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The Effect of Different Priming Applications on The Germination of Seeds of Some Hazelnut Cultivars

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HIGHLIGHTS

- Different priming applications on seeds of hazelnut cultivars.
- Different parameters on germination were examined and it was determined that the effects of primer applications showed different effects.

Abstract

Priming is a simple operation that partially hydrates seed in a controlled environment, followed by seed drying, allowing germination processes to commence without the development of radicles. In this study, the germination of shelled and kernel seeds of the Kara and Tombul cultivars was examined in relation to the effects of hormonal and hydro-priming treatments. According to the results, the control group produced the best shelled seed of the Kara cultivar in terms of germination rate, root length, root fresh and dry weight, plant fresh and dry weight, and number of leaves. The seeds of the Kara cultivar kernel, 60 minutes of Perlan + 2 days of soaking in water in the control group (56.0 pcs), and the kernel seeds of the Kara cultivar, respectively, and the seeds with shelled of the best Tombul cultivar (53.6 pcs), produced the best results when the root diameters were measured. The application of 30 minutes of Perlan + 2 days of soaking in water to the seeds kernel of the Kara cultivar produced the best results in terms of leaf area, and the control group produced the best results for the chlorophyll value in the seeds kernel of the Tombul and Kara cultivars.

Keywords: Coryllus avellana L.; germination priming; stratification

1. Introduction

One of the most significant species in the genus Corylus of the Betulaceae family is the European hazelnut (Coryllus avellana L.) (Serdar and Akyuz 2017). The demand for hazelnuts in the food business is rising, and there is a constant rise in production due to its high nutritional value worldwide. Turkey is the leader in the world with 665.000 tons of hazelnut production in an area of 735 thousand hectares. (Anonymous 2023).

Hazelnuts have been used for nearly 5000 years and are employed in numerous products, from their fruit to their wood (Silvestri et al. 2021). Although it thrives in cool, mid-altitude areas, the hazelnut tree can adapt to different environmental conditions. It is a type of fruit that grows in the form of a hazelnut bush, can be reproduced by bottom shoot, dip and grafting, and it has a monoic flower state. Fruit trees are typically reproduced vegetatively because of their heterozygous structure. It has been observed that propagation by tissue culture or by cutting of hazelnut plants have successful outcomes, however some other researches are

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still required to improve the production of hazelnut saplings (İslam et al. 2019; Kaplan et al. 2020; Rahemi et al. 2016). Hazelnut bush cultivation system is widespread, particularly in Turkey and the Mediterranean region (Silvestri et al. 2021) while single-stem cultivation system has recently been discovered to produce greater yield and fruit qualities due to less labor. On the other hand bush cultivation system has long been preferred since it renews itself with orchard bottom shoots and prevents erosion (İslam et al. 2019; Karata et al. 2017).

Studies on rootstock breeding began in the United States in the 1940s and are still going strong today because Corylus colurna L. has little to no tendency to shoots from the bottom. Grafting allows for the quick development of new species without bottom shoots (Wilkinson 2005) and also makes it possible to take advantage of rootstocks' outstanding qualities (Foidl and Paull 2008). Seedling and clone rootstocks are the two categories of rootstocks. Compared to clone rootstocks, seedling rootstocks produce disease-free individuals with a solid root system (Rahemi et al. 2016).

Because of their dormancy and pericarp structure, seeds with hard-shelled are challenging to germinate (Ulu 2022). Due to this circumstance, both the workforce and the sapling production period are extended. As with other fruit seeds, some pretreatments are made to hazelnut seeds to speed up germination. By folding, dormancy brought on by the embryo is overcome (Alkan et al. 2015). By eliminating the seed coat or surrounding tissues, physiological variables in the breaking of dormancy can be eliminated (Abbasi 2020). Plant growth regulators like auxin, cytokinin, gibberellin, abscisic acid, salicylic acid, 6-Benzyladenine, and Perlan, which encourage germination using the hormonal priming technique, are another way to overcome dormancy (Adkins and Bellairs 2000; Baskin et al. 2000; Keshtkar et al. 2008). Another pre-germination treatment is called "hydro-priming," which introduces very little water into the seeds during the initial stage of water uptake in an environment with 100% relative humidity (Karakurt et al. 2010). Additionally, it is well recognized that soaking techniques have a substantial impact on germination by allowing the inhibitors that cause dormancy to dissipate or move away from the seed by weakening the impermeable testa (Akın 2004; Edwards 1968; Güncan 1975).

To better understand how Perlan (18.5% GA4+7 + 18.8% 6-Benzyladenine) and hydro-priming applications, which have an increasing impact on germination, affect the germination of the widely produced Tombul and Kara hazelnut varieties in our nation.

2. Materials and Methods

The study was carried out in the climate cabinet of the Central laboratory of Bilecik Şeyh Edebali University during 2022 and 2023. In the study, 'Tombul' and 'Kara' hazelnut varieties, which have high economic value in hazelnut production,were used as material, The seeds of the two hazelnut cultivars were obtained from the producer's garden in Ordu province in 2022. The world's highest grade hazelnut cultivar, Tombul, is a very productive type with round-shaped fruits and excellent oil, protein, and whitening rates. The Kara cultivar is characterized by thick-shelled, dark-colored, big, low-fat hazelnuts. Perlan commercial preparation is a plant growth regulator produced by Fine Agrochemicals Limited, containing (18.5% GA4+7 + 18.8% 6-Benzyladenine.

Before the application, the seeds were soaked in 3% sodium hypochlorite solution for surface sterilization for 10 minutes, washed several times with distilled water and mixed into perlite placed and folded at +4 ºC for 3 months. Some pre-germination treatments were applied to the shelled and kernel seeds of both cultivars, after removing from stratification conditions (Table 1).

Table 1. Types and applications used in the experiment

Varieties	**Tombul**		**Kara**	
Seed shape	**Shelled**	**Kernel**	**Shelled**	**Kernel**
1. Application	Control		Control	
2. Application	30 min Perlan + 2 days soaking		30 min Perlan + 2 days soaking	
3. Application	60 min Perlan + 2 days soaking		60 min Perlan + 2 days soaking	

The collected data were subjected to analysis of variance at the 5% significant level by using the SPSS 23 package program.

3. Results

Tables 2 and 3 illustrate the effects of soaking in water for specific periods (30 and 60 minutes) of seeds treated with commercial preparation Perlan on germination.

The results showed that the pre-germination treatments were statistically significant (P<0.05) when seed germination rates were considered. In the control group, germination rate of shelled seeds of Kara cultivar was 80%, while germination rate was 20% in shelled seeds of Tombul and Kara cultivars treated with 60 minutes of Perlan and 2 days of soaking in water (Table 2).

Table 2. The effect of different applications on the parameters examined in the research

Application	Germination percentage (%)	Root length (mm)	Root diameter (mm)	Hypocotyl length (mm)	Hypocotyl diameter (mm)	Number of lateral root (number)
TOMBUL- Shelled						
Control	60,00ab	70,5ab	0,78bc	81,2abc	2,33d	56,0a
30 min PERLAN +2 days soaking	46,6 ab	57,3b	0,95bc	103,5abc	1,38d	29,6abc
60 min PERLAN +2 days soaking	20,0c	64,0b	1,40a	60,1bcd	2,10a	46,0ab
TOMBUL – Kernel						
Control	53,3abc	70,0ab	0,76bc	77,0bc	1,77cd	31,6abc
30 min PERLAN +2 days soaking	33,3bc	54,1b	0,68bc	90,4abc	1,60cd	44,6ab
60 min PERLAN +2 days soaking	40,0bc	55,0b	0,60c	61,4bcd	1,80cd	42,6abc
KARA- Shelled						
Control	80a	113,9a	0,59c	124,4a	1,75cd	36,0abc
30 min PERLAN +2 days soaking	26,6bc	55,1b	0,16d	0,0e	1,10e	31,3abc
60 min PERLAN +2 days soaking	20,0c	65,8b	0,83bc	47,4cde	1,30d	26,0abc
KARA- Kernel						
Control	53,3bc	77,2ab	0,77bc	109,9ab	1,39d	17,6c
30 min PERLAN +2 days soaking	40,0bc	52,3b	1,00b	89,0abc	3,10b	42,3abc
60 min PERLAN +2 days soaking	33,3bc	84,0ab	1,46a	24,3de	1,36d	53,6a

The difference of root length and root diameter was found to be statistically significant in our study. The best root length of the Kara cultivar shelled seeds in the control group was 113.99 mm, while the lowest was obtained after 30 minutes of Perlan + 2 days of soaking in water of the Kara cultivar seeds (52.3 mm) (Table 2). Rostamikia et al. (2018) reported that obtained from the kernel after four months of stratification period. The difference of root diameters by the aplications was also statistically significant in our study at P<0.05 level. . The highest root diameter values were obtained from kernel seeds (1.46 mm) of the Kara cultivar treated with 60 min Perlan + 2 days soaking. It is well recognized that hydro-priming and hormonal priming have beneficial effects on seeds, and our findings support this (Ceritoğlu et al. 2021).

The number of lateral roots was found to be statistically insignificant. The best number of lateral roots was determined to be 56.0 pcs in the control group shelled hazelnut seeds of the Tombul cultivar, 53.6 pcs in the 60 minutes Perlan+2 days soaking application applied to the kernel seeds in the Kara cultivar, and the least lateral root number was 17.6 pcs in the control group kernel seeds of the Kara cultivar. It turned out to be statistically significant (P<0.05) when the root fresh weights were analyzed (Table 3). The control group of shelled seeds of Kara cultivar had the highest fresh weight (2.95 g), followed by kernel seeds of Tombul cultivar (1.73 g) treated with 30 min Perlan + 2 days soaking. In terms of root dry weights, the control treatment in the shelled seeds of the Kara cultivar yielded 0.33 g, while the 30 minutes Perlan + 2 days soaking application in the kernel seeds of the Tombul cultivar yielded 0.32 g (Table 3). Table 3 shows the fresh and dry weights of the plants. The fresh weights of plants were found to be statistically significant (P<0.05). The shelled seeds of

the control group Kara cultivar yielded the best plant fresh weight (1.42 g). The number of leaves data obtained was judged to be statistically significant (P<0.05). The greatest number of leaves were obtained in the control application of seeds with shelled from the land cultivar and the application of 60 minutes Perlan + 2 days of soaking in kernel seeds from the Tombul cultivar. The optimal leaf numbers were found to be 6.08 pcs and 6.00 pcs (Table 3).

Table 3 shows the results of utilizing Adobe Photoshop CS6 Extend software (İpek et al. 2014) to compute the leaf area in cm2 based on the pixel value of the images generated by scanning the leaves with a gauge (ruler) using a scanner. It was obtained by soaking treated seeds of the Kara cultivar with the maximum leaf area, minus the shelled, in water for 30 minutes Perlan + 2 days. Table 3 provides the chlorophyll values (SPAD) on the germination of seeds from several pre-treated hazelnut cultivars. The control application Tombul and Kara cultivars kernel, yielded the highest concentration of chlorophyll. They discovered that there was no change in terms of chlorophyll indices in a study on the germination of Guava (Sidium guajava L.) seeds, which is similar to like our own conclusion (Nafiye et al. 2019).

Table 3. The effect of different applications on the parameters examined in the research

Application	Root fresh weight (g)	Root dry weight (g)	Plant fresh weight (g)	Plant dry weight (g)	Leaf number (number)	Leaf field (cm^2)	Amount of chlorophyll (SPAD)
TOMBUL- Shelled							
Control	1,20bc	0,12abc	0,82ab	0,32bc	5,00ab	28,2a	24,0b
30 min PERLAN +2 days soaking	1,73b	0,05bc	0,27b	0,14cde	2,66b	23,4ab	23,6b
60 min PERLAN +2 days soaking	0,18d	0,02c	0,27b	0,065de	1,20c	17,4ab	26,4abb
TOMBUL – Kernel							
Control	1,27bc	0,12abc	0,46b	0,29bcde	5,00ab	26,3ab	27,8a
30 min PERLAN +2 days soaking	0,19d	0,26abc	0,27b	0,31bcd	4,33ab	26,6ab	25,6ab
60 min PERLAN +2 days soaking	0,19d	0,32ab	0,46b	0,44ab	6,00a	19,2ab	25,0ab
KARA- Shelled							
Control	2,95a	0,33a	1,42a	0,62a	6,08a	24,4ab	26,9a
30 min PERLAN +2 days soaking	0,43cd	0,11abc	0,86ab	0,14cde	1,12c	29,5a	23,6b
60 min PERLAN +2 days soaking	0,45cd	0,080abc	0,21b	0,05e	2,66b	8,43b	25,9ab
KARA- Kernel							
Control	1,12bcd	0,16abc	0,45b	0,11cde	4,60ab	32,1a	27,8a
30 min PERLAN +2 days soaking	0,48cd	0,21abc	0,98ab	0,15cde	5,33ab	33,02a	25,3ab
60 min PERLAN +2 days soaking	1,46	0,16abc	0,20b	0,17cde	4,33ab	18,2ab	25,3ab

4. Discussion

Beyhan et al. (1999) the germination rate of seeds treated to stratification between 12.3% and 39.5% was determined in their study on seed germination and seedling growth of varied stratification and GA3 dose treatments in hazelnut cultivars. The maximum germination rate was discovered to be 64.17% in the Çakıldak cultivar and 37.08% in the Kalınkara cultivar in the study examining the effects of potassium humate on the germination of hazelnut kernels of various hazelnut varieties (Bostan et al. 2000). As the GA3 dose increased, the germination percentage increased, but after a certain level, the best germination was obtained at 75 ppm GA3 concentration, according to a study looking at the effects of various doses of GA3, and water applications on germination in Turkish hazelnut seeds (Aygun et al. 2008).

Yıldırım et al. (2009) in a study on the germination of Chamaecytisus drepanolobus (Boiss.) Rothm species seeds, it was shown that seeds kept in clean water for 48 hours had no germination whereas seeds kept in 10 ppm GA3 had the best germination. In a study where Ceratonia siliqua seeds were subjected to various chemical etching treatments before germination, it was found that 30 minutes of H2SO4 + soaking in water for 2 days followed by 30 minutes in H2SO4 solution gave the best results. (Gübbük et al. 2012). Carob seeds were immersed in water after being exposed to sulfuric acid or mechanical abrasion, and germination rates ranged from 10% to 80% (Kleynhans et al. 2016). Rostamikia et al. (2018). They evaluated the effects of folding in hazelnut genotypes on germination in seeds with and without a shelled in their study, and they discovered that kernel seeds had the highest germination rate of 51.66%. The maximum germination rate was found from the 60-day folding treatment without chemical application in the study where varied folding and chemical applications were done on the seeds of terebinth before germination (Hashim et al., 2018). Researchers reported that gibberellic acid had no influence on germination rate in elderberry seeds that were not treated with sulfuric acid, and that the germination rate remained constant at 67.50% with increasing doses of gibberellic acid (Odabas et al. 2020). When the germination rate achieved in our study is compared to other studies, it is shown that many studies obtain comparable or superior findings. The researchers discovered that soaking the elderberry plant seeds in sulfuric acid (15 minutes) and 500 ppm gibberellic acid solution (24 hours) boosted root length by 22.6% compared to control seeds. (Odabas et al. 2020). Okatan (2017) discovered that when abrasion and soaking in GA3 solution were applied to elderberry seeds, the rate of hypocotyl rose by 143%. The best hypocotyl diameter of 3.10 cm was obtained from kernel seeds of Kara cultivar after 30 minutes of Perlan + 2 days of soaking in water. They reported 6.2 mm in the control application as a result of the development status of the seedlings planted in the seedling plots by applying GA3 (0-50-100-200 ppm) at different rates without folding in the hazelnut seeds (Beyhan et al. 1999).

In a study on Malta plum seeds, the lowest root wet weight was 0.04 g after pre-treatment with GA3, whereas the greatest root weight was 0.09 g after 300 ppm GA3 application (Okatan 2017). In a study conducted on hazelnut seeds, they reported that the highest rate of root dry weight was obtained from the control group (56%) (Beyhan et al., 1999). For 24 hours, different concentrations of GA3 (control, 100, 200, and 300 ppm) were treated to Malta plum, and the root dry weight was 0.02 g in the control group and 0.05 g in the highest 300 ppm treatment (Okatan 2017).

They discovered that applying nitric and gibberellic acid to black elderberry seeds at different intervals had a detrimental influence on plumule fresh weight, resulting in a considerable drop (Odabas et al. 2020). Plant dry weights were statistically significant ($P<0.05$). The control group yielded the best plant dry weight (0.62 g) in the shelled seeds of the Kara cultivar. This was followed by the plant dry weight (0.44 g) of 60 minutes Perlan + 2 days of soaking.

5. Conclusions

Because of dormancy and the hard shell, germination takes a lengthy time in hard-shelled fruit species. Both breeding experiments and rootstock production require rapid and smooth germination. In this study, the responses of pre-germinated hazelnut seeds of Kara and Tombul cultivars to Perlan and soaking applications were determined. The control application of shelled seeds of the Kara cultivar produced the best results in many metrics tested, including germination percentage. Three months of cold folding was found to be advantageous for the cultivation of shelled seeds by direct sowing in nurseries and forest regions. Perlan application and soaking applications, in addition to folding, have a favorable influence on several parameters. As a result, it is suggested that the study should be expanded in future studies by increasing the number of species and applications.

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References

Anonymous (2023). https://www.fao.org/faostat/en/

Abbasi MR (2020). Breaking seed dormancy in some Iranian wild clovers (*Trifolium* spp.) selected as promising new germplasm. *Genetic Resources and Crop Evolution*, 67(6): 1577-1585.

Adkins S, Bellairs S (2000). Seed dormancy mechanisms of Australian native species. *Australian Centre for Mining Environmental Research*, 97-109.

Akın B (2004). Dormansi kırıcı yöntemlerin yabancı ot tohumları üzerinde etkileri. *Dumlupınar Üniversitesi Fen Bilimleri Enstitüsü, Biyoloji ABD, Basılmamış Yüksek Lisans Tezi, 53s*.

Alkan G, Ertan E, Hekimci B, Algül B E (2015). Sert Kabuklu Meyve Türleri Tohumlarinda Çimlenme Sonrasi Kök Kesimi Uygulamasinin Çöğür Gelişimi Üzerine Etkisi. *Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi*, *12*(1): 49-56.

Aygun A, Erdogan V, Bozkurt E (2008). Effect of some pretreatments on seed germination of Turkish hazel (Corylus colurna L.). *VII International Congress on Hazelnut* 845.

Baskin JM, Baskin CC, Li X (2000). Taxonomy, anatomy and evolution of physical dormancy in seeds. *Plant species biology*, *15*(2): 139-152.

Beyhan N, Marangoz D, Demir T (1999). GA3 ve katlama uygulamalarının fındıkta tohum çimlenmesi ile açıkta ve tüplü çöğür gelişimi üzerine etkisi.

Bostan SZ, İslam A, Yilmaz M (2000). Effect of potassium humate on hazelnut seed germination. *V International Congress on Hazelnut* 556.

Ceritoğlu M, Erman M, Fatih Ç, Şahin S, Abdulkadir A (2021). Bitki gelişimi ve stres toleransının geliştirilmesi üzerine sürdürülebilir bir strateji: Priming tekniği. *Türkiye Tarımsal Araştırmalar Dergisi*, *8*(3): 374.

Edwards M (1968). Dormancy in seeds of charlock: II. The influence of the seed coat. *Journal of Experimental Botany*, *19*(3): 583-600.

Foidl N, Paull R (2008). Moringa oleifera. *Encyclopedia of Fruit and Nuts. CABI, Oxfordshire, UK. pp. Intestinal Histomorphology and Nutrient Digestibility in Broilers chickens. Res. J. Recent Sci*, *1*: 2277-2502.

Gübbük H, Güneş E, Güven D, Nafiye A (2012). Keçiboynuzu tohumlarının kontrollü koşullarda çimlendirilmesi üzerinde araştırmalar. *Derim*, *29*(2): 1-10.

Güncan A (1975). Erzurum çevresinde bulunan yabancı otlar ve önemlilerinden bazılarının yazlık hububatta mücadele imkânları üzerinde araştırmalar. *Atatürk Üniversitesi*.

Hashım İ F, Aşkın M A, Yıldırım A N (2018). Bazı uygulamaların menengiç (*Pistacia terebinthus* L.) tohumlarının çimlenmesi ve çıkışı üzerine etkileri. *Ziraat Fakültesi Dergisi*, 13(1): 27-39.

İpek M, Arıkan Ş, Eşitken A, Pırlak L, Dönmez M F, Turan M (2021). Influence of bacterial inoculation on growth and plant nutrition of peach grafted in different rootstocks in calcareous soil. *Sains Malaysiana*, *50*(9): 2615-2624.

İslam A, İsa Ö, Karagöl S, Turan A (2019). Farklı IBA uygulamalarının Corylus colurna L.'nın odun çelikleriyle köklenmesi üzerine etkisi. *Akademik Ziraat Dergisi*, *8*(Özel Sayı): 45-48.

Kaplan N, İslam A, Ekbiç H B (2020). Çakıldak fındık çeşidinin in vitro sürgün ucu kültürü ile çoğaltılması. *Akademik Ziraat Dergisi*, *9*(2): 193-200.

Karakurt H, Aslantaş R, Eşitken A (2010). Tohum çimlenmesi ve bitki büyümesi üzerinde etkili olan çevresel faktörler ve bazı ön uygulamalar. *Uludağ Üniversitesi Ziraat Fakültesi Dergisi*, *24*(2): 115-128.

Karata S, Islam A, Tonkaz T, Özkutlu F, Rovira M, Romero A, Cristofori V, Silvestri C, Speranza S, Cetin S (2017). Examination of modern and traditional applications in hazelnut production. *IX International Congress on Hazelnut 1226*.

Keshtkar, A., Keshtkar, H., Razavi, S., Dalfardi, S. (2008). Methods to break seed dormancy of Astragalus cyclophyllon. *African Journal of Biotechnology*, *7*(21).

Kleynhans R, Bulannga M, Nenungwi L, Lehlaleroa M, Matsiliza-Mlathi B, Slabbert M (2016). Preliminary investigations on germination of Sutherlandia frutescens and emergence of Ceratonia siliqua seed. *VII International Symposium on Seed, Transplant and Stand Establishment of Horticultural Crops-SEST2016* 1204.

Nafiye A, Balkıç R, Tozlu İ, Altınkaya L, Soydal A, Gübbük H (2019). Guava (*Psidium guajava* L.) tohumlarının çimlenmesi üzerine araştırmalar. *Bahçe*, 48(1): 1-7.

Odabas S, Kara ŞM, Özcan MM (2020). Bazı Kimyasal uygulamaların siyah mürver (*Sambucus nigra* L.) tohumlarında dormansinin kırılması ve çimlenme üzerine etkisi. *Türk Tarım ve Doğa Bilimleri Dergisi*, *7*(4): 920-927.

Okatan V (2017). GA3 uygulamalarının malta eriği (*Eriobotrya japonica*) tohumlarının çimlenmesi ve çöğür gelişimi üzerine etkileri. *Gümüşhane Üniversitesi Fen Bilimleri Dergisi*, *7*(2): 309-313.

Özcan A, Sütyemez M (2017). Bazı ceviz (*Juglans regia* L.) çeşitlerinin çimlenme ve çöğür (anaçlık) gelişme performanslarının belirlenmesi. *KSÜ Doğa Bilimleri Dergisi*, *20*(1): 75-79.

Rahemi A, Taghavi T, Dale A (2016). A simple method to improve hazelnut grafting. *Journal of Nuts*, *7*(02): 83-87.

Rostamikia Y, Tabari Kouchaksaraei M, Asgharzadeh A, Rahmani A (2018). Effect of cold stratification on seed germination traits in three ecotypes of hazelnut (*Corylus avellana* L.). *Forest and Wood Products*, *71*(1): 1-12.

Serdar U, Akyuz B (2017). Sucker management methods in hazelnut cultivation. *IX International Congress on Hazelnut* 1226,

Silvestri C, Bacchetta L, Bellincontro A, Cristofori V (2021). Advances in cultivar choice, hazelnut orchard management, and nut storage to enhance product quality and safety: an overview. *Journal of the Science of Food and Agriculture*, *101*(1): 27-43.

Ulu S (2022). Yeni nesil dizileme yöntemi ile Türk fındığı (*Corylus colurna* L.) ve tombul fındığın (*Corylus avellana* L.) transkriptom analizlerinin yapılması ve karşılaştırılması. *Yıldız Üniversitesi Fen Bilimleri Enstitüsü, PhD Thesis.*

Yıldırım H, Pirhan AF, Gemici M, Gemici Y (2009). The contributions of taksonomical characters, echological characteristics and studies for seed germination of endemic Chamaecytisus drepanolobus (Boiss.) Rothm.(*Fabaceae*). *Biyoloji Bilimleri Araştırma Dergisi*, 2(2): 89-92.

Wilkinson J (2005). Nut grower's guide: the complete handbook for producers and hobbyists. *Landlinks Press*.