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A COMPARATIVE STUDY OF SEED GERMINATION AND SEEDLING EMERGENCE OF TWO WILD EDIBLE *ALLIUM* SPECIES ENDEMIC TO ZAGROS AREAS

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ABSTRACT

***Allium* L. is one of the largest and most diversified monocotyledonous genera worldwide. These taxa have wide geographical distribution range mainly occurred in the northern hemisphere with an important center of diversity in the Mediterranean and Irano-Anatolian regions. They include an important number of taxa of high economic values (wild edible, cultivated, medicinal, ornamentals, etc.). These geophytes species exhibit diversified adaptation strategies that permit them to persist under harsh environmental conditions. The present experimental study was designed to understanding better the environmental factors that control the natural regeneration of the two wild edible *Allium* (*A. calocephalum* and *A. notabile*) species endemic to Zagros areas via evaluating the effect of different (i) pre-sowing treatments on seed germination rate and (ii) soil depth on seedling emergence timing. The results of the present study confirmed relatively high seed and bulbs viabilities under the different pre-sowing treatments. In general, both *Allium* species have a relatively similar germination trend (around 80% without treatments) and seedling emergence (from bulbs at 5 cm) patterns. The high rate of seed germination for *A. calocephalum* was found under cold stratification for 1 month and soak in water for 3 days and GA3 1500 ppm with 83%, 86%, and 85%, respectively. The different germination pattern was found for *A. notabile* with 83%, 85%, 84% for soaking water for 2 and 3 days and GA3 1000 ppm, respectively. Whoever, these two threatened species from different taxonomical groups and habitats have different adaptation strategy. *A. notabile* is Mediterranean species exhibiting an optimum seedling emergence in autumn-early winter with summer underground organ dormancy to avoid the hot-dry conditions; While, *A. calocephalum* is Irano-Anatolian species exhibiting an optimum seedling in late winter-early spring permitting it to persist thanks to its avoidance strategy of the harsh winter climatic conditions. The results of this research support the idea that *Allium* species from different habitats exhibit different seed germination and seedling emergency strategies allowing it to persist. The evidence of this experimental study enriches our understanding of the diversified adaptation strategy of the plants. In this context, further experimental investigations are needed to evaluate the crucial rule of the seed germination ecology and bulbs dormancy strategies on the population dynamic and persistence.**

KEYWORDS: Geophytes, *Allium*, adaptation strategy, evolutionary ecology, Zagros, overharvesting, biodiversity conservation\
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INTRODUCTION

The genus *Allium* L. described by Linné in 1753, is one of the largest monocotyledonous genera (Govaerts et al., 2019). This genus includes more than 800 taxa worldwide (Hanelt et al., 1992; Fritsch et al., 2010). It includes a variable group of species and the debate continues about the taxonomic position of the *Allium* genus: In early classification, it has been placed under *Liliaceae* family (e.g. Flora of Iraq according to Wendelbo & Stuart, 1985) while they were often placed later in the *Amaryllidaceae* family (e.g. Phillips, 2010). Thanks to recently phylogenetic studies based on molecular data, they divided the *Allium* genus into several subgenera belonging to *Alliacaea* family (Freisen et al., 2006; Fritsch et al., 2010). Increasingly, the recent development in multidisciplinary approach including morphological, karyological, molecular studies adds substantially to our understanding of the taxonomy and evolution in the *Allium* genus (Hirshengger et al., 2010; Li et al., 2010). In this context, over the past decade there has an important number of the new species and/or new cryptic species of *Allium* have been described worldwide (Razyfard et al., 2011; Ekşi & Yildirim, 2019). These taxa are widely distributed thought the northern hemisphere with two important centers of diversity (primary center: Mediterranean Region and Irano-Anatolian with CW Asia; secondary center: North America) (Fritsch & Freisen, 2002; Freisen et al., 2006). These geophytes species naturally occur in the arid/semi-arid and temperate areas within a high habitats' diversity (steppe plains to Alpine zone, thought the foothills) (Hanelt et al., 1992; Kamenetsky, 1996; Kamenetsky & Rabinowitch, 2006).

Recent evidence suggests that the genus *Allium* is a good bioindicator showing important bio-structural adaptations correlated with geographical range and environmental conditions (Kamenetsky & Rabinowitch, 2006). This adaptation evolutionary process permits it to well survive under the Mediterranean type of climate, with its alternation of cool winters and hot dry summers, and thus to guarantee their persistence under harsh environmental conditions (Gutterman et al., 1995; Kamenetsky & Rabinowitch, 2006). By way of illustration, previous studies have found that the life cycle of *Allium* taxa is closely related to the climate cycle: the vegetative development stage often stop before the reproductive stage (both fruits and seeds) are fully mature (Fritsch & Freisen, 2002; Kamenetsky & Rabinowitch, 2006). Besides, their flowers usually need an important amount of low/high alternation temperatures while their seed development process is relatively rapid. During the seed formation time, the bulbs start loses their roots and shoot (above-ground organs). A number of studies have confirmed that these geophytes *Allium* species are well adapted to the severe climatic rhythm of the arid and semi-arid regions when their vegetation period and the root system is reduced and the bulbs enter in dormancy process (Gutterman et al., 1995; Kamenetsky & Rabinowitch, 2006; Phillips, 2010). Consequently, these geophytes species can avoid the hot dry summer thanks to their underground organs until the more clement environmental condition when the soil moisture reaches an appropriate level to sufficient stimulate the growth (Fritsch & Freisen, 2002; Kamenetsky & Rabinowitch, 2006).

The genus *Allium* includes an important number of taxa of a high economic significance: They include the edible species which cultivated as vegetables (e.g. onion: *A. cepa*; the garlic: *A. sativum*; the leek "kurrat": *A. ampeloprasum*). Furthermore, numerous other species are used as traditional spices and medicinal plants with high nutritional values. Besides that some *Allium* species have important ornamentals values cultivated in the parks and home-gardens (e.g. *A. giganteum*). Due to their high economic value, they are often cultivated regionally or locally (Fritsch and Friesen, 2002; Kamenetsky & Rabinowitch, 2006) while an important number of wild species are collected and/or overharvested for local use or sold in traditional markets (Kamenetsky & Rabinowitch, 2006; Firat & Aziret, 2016). In this context, the overharvesting activities by rural peoples besides the climate change are the leading causes of their population reduction and thus some of the mares seriously threatened by high demand of increased human population growth (Firat & Aziret, 2016; Véla et al., 2017).

In recent years, there has been an increasing amount of literature on seed germination ecology, natural regeneration and seedling emergence in both the laboratory and the field (Baskin & Baskin, 1998; Fenner & Thompson 2005; Leck et al., 2008). Particularly, the seed germination is an irreversible biological process affecting the population dynamic and persistent (Fenner & Thompson 2005; Leck et al., 2008). Therefore, understanding the environmental factors that control the natural regeneration of plant species in time and space is decisive for their survival notably for the threatened species and their future biodiversity conservation plans (Leck et al., 2008; Mattana et al., 2010; Youssef et al., 2011; Abdoallahi et al., 2012; Muhamed et al., 2019). In this context, a considerable amount of the literature has been published on seed germination ecology of *Allium* taxa (Guttermann et al., 1995; Gifre Alonso & Font Garcia, 2009; Nematollah et al., 2011). Data from the previous studies have indicated that the pre-sowing treatments can increase / decrease the seed germination rate of the *Allium* taxa and the results are mainly depend on the biological species target, their evolutionary life history and the pre-sowing treatments used (Guttermann et al., 1995; Baskin & Baskin, 1998; Fenner & Thompson 2005; Phillips, 2010; Winiarczyk et al., 2014): For example, Nematollah et al., (2011) found that the stratification treatments significantly improved the germination rate of the endemic Persian shallot *A. hirtifolium* boiss. In addition, Kamenetsky & Gutterman (2000) clearly showed that the temperature is a main environmental factor affecting the seed germination rate of some *Allium* taxa in an arid zone of C Asia while Gutterman et al. (1995) reported that there is no difference between germination rate of *A. rothii* in light and dark. Contrariwise, Gifre Alonso & Font Garcia (2009) showed that the darkness significantly accelerated the germination rate of two *Allium* sect. *Allium* in the Iberian Peninsula. Others environmental factors such as NaC1 concentration decreased the germination rate of *A. truncatum* (Feinbr.) Kollman & D. Zohary naturally occurred in the Negev Desert highlands (Gutterman et al., 1995).

Irano-Anatolian hotspot including Zagros territories is one of the high biological diversity values worldwide (Mittermeier et al., 2004) as well as an important diversity center for *Allium* Genus (Fritsch & Freisen, 2002). By way of illustration, there are more than 200 *Allium* taxa naturally occur in Turkey (Kaya, 2014), 120 in Iran (Freisen et al., 2006; Fritsch & Abbasi, 2008) and 40 in Iraq (Wendelbo & Stuart, 1985). Furthermore, these Zagrosian areas include an important number of rare, endemic and threatened *Allium* species (Razyfard et al., 2010; Kaya, 2014). In addition, these Zagros areas including the Mesopotamian fertile plains are under anthropogenic activities (cultivation, grazing, etc.) for millennia. In this anthropogenic circumstance, previous studies have found that the overharvesting of wild edible *Allium* from their natural habitats has induced an obvious decline in their population and they exposure to the extinction risk (Firat & Aziret, 2016; Véla et al., 2017). In this context, both wild edible and endemic *Allium* species to Zagros area (*A. calocephalum* Wendelbo and *A. notabile* Feinbrun) are seriously threatened by the overharvesting activities (Firat & Aziret, 2016; Véla et al., 2017). In addition, our understanding of their seed germination ecology and propagation are inexistent, and in need of additional scientific investigations. Therefore, the present experimental study focused on the development of a protocol for their propagation by both seeds and bulbs. Particularly, this research study seeks to (i) provide a new contribution in terms of the effect of some pre-sowing treatments on the seed germination rate and bulbs propagation of two endemic *Allium* to Zagros areas; (ii) examine the seedling emergence timing related to seed sowing pretreatment. From economic botany perspectives, the results of this field experiment study will provide a solid database for both governmental and private nursery sectors on seed germination and seedling emergence timing of *Allium* taxa. Indeed, in the Kurdistan region, this agro-socio-economic initiative "cultivation of wild edible *Allium* has never been addressed. Therefore, this field cultivation experiment which could provide a source of income to many small farmers in a rather low investment as well as contributing to nature protection by minimizing clipping from the wild.

MATERIALS AND METHODS

Experimental Site Study

For this research, a germination experiment was carried out at the Forestry nursery field of College of Agricultural Engineering Sciences, University of Duhok, Kurdistan Region of Iraq. The geolocation is: Latitude: 36.860396; Longitude: 42.868776; Altitude 480 m above sea level (asl). The scientific experiment started on 24 October 2018 to study the potential propagation of *A.calocephalum* and *A.notabile* by both seeds and bulbs. The seed and bulbs cultivation experiment were situated in Zagrosian semi-arid region (Peel et al., 2007; Youssef et al., 2019). From the bioclimatic standpoint, this research site study has Xero-Thermo-Mediterranean bioclimate: Annual rainfall of 2018 was 798 mm; Mean of temperature was 19.4°C; Winter MIN mean daily around 0°C while the MAX is under 40°C (Source: Agro-Meteorological of College of Agricultural Engineering Sciences, University of Duhok). Globally, the precipitation season starts on October-November and ended on May, with at least four months without rainfall (Youssef et al., 2019).

Seeds Collection And Pre-Sowing Treatments

In this research study, the seeds of two endemic wild *Allium* to Zagros areas (*A. calocephalum* and *A. notabile*) were used in the field experiment. We directly collected from the field, the fully matured seeds and bulbous with a vigorous and healthy appearance growing. Immature and damaged seeds were eliminated while the mature dry seeds were stored in glass jars and the bulbs stored in a dark environment at room temperature (around 20º C) until the beginning of the germination experiment. The seeds and bulbs of *A. calocephalum* were collected in June 2018 from the north aspect of Gara Mountain (Hariké Village, Deralok District: Latitude: 37.0136820; Longitude: 43.6859840; elevation 1096 m asl). While the seeds and bulbs of *A. notabile* were collected in July 2018 from south aspect of Gara Mountain (above Bané village: Latitude: 36.9147300; Longitude: 43.2359380; elevation 967 m asl).

In this experimental research for both *Allium* species, different pre-sowing treatments were tested to assess the best treatment in term of germination success rate. Which were: untreated seeds which used as the control; hot water (60°C) with three categories(5, 10 and 15 minutes soak time); normal "distilled" water (15-20°C) with three soak time categories (1, 2 and 3 days soaking); Gibberellic Acid (GA3) with three concentration 500 ppm, 1000 ppm and 1500 ppm were soaked in GA3, for 5 minute; Finally, the cold stratification, moisturized seeds with distilled water were placed in a sealed plastic box in a refrigerator at a temperature below +5°C, for 30, 60 and 90 days under constant light conditions. After pre-sowing treatment, the seeds were planted in medium pots (Diameter 13 x10 cm height) containing a mixture of sandy soil, field soil and Peat-moss (1:1:1). A 100 seed lot issued were selected from each pre-sowing treatment per *Allium* species. These 100 seed lots were then divided into four replication and put in four different pots "four replication"; Then, 25 seed per pot were cultivated at around 1 cm soil depth according to the method of Krussmann (1981). A total of 1300 seeds were cultivated for each *Allium* species. The pots (104 in total) had been irrigated once per week, if needed, during the complete period of the germination experiment. On other hands, the bulbs were cultivated directly in the soil according to different soil depth (5, 10, 15 and 20 cm) to test the effect of the soil depth on the seedling emergence of both endemic *Allium* species. The bulbs were cultivated in rows (4 m long; 95 cm width; 10 cm space between rows) in sowing media made-up from a mixture of sandy soil, field soil and Peat-moss (1:1:1). There were 16 quadrate plots used for four soil depth (5, 10, 15 and 20 cm) with four replications for each soil depth and 5 bulbs in each replicate were planted. This germination experiment was arranged in nursery according to a completely randomized design by dividing 1300 seeds into four replication groups (4 replications x 25 seeds) for each treatment used in this study. The observation of seedling emergence and measurement of germination rate were carried out weekly during the research experiment (from 24 October 2018 to 30 June 2019). Seedling emergence was accounted when the shoot of the seedling came around 1 cm above the ground.

For statistically analyzing the seeds germination rate and the seedling emergence, the data have been arranged in an excel sheet (© Microsoft office); and then the data was treated by the analysis of variance (ANOVA) and Student-Newman-Keuls test to do the comparison two-by-two using R-program (R Development Core Team, 2019)

RESULTS AND DISCUSSION

Allium calocephalum seed germination ecology

In-plant life cycle, seeds are important structures to maintain species survival where their germinations are often related to specific environmental conditions (Fenner & Thompson, 2005; Baskin & Baskin, 1998; Leck et al., 2008; Willis et al., 2014). In this context, the seeds of many species do not germinate due to temporary dormancy mechanisms that may be broken as a result of the exposure of the seed to environmental factors during an appropriate period of time (Baskin & Baskin, 1998; Donhoue, 2005; Hoyle et al., 2015). Concerning *A. calocephalum*, the results obtained from experimental data are shown in Fig. 1. These results were clearly confirmed a high percentage of viable seeds where they germinated with different rate degree for all pre-sowing treatments. In spite of the germination rate and seedling emergence timing responded differently to pre-sowing treatments, whoever, the variance analysis and Student-Newman-Keuls test have not shown significant differences between the treatments (P value > 0.05). These insignificant differences can be explained in part by the high inter and intra variations of the pre-sowing treatments. Indeed, interestingly, the germination rate was 80% without any treatment “control”. The findings of the present study are consistent with those of Gifre Alonso & Font Garcia (2009) and Guttermann et al. (1995) who found similar germination results (around 80%) for *Allium* species. As shown in Fig. 1, several pre-sowing treatments have negative effect on seed germination (lower than the control): They were hot water (5, 10 and 15 minutes with germination rate: 77%, 74% and 73% respectively), seed soaking for one day (germination rate: 76%), stratification (for 2 and 3 months with 77% germination rate for the both treatment time) and GA3 with concentration 500 ppm (germination rate: 78%). A possible explanation for this reduction germination rate is that the *Allium* seed coat is relatively thin (Celep et al., 2012) and thus some pre-sowing treatment like hot water leads to seed embryo death (Baskin & Baskin, 1998). On the other side, some other pre-sowing treatments have increased the germination rate of *A. calocephalum*. By way of illustration, the germination rate for immersion of seeds in water for 2 days and 3 days, stratification for 1 month and using GA3 with 1500 ppm were 81%, 86%, 83 and 85% respectively. This increasing seed germination rate can be explained in part by the micro-environmental conditions where *A. calocepahalum* naturally occur (middle to high forest zone of Zagros mountains between 1200 to 1800 m asl where the climatic conditions are characterized by a cold-humid winter). Consequently, the stratification of its seed for one month, GA3 1500 ppm and the soaking time to one day stimulate the initiating of the embryo metabolism process. These results accord with other classical earlier studies on seed germination ecology topic (Baskin & Baskin, 1998; Fenner & Thompson, 2005; Phillips, 2010). For example, Nematollah et al. (2011) were clearly showed that the stratification time after the sixth improved the germination rate of the threatened endemic Persian shallot *A. hirtifolium* boiss.

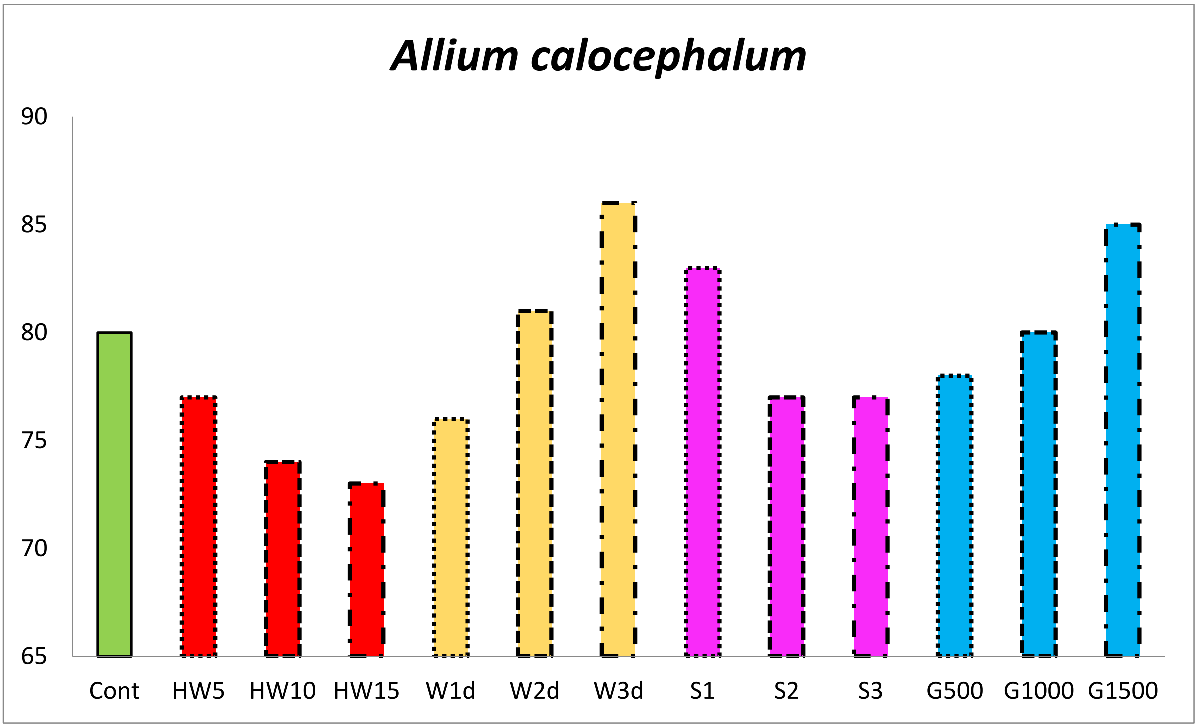


Fig. (1): *A. calocephalum* seed germination rate under various pre-sowing treatments, Cont = Control, HW5 = Hot water at 5 min, HW10 = Hot water at 10 min, HW15 = Hot water at 15 min, W1 = Seed in water 1 day, W2 = Seed in water 2 days, W3 = Seed in water 3 days, S1 = Stratification 1 month, S2 = Stratification 2 month, S3 = Stratification 3 month, G500 = GA3 500 ppm, G1000 = GA3 1000 ppm, G1500 = GA3 1500 ppm.

It is apparent from Fig. 2 that there is a clear trend of seedling emergence in late winter-early spring. In fact, the first seedling emergence started in January while it obtained the optima seedling emergence from February to March. This optima germination rate achieved where the mean temperature was 10 to 25 C° in nursery condition. These findings seem to be consistent with an earlier study in seed germination ecology of *Allium* species, which showed that they fast germinate at 10 to 20 C° (Gutterman et al., 1995). Interestingly, this germination strategy of *A. calocephalum* at the right time of the year "late winter-early spring" when temperatures reach a daily 10-25 C° which will give the seedlings a higher chance of survival under the harsh and unpredictable Irano-Anatolian environmental conditions (Gutterman et al., 1995; Piotto& Di Nio, 2003; Mahdi et al., 2018a&b).

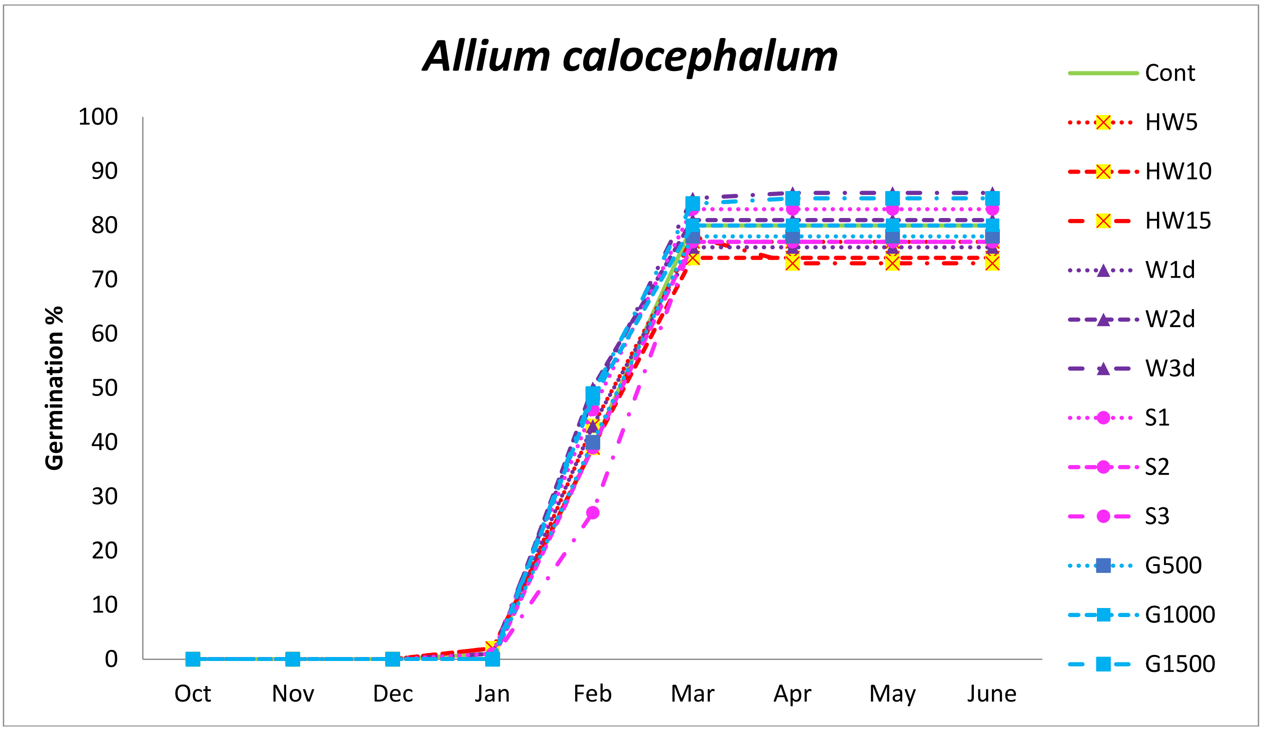


Fig. (2):*A. calocephalum* seedling leek emergence, Cont = Control, HW5 = Hot water at 5 min, HW10 = Hot water at 10 min, HW15 = Hot water at 15 min, W1 = Seed in water 1 day, W2 = Seed in water 2 days, W3 = Seed in water 3 days, S1 = Stratification 1 month, S2 = Stratification 2 month, S3 = Stratification 3 month, G500 = GA3 500 ppm, G1000 = GA3 1000 ppm, G1500 = GA3 1500 ppm.

***Allium notabile* seed germination ecology**

It is a wild leek endemic to the southern slopes of the Zagros Mountains (Zawita-Atrush in Duhok governorate and Qara-Dagh in Sulaymaniya governorate), Kurdistan Region of Iraq (Wendelbo & Stuart, 1985). This edible leek species is most probably harvested by rural people in confusion with several others wild leek species of *Allium* sect. *Allium* (Véla et al., 2017). From agro-socio-economic perspectives, the ethnodomestication initiative of this wild edible leek will be considerably contribute to minimizing its collection from natural habitat. In this context, the results of this seed germination study will provide a significant source of information for its cultivation and semi-domestication. From the experimental data in Figure 3, it is apparent that it has a relatively good germination rate around 78 % without any pre-sowing treatments. This result of germination is similar to the previous wild garlic (*A. calocephalum*) as well as accords with earlier studies showed that the seeds of *Allium* species have a high viability germination rate (Guttermann et al., 1995; Gifre Alonso & Font Garcia, 2009). However, some pre-sowing treatments decreased the germination rate: By way of illustration, for the stratification with 1, 2 and three months the germination rate were 72%, 74%, and 72% respectively. This observed decreasing was expected and suggests that it prefer clement climatic conditions. A possible explanation for this might be that it occurs in rocky dry grasslands in steppic open Oak and Pine forest under Mediterranean bio-climate (Véla et al., 2017). On the other hand, the GA3 with the three concentration level (500, 1000, 1500 ppm) and soaking seeds in water for 2 and 3 days increase the germination rate. The GA3 results differ from Nematoallah et al. (2011) indicate the GA3 concentration did not affect the germination rate, but they are broadly consistent with earlier seed germination studies (Baskin & Baskin; 1998). While it seems possible that the results of the seed soaking for 2 and 3 days lead the water to enter inside the seeds and thus help the development of the embryo.

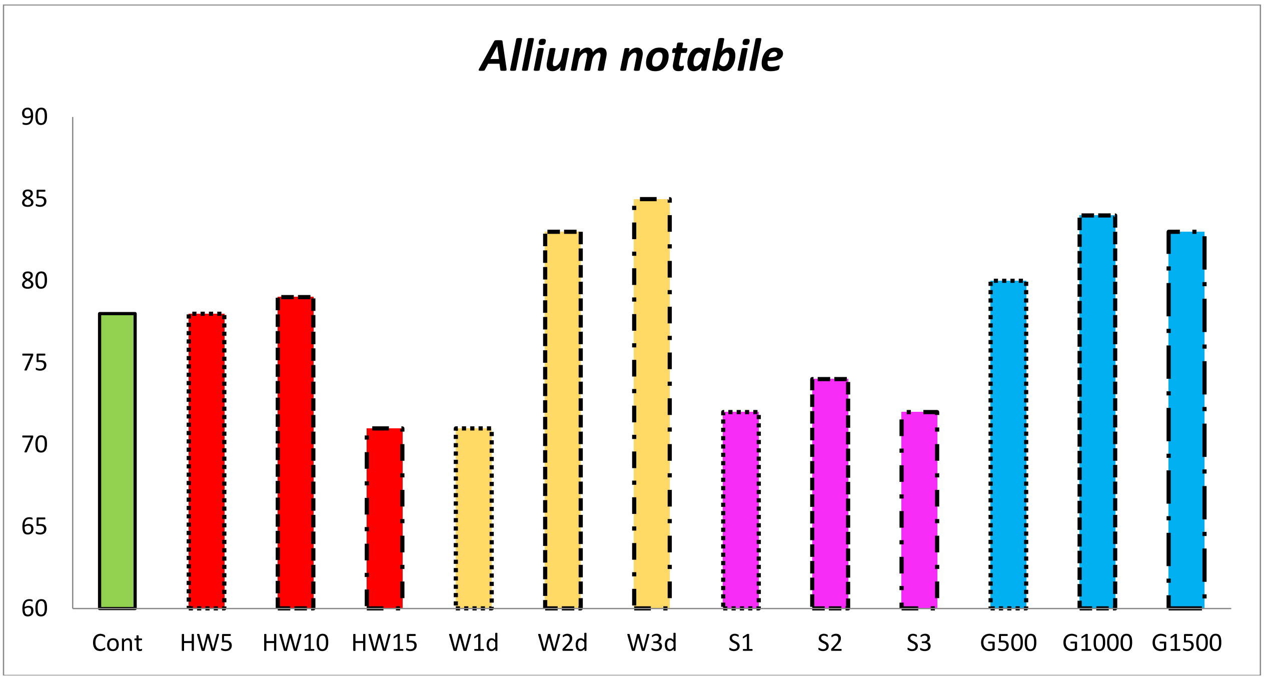


Fig. (3): *A. notabile* seed germination rate under various treatments, Cont = Control, HW5 = Hot water at 5 min, HW10 = Hot water at 10 min, HW15 = Hot water at 15 min, W1 = Seed in water 1 day, W2 = Seed in water 2 days, W3 = Seed in water 3 days, S1 = Stratification 1 month, S2 = Stratification 2 month, S3 = Stratification 3 month, G500 = GA3 500 ppm, G1000 = GA3 1000 ppm, G1500 = GA3 1500 ppm.

In the current study, the seedling emergence timing of *A. notabile* provided a significant adaptation strategy to Mediterranean bio-climate. The results, as shown in Fig. 4, indicate that it has autumn-early winter seedling emergence. For example, the first seedlings start to emerge in November with an optimum seedling emergence on January-February. Furthermore, its seeds relatively germinate quickly (2-3 weeks) where the mean temperature was 15 to 25 C° in nursery condition. In fact, this Mediterranean wild leek germinates in autumn, like most of the annual Mediterranean species after the first autumnal rainfall (Thompson, 2005; Youssef et al., 2011). This autumnal fast-growing adaptation strategy will likely give the seedlings to benefits from Mediterranean winter clemency condition and thus a higher chance of survival the next year. These findings accord with most earlier studies in seed germination ecology of Mediterranean plant species (Gutterman et al., 1995; Leck et al., 2008).

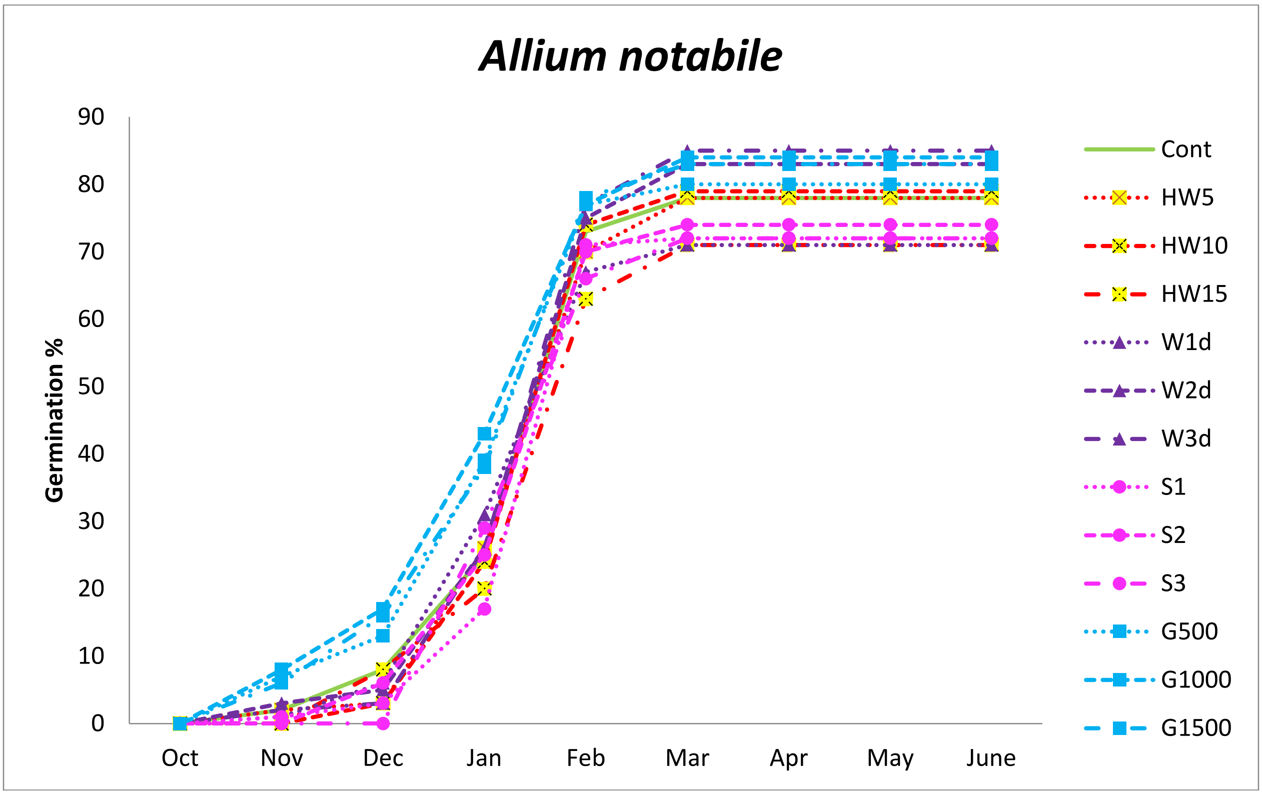


Fig. (4): *A. notabile* seedling leek emergence, Cont = Control, HW5 = Hot water at 5 min, HW10 = Hot water at 10 min, HW15 = Hot water at 15 min, W1 = Seed in water 1 day, W2 = Seed in water 2 days, W3 = Seed in water 3 days, S1 = Stratification 1 month, S2 = Stratification 2 month, S3 = Stratification 3 month, G500 = GA3 500 ppm, G1000 = GA3 1000 ppm, G1500 = GA3 1500 ppm.

Bulbous Cultivation And Soil Depth

In recent years, seedling emergence is known to be related by climatic, intrinsic biological and soil depth factors (Holm 1972; Baskin & Baskin, 1998; Fenner & Thompson, 2005; Leck et al., 2008). Unfortunately, the biological reasons for soil depth inhibition have not yet been fully understood due to a complex biological evolutionary process. Whoever, globally, previous studies suggest that the soil depth inhibition is mainly due to decreasing of light penetration, thermal fluctuation and gas exchange (Barkham, 1980; Roberts & Totterdell, 1981; Benvenuti et al., 2001). Furthermore, recent evidence suggests that the bulbs planting depth significantly affect the growth, yield and emergence success of the geophytes species (Alam et al., 2013; Marcinek et al., 2013). In this context and from ethnodomestication perspective, it is therefore meaningful to acquire maximum knowledge on wild edible bulbs cultivation and their emergence ability according to various soil depths. Interestingly, high seedling emergence was found when the bulbs cultivate at 5 cm for *A. calocephalum* and at 5 and 10 cm for *A. notabile* (Fig. 5). These results support previous research into this brain area which links seedling emergence and soil depth (Benvenuti et al., 2001; Alam et al., 2013) and confirms the general rule that the plant seeds and bulbs cultivate at twice/three times as deep in the soil as their size. At 15 cm soil depth, both edible bulbous species have similar seedling emergence decreasing pattern (with 35 and 40 seedlings for *A. calocephalum*and *A. notabile*, respectively). The most striking result to emerge from the data is that there is any seedling emergence at 20 cm for both *Allium* species. This general pattern of decreasing seedling emergence with increasing soil depth has been demonstrated by earlier research studies (Benvenuti et al., 2001; Alam et al., 2013). This observed seedling emergence pattern which is inversely correlated with burial depth could be attributed to lack sufficient amount of oxygen, light and/or the bulbs reserve capacity (Benvenuti et al., 2001; Kamenetsky et al., 2004; Alam et al., 2013). For example, Barkham (1980) reported that the bulbs of *Narcisus* species planted at shallower depths (less 5 cm) produced more vegetative daughters than did deeper planted bulbs (more than 10 cm depth).

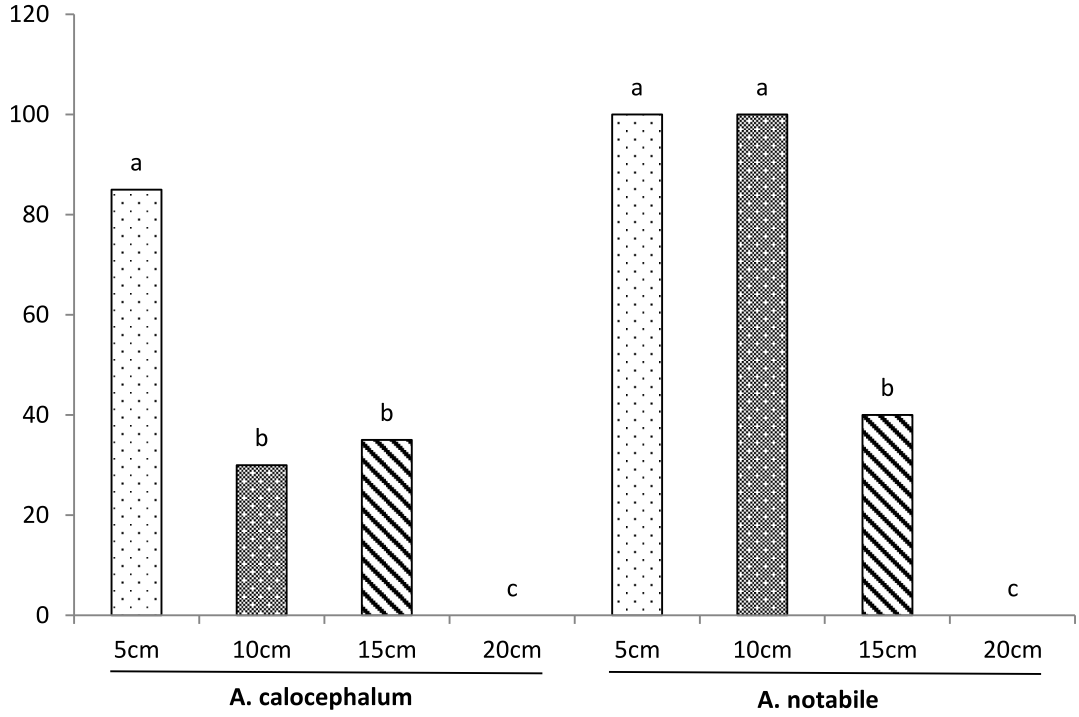
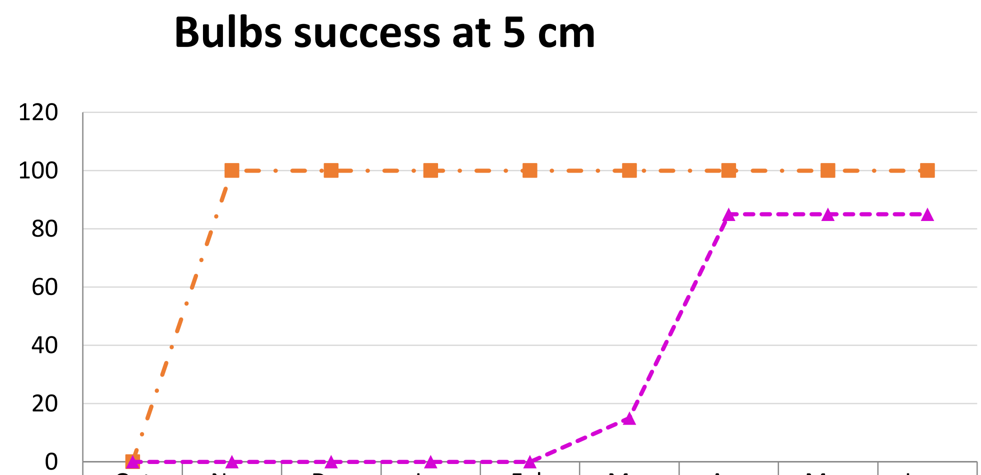


Fig. (5): *Allium* bulbs emergence at a different soil depth. The code a,b,c, indicate the differences between the soil depth according to Student–Newman–Keuls test at level 0.05.

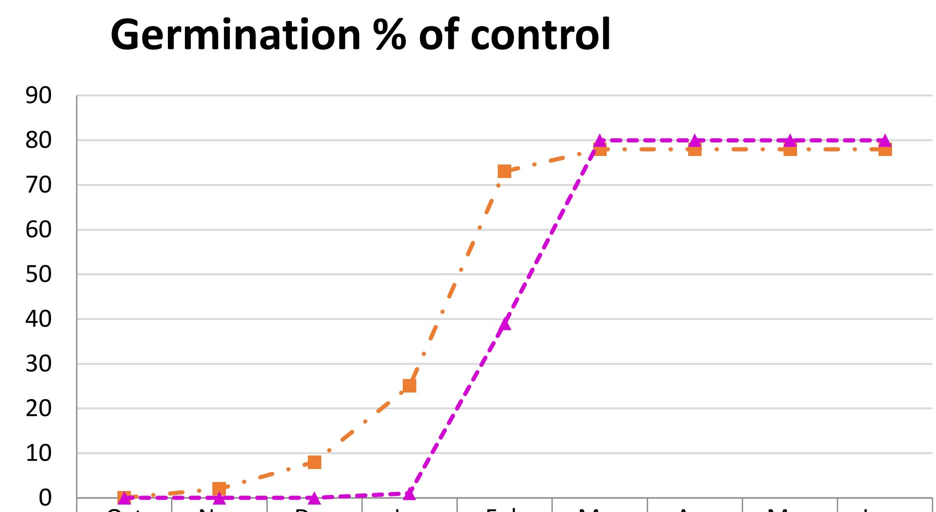
***Allium* Seedling Emergence Strategy**

It is becoming increasingly difficult to ignore the diversity of plant adaptations to their natural environment. In recent years, these divers adaptation strategies have been broadly studied at multiple scales and scientific discipline (from gene to ecosystem and from molecular biology to biogeography) (Grime, 2006; Leck et al., 2008; Hoyle et al., 2015; Volaire, 2018). Recently, knowledge of plant adaptation strategy has aroused increasing interest in the context of biodiversity conservation. Geophytes species have some kind of underground storage organs (ex: bulb, tuber, etc.) that grow naturally at some depth in the soil, and each year they renew their reproductive organs. *Allium* species as the most diversify geophytes taxa group, their bulbous have various dormancy disputative traits that allow it to maximize survival success by increasing the vegetative growth in the most suitable season (Kamenetsky & Rabinowitch, 2006; Phillips, 2010). Thanks to their unique life-form “bulbs” the follow the drought avoidance strategies: The reserve in their bulbous provides a precious resource allowing the *Allium* species to persist the unfavorable climatic season (hot and dry summer) by entering dormant phase until soil moisture and temperature reach appropriate level to stimulate the vegetative growth (Fritsch & Freisen, 2002; Kamenetsky & Rabinowitch, 2006; Phillips, 2010). Interestingly, from the data of Figure 6 a&b, it is apparent that the two wild edible *Allium* species have different seedling emergence strategy: Indeed, *A. notabile* as Mediterranean species, and its optimum emergence from both seeds and bulbs is in autumn-early winter. This early emergence most likely enables the bulbs to develop strong roots and vegetative growth which in tour will support the flowering phase in the summer. This finding supports the Mediterranean adaptative plant strategies with summer dormancy to avoid hot-dry conditions. Consequently, the plant growth begins in autumn-early winter, the vegetative development continues through the clement winter and spring while the flowers occur in late spring-summer, and then underground storage organ enters in dormancy to avoid drought (Fritsch &Freisen, 2002; Kamenetsky and Rabinowitch 2006). On the other hand, *A. calocephalum* from section Melanocrommyum., is a real Irano-Anatolian species, and its optimum emergence according to our results is in late winter-early spring enable it to avoid the harsh winter climatic conditions (snow and frost) and thus it will give their seedlings a higher chance to survive. This finding corroborates the Irano-Anatolian adaptative plant strategies by avoidance of the harsh climatic conditions (cold winter and dry-hot summer) where the above-ground growth rate is maximum reduced while the fall development is achieved in spring (Pistrick 1992; Fritsch & Freisen, 2002; Kamenetsky & Rabinowitch, 2006). From ethnobotanical standpoint, a considerable wild edible plant species are collected for home consumption and/or sold in traditional markets (Hadjichambis et al., 2008; Schulp et al., 2014; Youssef et al. 2017). These wild edible plants have important economic value and are often cultivated "semi-domesticated" regionally or locally (Hanelt, 2001; Hadjichambis et al., 2008). Under this permanent overharvesting pressure, their natural populations are seriously threatened and thus exposure to the extinction risk. In the new global economy approach, it is becoming increasingly difficult to ignore the environmental factors controlling the natural regeneration of threatened wild edible species. In this dramatical circumstance, investigating the seed germination ecology of the two wild edible *Allium* species has become vital for their future biodiversity conservation strategies.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
A. notabile	0	100	100	100	100	100	100	100	100
A. calocephalum	0	0	0	0	0	15	85	85	85

Fig. (6a): Bulbs emergence rate at 5 cm in both species



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
A. notabile	0	2	8	25	73	78	78	78	78
A. calocephalum	0	0	0	1	39	80	80	80	80

Fig. (6b): Seed germination rate of control in both species

CONCLUSION

This paper has given an account of the seed germination ecology and seedling emergence of two wild edible *Allium* species endemic to Zagros areas. This comparative seedling emergence study of two *Allium* species, one inhabiting foothill under Mediterranean climate and the other mountains under Irano-Anatolian climate, attribute to a better understanding of the adaptation mechanisms of these species under harsh and unpredictable Zagros conditions. The both *Allium* species have a relatively similar pattern with good germination rate (around 80% without treatments) and seedling emergence from bulbs at 5 cm. Whoever, they differ in their adaptation strategy (emergence timing strategy) to better tolerant/avoid the unfavorable germination and seedling niche. A possible explanation of this different adaptative strategy might be that these two *Allium* species belong to different taxonomical groups and occurs in different habitats. Therefore, the findings of this research enhance better our understanding of the seed germination ecology and seedling emergency strategies and it will be interesting to assess the effect of overharvesting in their population dynamics and thus their conservation status.

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پوختە

پیڤازوك ئێك ژ مەزنترین و جوراوجورترین جنسێ ئێك لەپەیە د جیهانێدا. ئەڤ پولینە ناوچەیەكا جوگرافیا مەزن بخوڤە دگریت كو بشێوەیەكی سەرەكی دكەڤیتە باكورێ نیڤ بازنەیا عەردی و هەروەسا ل ناوچەیا دەریا ناڤەراست و ایران و ئاناتولیا كو تێتە هەژمارتن ب ناوچەكا گرنگا جوراوجوری ل جیهانێ. ئەڤێ ناوچێ گەلەك جورێن گرنگ كو خودان پلەیەكا بەرزا ئابورینە بخوڤە دگریت (رووەكێن سروشتی یێن خوارنێ، یێن چاندنێ، گیا دەرمانك، رووەكێن جوانیێ، هتد...). ئەڤ جورێن رووەكا خودان ستراتیژیەكا جیاوازن بو خوگونجاندنێ، ئەڤ چەندە وەلێ دكەت كو خو راگریت ل بن كاودانێت سەقایێ دژوار. ڤەكولینا نوكە یا هاتیە دارێژتن بو پتر زانینا هوكارێت سەقای كو كونترول لسەر شینبوونا سروشتی یا هەر دوو جورێت پیڤازا سروشتی یا خوارنێ یا هەی كو خومالی نە ل ناوچەیا زاگروس، برێكا هەلسەنگاندنا كارتێكرنا جیاواز یا (1) كارلێك كرنا توڤی بەری چاندنێ لسەر رێژەیا شینبوونا توڤی و (2) كارتێكرنا كیراتیا ئاخێ لسەر شینبوونا پیڤازا رووەكی. ئەنجامێ ڤەكولینا نوكە دیار دكەت كو توڤ و پیڤازا ڤان هەردوو جورا شییانەكا باش یا هەی د شینبونێ دا ل بن كارلێكێت جیاواز یێت بەری چاندنێ. ب شێوەیەكێ گشتی هەردوو جورێت پیڤازا رێژەیا شینبوونا وان نێزیك ئێكن (ب رێژەیا 80% ژ توڤی بێ كارلێك) و دگەل رێژەیا شینبوونا تا رادەیەكی وەكهەڤ یا پیڤازا رووەكی ل كیراتیا (5سم) لبن ئاخێدا. رێژەیا بلند یا شینبونا توڤی د جورێ (A. calocephalum) هاتە تومار كرن د پاراستنا توڤی ل بن سەرمایێ بو ماوێ 1 هەیڤ و نوقم كرنا توڤی د ئاڤێدا بو ماوێ 3 روژادا و هورمونێ جبریلین (GA3 1500 ppm) ئەو ژی ب رێژەیا شینبوونا 83%، 86%، و85% ل دیف ئێك بو هەر ئێكێ ژوان. رێژەیا شینبونێ بو جورێ (A. notabile) جیاواز ژ جورێ دی هاتە تومار كرن ئەو ژی ب رێژەیا 83%، 85%، 84% د نوقم كرنا توڤی د ئاڤێ دا بو ماوێ 2 و 3 روژا و د هورمونێ جبریلین (GA3 1000 ppm) دا ل دیف ئێك بو هەر كارلێكەكێ. ئەڤ دوو جورێت لبن گەڤا ژناڤچونێ ژ دوو كومەلێت پولێن و وار جیاواز خودان ستراتیژیەكا ژێك جیاوازن د خوگونجاندنێدا. پیڤازا (A. notabile) ژ جورێت ناوچا دەریا ناوەراستە كو شینبوونا وێ دكەڤیتە پاییزێ و دەستپێكا زستانێ دگەل خوراگرتنا وێ ل وەرزێ هاڤینێ لبن ئاخێ بو خو پاراستن ژ سەقایێ گەرم و هشك. دەمەكیدا (A. calocephalum) ژ جورێت ناوچا ایران و ئاناتولیا یە كو دەسپێكا شینبوونا وێ دكەڤیتە دوماهیكا زستانێ و دەستپێكا بوهارێ ئەڤ چەندە ژی وەلێ دكەت كو جورێ خو بپارێزیت، سوپاس بو ڤی جورێ ستراتێژیێ ژ بو خو پاراستن ژ سەقایێ دژوار یێ زستانێ. ئەنجامێن ڤێ ڤەكولینێ پشتگیریا وێ بیروكێ دكەن كو جورێن پیڤازا ژ جهێن جودا خودان جیاوازیەكا تایبەتن د ستراتیژیا شینبوونا توڤی و بنكێ پیڤازێدا كو وەلێ دكەت جوریا خو بپارێزن. بەلگەیێن ڤێ ڤەكولینێ پێزانینێن مە زەنگین دكەن لسەر جوراوجوریا ستراتیژیا خوگونجاندنا رووەكا. لبن سیبەرا ڤێ چەندێ، پتر ڤەكولین و لێگەریان پێتڤینە بو هەلسەنگاندنا بریارا گونجای لسەر ژینگەها شینبوونا توڤی و ستراتیژیا خوراگرتنا پیڤازێ لسەر بەردەوامی یا كومەلگەهی و خوپاراستنێ دا.

الخلاصة

يعد الابصال أحد أكبر الأجناس الأحادية النسيلة وأكثرها تنوعًا في جميع أنحاء العالم. هذه الأصناف لها نطاق توزيع جغرافي واسع يوجد بشكل رئيسي في نصف الكرة الشمالي مع تمركز تنوع مهم في منطقتي البحر الأبيض المتوسط وإيران و الأناضول. وهي تشمل عددًا كبيرًا من الأصناف ذات القيمة الاقتصادية العالية (الصالحة للأكل ، المزروعة ،نباتات طبية ، نباتات الزينة ، إلخ). فإن هذه الأنواع الجيوفيتية تظهر استراتيجيات تكيف متنوعة تسمح لها بالاستمرار في ظل ظروف بيئية قاسية. وتظهر هذه الأنواع الجيولوجية استراتيجيات تكيف متنوعة تسمح لها

بالاستمرار في ظل ظروف بيئية قاسيه. صممت هذه الدراسة لفهم العوامل البيئية التي تتحكم بشكل أفضل في التجديد الطبيعي لنوعي الابصال الصالحة للأكل الاصيلة في مناطق زاغروس من خلال تقييم تأثير مختلف معالجات ما قبل البذار على معدل إنبات البذور و (2) عمق التربة على ظهور الشتلات. أكدت نتائج هذه الدراسة قدرات البذور والبصل عالية نسبيا تحت المعاملات المختلفة قبل البذر. وجدت هذه الدراسة أن نوعي الابصال عمومًا لهما إنبات مماثل نسبيًا (حوالي 80٪ بدون علاج) وأنماط ظهور الشتلات (د 5 سم) تحت التربة. تم العثور علي نسبه عاليه من إنبات البذور ل(*A. calocephalum*) تحت تطبق البارد لمدة شهر واحد و نقع في الماء لمدة 3 أيام و الجبريلين (GA3 1500 ppm) مع 83 ٪ ، 86 ٪ ، و 85 ٪ ، علي التوالي. تم العثور علي نمط الإنبات مختلف ل (*A. notabile*) مع 83 ٪ ، 85 ٪ ، 84 ٪ لتمرغ المياه لمده 2 و 3 أيام و الجبريلين (GA3 1000 ppm) ، علي التوالي .هذان النوعان المهددان من مختلف المجموعات التصنيفية والموائل لديها استراتيجية تكيف مختلفة. (*A. notabile*) هي الأنواع المتوسطية التي تظهر ظهور الشتلات الأمثل في فصل الخريف وبداية الشتاء مع سكون تحت عمق التربة في الصيف لتجنب الظروف الجافة الحارة. في حين أن (*A. calocephalum*) هي الأنواع الإيرانية - الأناضولية التي تنمو الشتلات المثالية في أواخر الشتاء وأوائل الربيع مما يسمح لها بالاستمرار بفضل إستراتيجيتها لتجنب الظروف المناخية الشتوية القاسية. تدعم نتائج هذا البحث الفكرة القائلة بأن أنواع الأبصال من الموائل المختلفة تظهر استراتيجيات إنبات البذور المختلفة واستراتيجيات ظهور الشتلات مما يسمح لها بالاستمرار. نتائج هذه الدراسة التجريبية يزيد من فهمنا لاستراتيجية التكيف المتنوعة للنباتات. في هذا السياق ، هناك حاجة إلى مزيد من الدراسات لتقييم الدور لبيئية إنبات البذور واستراتيجيات سكون الابصال على ديناميكية السكان والمثابرة.