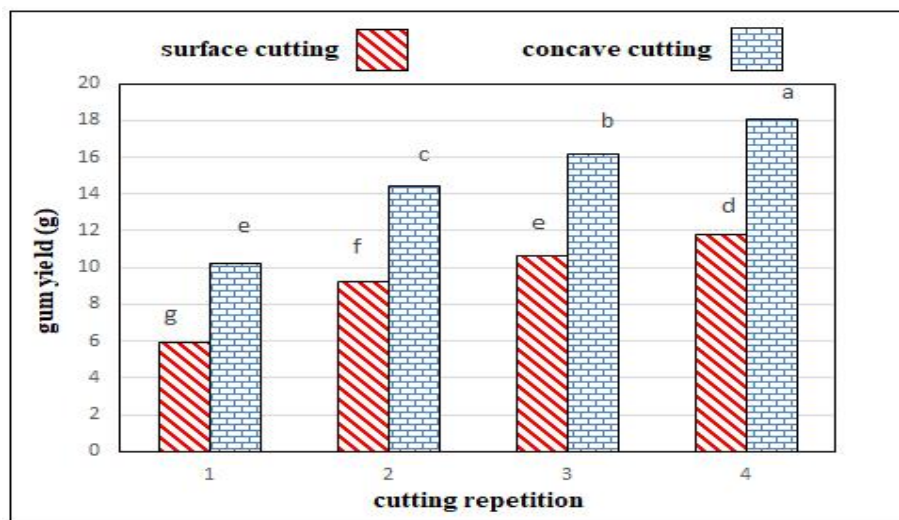
Table 1 ANOVA of root cutting method, number of root cutting, and time duration after root cutting on *Dorema ammoniacum* D.Don root

Source of Variation	Sum of Square	DF	Mean Square	F Value
Block	2.72	3	0.907 ^{ns}	1.25
Root cutting method (M)	1125.19	1	1125*	1552.67
root cutting repetition (C)	1039.08	3	346*	477.95
Time of after root cutting (T)	491.75	4	122*	169.64
M*C	20.39	3	6.79*	9.38
M*T	42.36	4	10.59*	14.61
C*T	36.94	12	3.07*	4.25
Interaction (R*N*T)	11.80	12	0.983*	1.36
Error	84.78	117	0.725	

*and ^{ns} are significant and non-significant at 5% probability level respectively

There was also a statistically significant relationship between the cutting repetition of *D. ammoniacum* root and the increased gum content in both surface and concave methods at 5% level. In this test, in the surface method, the amount of gum obtained from one *D. ammoniacum* root cutting was 6 g per plant and in four cuttings; it was increased to 11.8 g per plant. Whereas, in concave root cutting method, the gum yield was increased from 10.2 g / plant (once root cutting) to 18 g/plant (4 times cutting) and it was significant at 5% level (Fig. 5).

Statistical results of the effect of stopping time after cutting on the amount of the *Dorema* root gum showed that, in the surface cutting method, the amount of gum was increased in the first days after cutting and it reached 10.2 g after four days; however, it showed a slight effect on the gum leakage after day six. Also in the study of the effect of stopping time after root cutting on the amount of gum yield in concave method, at the first 6 days after root cutting, the amount of leaked gum was increased to 15.8 g per plant, however, in the stopping time treatments of 8 to 10 days after cutting, there was a very slight increase (Fig. 6).

**Fig. 5** Effect of root cutting repetition on gum extracted from roots of *Dorema ammoniacum* D.Don in surface and concave cutting methods

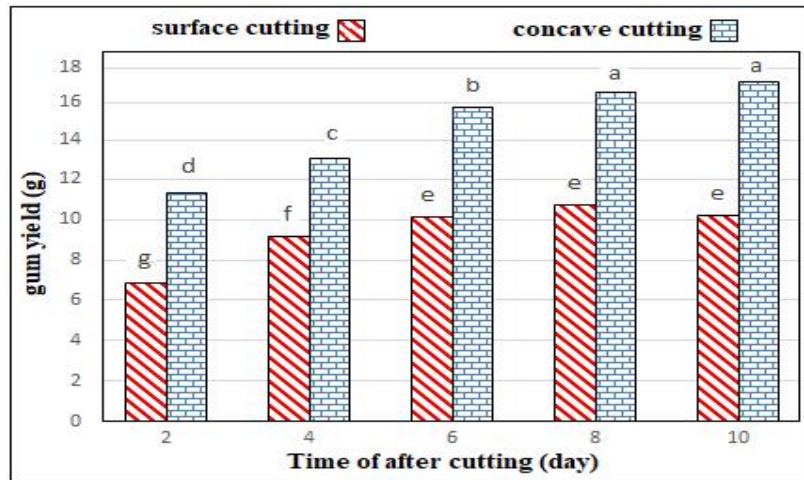


Fig. 6 Effect of stopping time after root cutting on the amount of *Dorema ammoniacum* D.Don root gum yield

The results of the interaction between the number of root cuttings and the stopping times (time duration) after root cutting showed that, the amount of gum yield root is increased by increasing root cutting

number from 1 to 4 and increasing stopping time after root cutting from 2 days to 10 days, but this increase was not significant at all levels ($p < 0.05$) (Fig. 7).

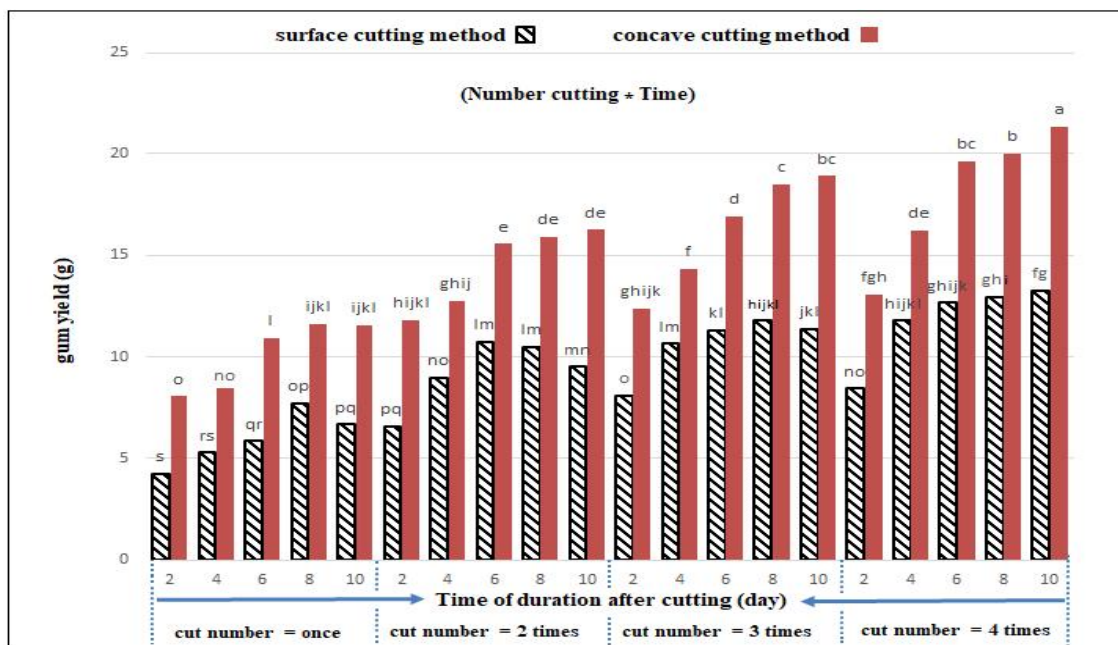


Fig. 7 Interaction between the number of root cutting and time duration after root cutting the *Dorema ammoniacum* D.Don root on root gum yield

For example, the interaction between the treatments 1, 2 and 3 times root cutting in surface method and 8 to 10 days after cutting showed that the amount of leaked gum is decreased by increasing the number of root cuttings and the duration time of post-cutting. Although the amount of gum is increased by increasing the number and duration time of root cutting at some experiment levels, this increase is

not significant at a significance level of 5% (Fig. 7). There were similar observations in the concave root cutting (Fig. 7). The results of surviving plants under testing in the next year showed that, out of 160 *Dorema* bushes whose roots were subjected to different treatments of root cutting, 95 bushes whose root 3 to 4 times cut or whose roots were exposed to the air for 8 to 10 days, they died and didn't regrowth

in the next year. Thus, it can be concluded that 2 times root cutting with the time interval of 6 days after each cutting is the most suitable root cutting method for *D.ammoniacum* root with an average harvest of 16 g gum per plant and with the purpose of plant survival in the area under study.

Discussion

Based on the obtained results, by applying the suitable root cutting method, appropriate number of root cutting and determining the exact time of harvesting of the gum yield after cutting on the *Dorema ammoniacum* root (bushes older than three years except the last growth year), gum can be harvested from its roots without endangering the plant's regeneration. In this study, it was determined that 2 times cutting on the *D.ammoniacum* root through concave cutting method and then harvesting gum yield 6 days after each cutting is the most suitable method for exploiting from *D.ammoniacum* root, but increasing the number of root cutting leads to the elimination of the species, which is consistent with the findings of Pirmoradi [25], Gholami and Faravani [24]. Also, regarding the effect of the number of root cutting on the survival of *Ferula gummosa* plant, which is a member of Apiaceae family, Nabiei cited that 3 times root cutting is suitable for this plant [27]. Other researchers reported that the root diameter in *Ferula assa-foetida* species (which it is like *Dorema* plant from Apiaceae) has a significant effect on amount of gum yield, and to collect more gum from thicker roots we can repeat the root cutting up to nine times [28]. Although this means that the more root cutting the more gum yield, but they did not point to plant regeneration after root cutting. Although the results showed that the root of 3-year-old *Dorema* bushes should not be cut more than twice, it seems that in older plants with thicker roots we can increase the number of root cutting. In this regard we can refer to Karimian and his colleagues that carried out a study on *Ferula assa-foetida* also concluded that there is a significant difference between gum yield in the *Ferula assa-foetida* root with various age classes [29]. Results related to time duration after root cutting demonstrated that the time stop more than 6 days after root cutting can lead to root rot and plant death. In this regard, Gholami and Faravani reported that stopping time more than 6 days after each cutting for gum harvesting would endanger the regeneration of the plant [24]. It seems the types of

root cutting and the time duration after root cutting is different in some species. Moradi and his colleagues reported that for extracting maximum gum from *Ferula gummosa* root (Apiaceae) it is necessary to make a cut to a depth of half a centimeter below the site of the previous cut after 7 days [30]. Other results showed that most bushes that their roots were cut 2 times or less by the concave method could grow in the following spring and continued growing. In this regard, Gholami and Faravani stated that the highest percentage of cut plant survival was in concave root cutting method (58.3%) and then in the staircase method (54.3%) [24]. Since the traditional cutting method leads to the dissection of the vegetative bud and ultimately, to the plant's death in monocarpic plants such as *Ferula assa-foetida*, this researcher and his colleague rejected this method [31]. It seems that since the roots of monocarpic plants, such as *D.ammoniacum*, *F.assa-foetida* and *F.gummosa* for exploiting are exposed to the air for several days, this result in decay and contamination roots and it leads to death of plant, although this requires further investigations.

References

1. Mozaffarian V. The family of Umbelliferae in Iran (Keys and distribution), Rese Institute Forests Rang. 1973.
2. Zargari A. Medical plants, University of Tehran. 1992.
3. Eskandani M, Dadizadeh E, Hamishehkar H, Nazemiyeh H, Barar J. Genotoxicity and apoptotic properties of phenolic compounds from the seeds of *Dorema glabrum* Fisch. CA. BioImpacts. 2014;4:191-198
4. Javadi B, Iranshahy M, Emami SA. Anti cancer Plants in Islamic Traditional Medicine. In: Complementary Therapies for the Body, Mind and Soul, In Tech, Croatia. 2015;111-144.
5. Leaman DJ. Medicinal plant conservation, newsletter of the medicinal plant specialist group of the IUCN species survival commission. Silphion. 2006;13:24-26.
6. Naghibi F, Ghafari S, Esmaeili S, Jenett-Siems K, Naghibione. A Novel Sesquiterpenoid with Antiplasmodial Effect from *Dorema hyrcanum* Koso-Pol. Root, a Plant Used in Traditional Medicine. Iran J Pharm Res. 2015;14:961-968.
7. Sharafzadeh S, Alizadeh O. Some Medicinal Plants Cultivated in Iran. J. Appl. Pharm. Sci. 2012;2:134-137.
8. Batooli H, Haghiri Ebrahimabadi A, Mahmodi B, Mazochi A. Comparison of essential oil chemical composition of vegetative and reproductive organs of *Dorema ammoniacum* D. Don. In Shahsavaran, Kashan. Iranian J Med Aroma Plants. 2014;30:746-755.
9. Mohammadi Q, Aliha M. About *Ferula gummosa*, Research Institute of Forest and Rangelands. 1989.

10. Jalili A, Jamzad Z. Red data book of Iran, Research Institute of Forests and Rangelands, Tehran. 1999.
11. Kapoor LD. Handbook of Ayurvedic medicinal plants, Routledge. 2017.
12. Delnavazi MR, Tavakoli S, Rustaie A, Batooli H, Yassa N. Antioxidant and antibacterial activities of the essential oils and extracts of *Dorema ammoniacum* roots and aerial parts. *Res J Pharmaco (RJP)*. 2014;1:4:11-18.
13. Irvani N, Solouki M, Omidi M, Zare AR, Shahnazi S. Callus induction and plant regeneration in *Dorema ammoniacum* D. Don, an endangered medicinal plant. *Plant Cell Tiss Organ Cult*. 2010;100:293-299.
14. Abizadeh M, Hosseinmardi N, Ebrahimi S, Janahmadi M, Shojaii A, Motamedi F. The effect of *Dorema ammoniacum* pretreatment on the progression of seizures induced by chemical kindling in rats. *Pajoohande*. 2014;19:228-234.
15. Adhami HR, Lutz J, Kahlig H, Zehl M, Krenn L. Compounds from gum ammoniacum with acetylcholinesterase inhibitory activity. *Sci pharm*. 2013;81:703-805.
16. Zarshenas MM, Arabzadeh A, Tafti MA, Kordafshari G, Zargaran A, Mohagheghzadeh A. Application of Herbal Exudates in Traditional Persian Medicine. *Galen Med J*. 2013;1:78-83.
17. Raeesdana A, Farzaei MH, Amini M, Rahim R. Chemical composition of essential oil and evaluation of acute and sub toxicity of *Dorema ammoniacum* D. Don. *Oleo-Gum-Resin in rats*. *Afr J Tradit Complement Altern Med*. 2018; 15:26-33.
18. Mobeen A, Siddiqui MA, Quamri MA, Itrat M, Imran Khan MD. Therapeutic potential of Ushaq (*Dorema ammoniacum* D. Don): A unique drug of Unani medicine. *Intern J Unani Integ Med*. 2018;2:11-16.
19. Yassa N, Rustaie A, Tavakoli S, Delnavazi MR, Batooli H. Antioxidant and antibacterial activities of the Essential oil and extracts of *Dorema ammoniacum* roots and aerial parts. *Res J pharmaco*. 2014;1:11-18.
20. Yousefzadi M, Heidari M, Akbarpour M, Mirjalili MH, Zeinali A, Parsa M. In vitro Cytotoxic Activity of the Essential Oil of *Dorema ammoniacum* D. Don. *Middle East J Sci Res*. 2011a;7:511-514.
21. Ming Lin F, Neil E, Marsh G, Nina Lin X. Recent progress in hydrocarbon biofuel synthesis: pathways and enzymes. *Chinese chemical letters*. 2015;26:431-434.
22. Hosseini SAR, Naseri HR, Azarnivand H, Jafari M, Rowshan V, Panahian AR. Comparing Stem and Seed Essential Oil in *Dorema ammoniacum* D. Don from Iran. *J Essent Oil Bear Plants*. 2014;17:1287-1292.
23. Farhang HR, Vahabi MR, Allafchian AR. Chemical compositions of the essential oil of *Gundelia tournefortii* L. (Asteraceae) from Central Zagros, Iran. *J Herbal Drugs*. 2015;6:227-233.
24. Gholami B, Faravani M. The possibility of crop cultivation and utilization of edible gum from herb (*Dorema ammoniacum* D. Don) in dry land farming. *J Agric Sci*. 2015;60:369-380.
25. Pirmoradi M. Investigating of different cutting methods and some other factors on yield and survival of *Ferula assa-foetida*, Tarbiat Modares University. 2003.
26. Ghasemi Arian A. Effect of land management on ecological characteristics of *Dorema ammoniacum* D. Don, Ph.D. Dissertation, Ferdowsi University. 2016.
27. Nabiei MG. An investigation on the effect of Gum extraction using side cut on plant lump on yield of *Ferula gummosa*. *Iranian J Med Aroma Plant Res*. 2003;19:269-285.
28. Omidbaigi R, Pirmoradi, M R. A study of the effect of root diameter and incision time on gum yield in medicinal-rangeland *Asafoetida* (*Ferula assafoetida* L.) plant. *Iranian J Natural Res*. 2006;58:268-269.
29. Karimian V, Sepehri A, Barani H. Effects of different utilization methods of *Ferula assa-foetida* L. on oleo-gum-resin production (Case Study: Tangsorkh rangeland, Kohgiluyeh and Boyerahmad province). *J Rang*. 2018;12:295-304.
30. Moradi P, Mousavi F, Ganj Khanlo B, Aghajanlo A, Hosseini Monfared H. *Ferula gummosa* medicinal plant technical journal. Jihad-e-Agriculture Organization in Zanjan Province, Iran. 2015.
31. Gholami B, Faravani M. Effect of different cutting methods and times of cutting on growth performance and gum resin production of *Ferula assa-foetida*. *J Agric Sci*. 2014;59:35-44.