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DETERMINATION OF GERMINATION CHARACTERISTICS OF *Calligonum polygonoides* AND *Koelreuteria paniculata* SEEDS

Utvrđivanje karakteristika klijavosti sjemena vrsta *Calligonum polygonoides i Koelreuteria paniculata*

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Abstract

The success of the afforestation works (ecological and biological compatibility, economic success, etc.) depends on the use of seeds of known origin or quality seedlings. For this reason, it is important to determine seed characteristics and to eliminate dormancy. In this study, it was aimed to determine the germination characteristics of seeds of *Calligonum polygonoides* L. collected from Iğdır and *Koelreuteria paniculata* Laxm. obtained from Trabzon. In order to eliminate the dormancy for *Calligonum polygonoides*, 11 different pretreatments including control, cold water (1-2 days), hot water (10-15 min), gibberellic acid (GA_3 1000 ppm, GA_3 3000 ppm), sulfuric acid (H_2SO_4, 5-10 min), 5 min with H_2SO_4 + 20 min with GA_3 1000 ppm and 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm were applied. The highest germination percentage was obtained as 50% in sulfuric acid (5 min) pretreatment, while the lowest germination percentage was obtained as 3.33% in control pretreatment. In hot water pretreatments, germination didn't occur. In order to eliminate the dormancy for *Koelreuteria paniculata*, pretreatments including control, cold water (1 day), hot water (10 min), GA_3 1000 ppm, GA_3 3000 ppm, H_2SO_4 5-10 min, 5 min with H_2SO_4 + 20 min with GA_3 1000 ppm and 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm were applied. While the lowest germination percentage occurred as 73.33% in H_2SO_4 (10 min) pretreatment, the highest germination percentage took place as 93.33% in 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm and cold water (1 day) pretreatments.

***Key words**: Calligonum polygonoides, Koelreuteria paniculata, seed, dormancy, pretreatment.*

INTRODUCTION - *Uvod*

Seed germination and seedling establishment are the most crucial periods in the plant life cycle (MAYER and POLJAKOFF-MAYBER, 1989). Germination starts with water uptake by seeds and terminates with the initial elongation of the embryonic axis (BEWLEY, 1997). Completion of germination can be seen by the emergence of the radicle (OGAWA et al., 2003). On the other hand, seed dormancy is a physiological condition in which the seeds cannot germinate even under the most suitable germination conditions or do not exhibit uniform germination. Seed germination is generally hampered by external factors (oxygen, temperature, humidity and light) and internal

factors (e.g. seed coat, endosperm embryo) (BEWLEY and BLACK, 1982; BRADBEER, 1988; COPELAND and MCDONALD, 2001; KOORNNEEF, et al., 2002; BASKIN and BASKIN, 2004; BLACK et al., 2008).

Goldenrain-tree (*Koelreuteria paniculata* Laxm.) spread as native species in China and well established in Korea. It is a woody perennial, mainly used for landscape purposes due to its beautiful yellow flowers and green leaves. It is wide spread as an ornamental tree but the propagation is difficult because of apparent seed dormancy (PARK and REHMAN, 1999; REHMAN and PARK, 2001). Seed coat, embryo or the combination of the two can be reason the dormancy; this is why the seeds need to be well prepared before sowing (PARK and REHMAN, 1999; SABINA, 2009; SABINA and CORNELIA, 2011; REHMAN and PARK, 2000a).

Calligonum polygonoides L. (*Polygonaceae*) is a dominant perennial shrub in active sand dunes and stabilized sand fields (MAO and PAN, 1986; TAO, 2000). The species can persist in mobile sandy dunes under extreme drought conditions (LIU, 1985-1990). It is known for high tolerance to water deficiency in the Tunisian Saharian regions and appears to be appropriate for revegetation of desert (MAO et al., 1983; MAO and PAN, 1986; ZHANG, 1992; TAO, 2000). This shrub has great potentialities to provide different products and services as forage, traditional medicine, halting desert encroachment and stabilizing sand dune (LIU, 1985-1990; TAO, 2000). Seed coat hardness and impermeability to water may be the most important causes of *Calligonum* spp. dormancy (YU and WANG, 1998; TAO et al. 2000; REN and TAO, 2004).

Unfortunately, there is limited information concerning the potential seed dormancy problems of *Koelreuteria paniculata* and *Calligonum polygonoides*. For this reason, the objective of the present study was to devise an effective method for breaking dormancy of *Koelreuteria paniculata* and *Calligonum polygonoides* seeds.

In this study, it is examined that the effects of several pretreatments on germination of *Koelreuteria paniculata* and *Calligonum polygonoides* seeds, with the goal of providing practical suggestions for breaking dormancy.

MATERIALS AND METHODS - *Materijal i metode*

It was aimed to determine the germination characteristics of seeds of *Calligonum polygonoides* L. collected from Iğdır and *Koelreuteria paniculata* Laxm. obtained from Trabzon. After the collection of seeds, empty and rotten seeds were removed. *Koelreuteria paniculata* seeds were manually scarified by piercing seeds with a needle at the cotyledon end. Seeds were allowed to air-dry and stored at ambient temperature (25 °C). Germination experiments were conducted at 25±2 ºC temperature and 70±2% humidity level at the Research and Application Greenhouse. Peat+soil+perlite determined by 7:2:1 ratio was used as germination medium. Line sowing method was used in the sowing of the seeds and sowing was conducted based on the randomized complete block design. In the prepared crates, lines were opened to the depth of 2-3 times of the thickness of the seed with the line opening bar. Seeds were sowed with 3x10 sampling in October. Each treatment was replicated three times and

10 seeds were used in each replicate. In total, it was used 270 seeds for *Koelreuteria paniculata* and 330 seeds for *Calligonum polygonoides* in the scope of this study. In order to eliminate the dormancy for *Calligonum polygonoides*, 11 different pretreatments including control, cold water (1-2 days), hot water (10-15 min), gibberellic acid (GA_3 1000 ppm, GA_3 3000 ppm), sulfuric acid (H_2SO_4, 5-10 min), 5 min with H_2SO_4 + 20 min with GA_3 1000 ppm and 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm were applied. *Koelreuteria paniculata*, 9 different pretreatments including control, cold water (1 day), hot water (10 min), GA_3 1000 ppm, GA_3 3000 ppm, H_2SO_4 5-10 min, 5 min with H_2SO_4 + 20 min with GA_3 1000 ppm and 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm. Germination status was recorded every day. Seedling emergence (cotyledons visible at the media surface) was expressed as the percentage of viable seeds.

Germination data related to this study were analyzed using the SPSS 23 statistical program.

RESULTS - *Rezultati*

As a result of the study, the results of variance analysis and the germination percentage related to applied pretreatments for removing of dormancy in seeds of *Calligonum polygonoides* and *Koelreuteria paniculata* are given in Table 1.

Table 1. The results of germination percentages related to pretreatments
Tabela 1. Rezultati procenta ostvarene klijavosti u odnosu na tretmane

Species	Treatments	Germination Percentage (%)	F	P
Koelreuteria paniculata	1-Control	76.67	164.769	0.000*
	2-Cold water (1 day)	93.33		
	3-Hot water (10 min)	86.67		
	4-GA_3 1000 ppm (30 min)	83.33		
	5-GA_3 3000 ppm (30 min)	83.33		
	6-H_2SO_4 5 min	76.67		
	7-H_2SO_4 10 min	73.33		
	8-H_2SO_4 5 min + GA_3 1000 ppm (20 min)	90.00		
	9-H_2SO_4 10 min + GA_3 3000 ppm (20 min)	93.33		
Calligonum polygonoides	1-Control	3.33	1238.657	0.000*
	2-Cold water (1 day)	36.67		
	3-Cold water (2 day)	40,.0		
	4-Hot water (10 min)	0.00		
	5-Hot water (15 min)	0.00		
	6-GA_3 1000 ppm (30 min)	26.67		
	7-GA_3 3000 ppm (30 min)	33.33		
	8-H_2SO_4 (5 min)	50.00		
	9-H_2SO_4 (10 min)	46.67		
	10-H_2SO_4 5 min + GA_3 1000 ppm (20 min)	36.67		
	11-H_2SO_4 (10 min) + GA_3 3000 ppm (20 min)	20.00		

* $P<0.05$ (There is a statistically significant difference.)

As can be seen from Table 1, there were statistically significant differences ($P<0.05$) in terms of pretreatments for both species. While the lowest germination percentage in *Koelreuteria paniculata* seeds occurred as 73.33% in H_2SO_4 (10 min) pretreatment, the highest germination percentage took place as 93.33% in 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm and cold water (1 day) pretreatments. For the seeds of *Calligonum polygonoides*, the highest germination percentage was obtained as 50% in sulfuric acid (5 min) pretreatment, whereas the lowest germination percentage was obtained as 3.33% in control pretreatment. In hot water pretreatments, germination didn't occur in *Calligonum polygonoides* seeds.

Duncan test was performed to determine the groups that were occurred in terms of pretreatments for germination percentages (Figure 1 and Figure 2).

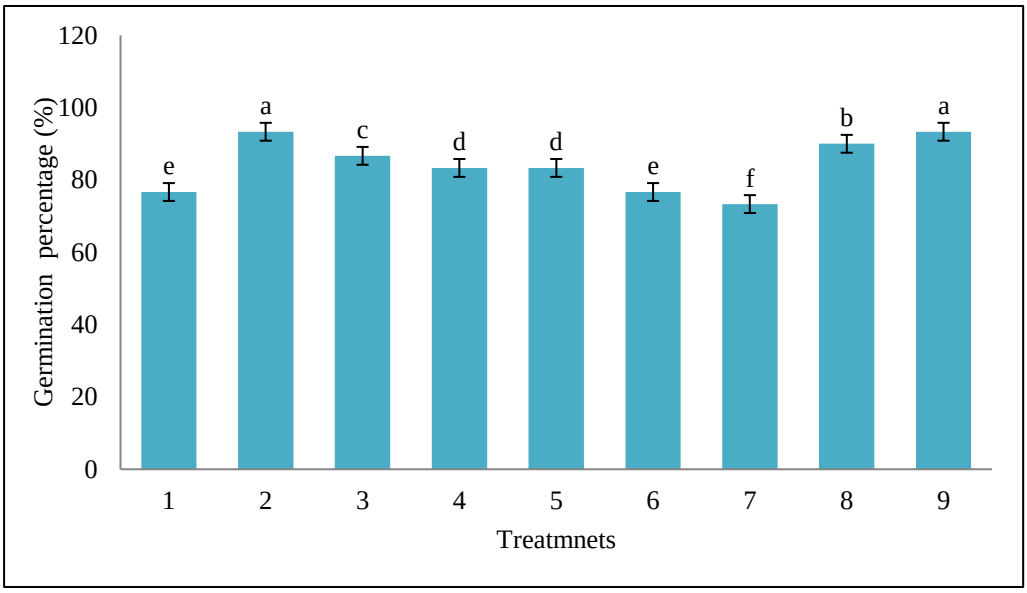

Figure 1. Duncan test results for *Koelreuteria paniculata*
Figure 1. Rezultati Duncan testa za Koelreuteria paniculata

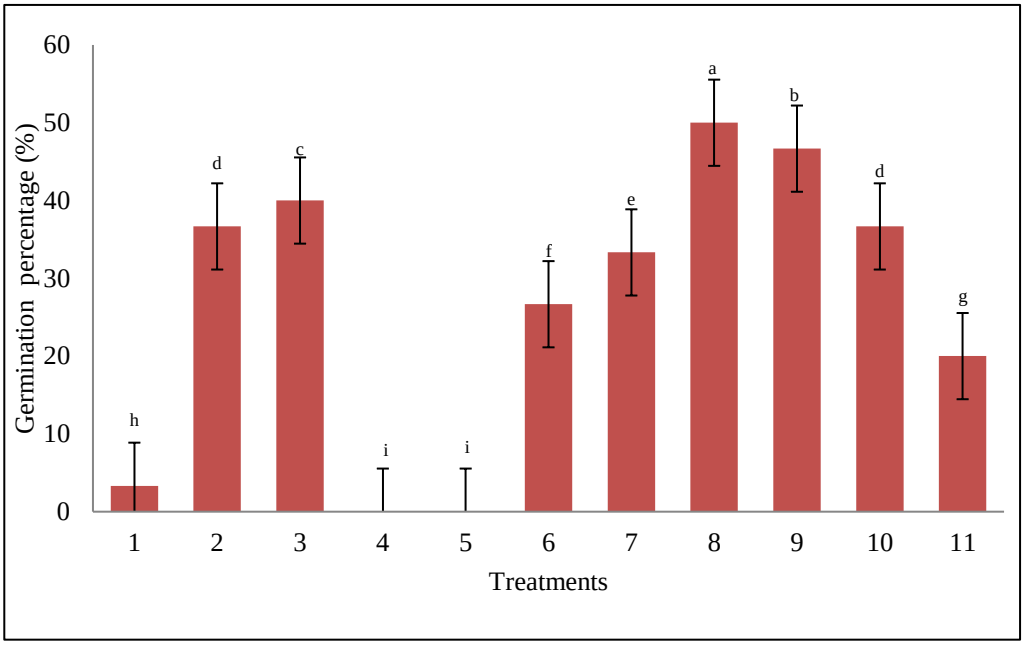

Figure 2. Duncan test results for *Calligonum polygonoides*
Figure 2. Rezultati Duncan testa za *Calligonum polygonoides*

As a result of the Duncan test, it was seen that there were 6 groups in *Koelreuteria paniculata* and 9 different groups in *Calligonum polygonoides*. For *Koelreuteria paniculata*, Cold water (1 day) and H_2SO_4 10 min + GA_3 3000 ppm (20 min) pretreatments created first group with the highest values, and H_2SO_4 (10 min) took place the last group having the lowest value. For *Calligonum polygonoides*, first group was created by H_2SO_4 5 min pretreatment, while the last group was formed by hot water 10 min and 15 min pretreatments.

DISCUSSION - *Diskusija*

REHMAN and PARK (2000a) reported that scarified seeds of goldenrain tree, without soaking or after soaking–redrying, had 44% germination after 60 days of moist chilling, which was increased to more than 50% when Seeds were soaked or soaked–redried in DW or GA_3 for 5 h and moist chilled for 60 days (DW) and 30 days (GA_3). However, germination of seeds soaked for 24 h and moist chilled was very low, but increased if the seeds were redried after soaking. Dry chilling after soaking or soaking–redrying for 24 h also promoted germination and a maximum of >50% germination was achieved after 15 days of dry chilling. In other research, exogenous application of 100, 200 and 300 ppm GA_3 increased germination of scarified seeds from 0 (control) to 17, 18 and 15%, respectively. Pre-chilling in distilled water (DW) for 60 days increased germination to 44%. Compared with DWchilled seeds, germination of seeds chilled for

15 days in GA3 was significantly increased and germination of Seeds chilled in 100, 200 and 300 ppm GA3 was 60, 51 and 54%, respectively, after 30 days (REHMAN and PARK, 2000b). The highest germination (94%) was obtained using 100 mL/L EM 1 application and stratification for 45 days at 4°C. Stratification was also effective for breaking dormancy of *K. paniculata* seeds with EM 1 and 45 days or 60 days of stratification (ERTEKIN, 2011). RUDOLF, (1974), examined untreated seeds and found germination of only 2% after 29 days, whereas germination increased to 52% after acid plus stratification treatment. No unscarified seed germinated in any of the treatments, indicating that goldenrain tree seeds have hard, impermeable seed-coat dormancy. In this study, high germination (93.33%) was obtained in 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm and cold water (1 day) pretreatments.

The germination response of *Calligonum azel*, *C. arich* and *C. comosum* to mechanical, physical and chemical scarifications, applied for overcoming dormancy, has been studied under controlled conditions. In all three *Calligonum* species, the germination of the untreated (control) seeds was relatively low, indicating the presence of coat-imposed dormancy in a fraction of the studied seeds. Chemical scarification with sulphuric acid (96%) was effective in breaking seed dormancy and consequently in increasing the rate and the final percentage of germination (DHIEF et al., 2012). YU and WANG (1998), showed that the seed dormancy rates of the three *Calligonum* species are more than 95%, and the dormant degrees are rather deep. REN and TAO (2004), studied the effects of abrasion, sulphuric acid, boiling water, cold stratification and seed exudates (water-soluble inhibitors from the testa) treatments on the germination of 10 *Calligonum* species. They concluded that the rate and the percentage of the germination of these species are greatly increased by mechanical or chemical scarification; however, the lowest values are obtained with the exudate treatment. According to ZHANG (1992), the most appropriate pretreatments for *Calligonum* species are sulfuric acid and cold stratification. In the present study, the seed germination percentage of *Calligonum polygonoides* was enhanced by an immersion time in sulphuric acid and increased with time until 5 min.

In conclusion, 10 min with H_2SO_4 + 20 min with GA_3 3000 ppm and cold water (1 day) pretreatments can successfully break dormancy in goldenrain tree seeds, resulting in the easy production of seedlings. Hence, goldenrain tree is a suitable for planting in urban parks and gardens. Sulfuric acid (5 min), with the highest germination percentage (50%), can be used in order to eliminate the dormancy for *Calligonum polygonoides*. In the context of the potential use of *Calligonum* species as an alternative in the arid desert regions, it can be suggested that seed germination and seedling emergence under the natural environmental conditions still deserve further research.

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SAŽETAK

Uspjeh pošumljavanja (ekološka i biološka kompatibilnost, ekonomska opravdanost, itd.) zavisi od upotrebe sjemena poznatog porijekla ili kvalitetnih sadnica. U ovu svrhu, važno je utvrditi karakteristike sjemena i eliminisati dormantnost. Cilj ovog rada bio je utvrditi klijavost sjemena *Calligonum polygonoides* L. sakupljenog u Iğdıru i *Koelreuteria paniculata* Laxm. Sakupljenog u Trabzonu. Da bismo eliminisali dormantnost za sjeme *Calligonum polygonoides*, uključili smo 11 različitih pre-tretmana, uključujući kontrolu: hladna voda (1-2 dana), vrela voda (10-15 min), giberelinska kiselina (GA_3 1000 ppm, GA_3 3000 ppm), sumporna kiselina (H_2SO_4, 5-10 min), 5 min sa H_2SO_4 + 20 min sa GA_3 1000 ppm i 10 min sa H_2SO_4 + 20 min sa GA_3 3000 ppm. Najveća klijavost, od 50% ostvarena je u pre-tremanu sa sumpornom kiselinom (5 min), dok je najmanji procenat klijavosti (3,33%) bio u kontrolnom pre-tretmanu. U pre-tretmanu sa vrelom vodom nije bilo klijavosti. Za sjeme vrste *Koelreuteria paniculata*, u svrhu eliminisanja dormantnosti izvršili smo slijedeće pre-tretmane sa kontrolom, hladna voda (1 dan), vrela voda (10 min), GA_3 1000 ppm, GA_3 3000 ppm, H_2SO_4 5-10 min, 5 min sa H_2SO_4 + 20 min sa GA_3 1000 ppm i 10 min sa H_2SO_4 + 20 min sa GA_3 3000 ppm. U ovom slučaju, najniži procenat klijavosti (73,33%) uočen je u pre-tretmanu sa H_2SO_4 (10 min), dok je najveća klijavost od 93.33% zabilježena u pre-tretmanu sa 10 min u H_2SO_4 + 20 min sa GA_3 3000 ppm i hladnoj vodi (1 dan).

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