Pol. J. Environ. Stud. Vol. 24, No. 2 (2015), 689-693
DOI: *10.15244/pjoes/30119*

Original Research

Effects of Water Stress on Seed Germination for Select Landscape Plants

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Received: 13 August 2014
Accepted: 2 October 2014

Abstract

In this study, the effect of water stress on the germination rate of the seeds of nine pieces of species used for landscaping works in Kastamonu is investigated. The seeds of these species have been subject to germination trials with water stress level between 0 and -8 bar and the germination percentages of the seeds have been identified. The water stress was constituted with the use of polyethylene glycol (PEG-6000) solution and germinations were carried out at 25ºC in a period of 35 days. Depending on the water stress as a result of these studies, it has been stated that the percentages of all species have decreased as from -2 bar water stress; there are no germinations in -6 bar water stress for the tree of heaven, and in -8 bar water stress for *Cupressus arizonica* and *Sophora japonica*. We found that the species most resistant to water stress are *Pinus nigra, Cupressus sempervirens,* and *Pinus brutia*.

Keywords: drought, landscape plants, water potential, germination, PEG (polyethylene glycol), water stress

Introduction

Drought increasing daily and the thirstiness as a result of this make their destructive effects felt in green fields as it is in all parts of our lives. Almost all of the green fields constituted with the approach of classical landscaping design which requires great amounts of water, especially in our metropolitan cities, can be damaged greatly in a few months in which water usage is restricted [1-4].

While the purpose was healing the environment-ambience quality in the applications of landscaping architecture and repairing the damaged environmental conditions in previous years, the wise usage of water for the worries depending on climate change and herbal applications resistant to drought have come to the fore recently [5-9]. The plants used in landscaping fields are desired to be resistant to drought and this becomes the most important criterion that affects the choice of plants in some regions [10-13]. It is of great importance for the wise usage of water that species and origins resistant to drought are identified, and these kinds of species and origins be used for landscaping.

Different methods are used for the purpose of indentifying the resistance of species against drought. One of these methods is to conduct PEG applications on the seeds in different concentrations. PEG applications have been used in many species for the purpose of identifying their resistance to drought and it has given successful results [14, 15].

This study was aimed at identifying the water stress tolerance for some plants used in landscaping works. Trials have been conducted on nine species chosen for this purpose and the water stress reactions of the species in different levels were determined.

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Table 1. Effects of water potential on germination percentage.

Species	Germination Percentage (%)				
	Control	-2 BAR	-4 BAR	-6 BAR	-8 BAR
Pinus brutia	64.4	47.2	36.3	25.7	22.1
Pinus nigra	72.8	59.1	57.06	48.38	47.32
Koelreuteria paniculata	23.5	8.3	6.5	4	3
Cupressus sempervirens	64.7	56	52.5	40.6	23.6
Pyracantha coccinea	30.7	17.5	14	4	3
Thuja orientalis	50.7	68.9	44.3	37	14.5
Sophora japonica	36	31.2	21.2	3	0
Cupressus arizonica	7.1	10.1	5	3	0
Ailanthus altissima	58.3	55.1	6	0	0

Material and Methods

Our study included nine species: *Pinus nigra, Pinus brutia, Koelreuteria paniculata, Pyracantha coccinea, Thuja orientalis, Sophora japonica, Ailanthus altissima, Cupressus sempervirens,* and *Cupressus arizonica,* all of which are frequently used in landscaping applications. The fruits and cones of these species were gathered in October in the parks and gardens in Kastamonu, and seeds were attained after cleaning the cones and fruit fleshes. The seeds, except those of *Pinus nigra* and *Pinus brutia,* were subject to stratification for eight weeks and then germination trials were conducted in -2, -4, -6, and -8 bar water stress. In addition a control group was used. The water potential of the germination substrates (0, -2, -4, -6, and -8 bars) was determined using PEG-6000 solution, prepared as described by Michel and Kaufmann [16, 17].

Germination tests were performed in 11 cm diameter glass petri dishes on two layers of filter paper saturated with water solutions. 50 pieces of seeds were placed in each petri dish in a way that the seeds will not touch each other and the study was conducted with 4-repetitions. In this way, a total of 9,000 seeds consisting of 50 pieces of seeds, four repetitions, five application, and nine species were used in the study.

The seeds were subject to germination within 35 days in 25±1.0ºC constant-temperature in a germination cabinet, and the filter papers were renewed each of three days. As a result of the study, the decreases in the proportion of germination were calculated in different water stress levels when compared to the control group. In this way we attempled to find the species least affected by the remaining water stress.

Results

As a result of the study, the percentages of germinations for the species in different water stress levels is given in Table 1 and Fig. 1.

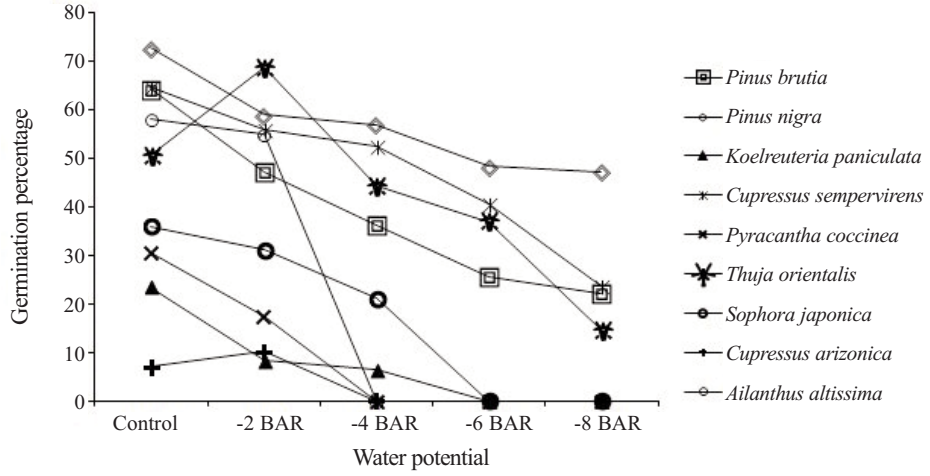

Fig. 1. Effects of water potential on germination percentage.

Table 2. Effects of water potential on cumulative germination percentage.

Species	Germination Percentage				
	Control	-2 BAR	-4 BAR	-6 BAR	-8 BAR
Pinus brutia	100	73.3	56.4	39.9	34.3
Pinus nigra	100	81.2	78.4	66.5	65
Koelreuteria paniculata	100	35.3	27,7	17	12.8
Cupressus sempervirens	100	86,6	81.1	62.8	36.5
Pyracantha coccinea	100	57	45.6	13	9.8
Thuja orientalis	100	135.9	87.4	73	28.6
Sophora japonica	100	86.7	58.9	8.3	0
Cupressus arizonica	100	142.3	70.4	42.3	0
Ailanthus altissima	100	94.5	10.3	0	0

We found that the percentage of germination changes between 7.1% (*Cupressus arizonica*) and 72.8% (*Pinus nigra*) in control group. We also found out that the percentage of germination decreased when compared to the control group in all species for which -4, -6 and -8 bar water stress were applied, and there is no germination for *Ailanthus altissima* in -6 bar water stress level and for *Sophora japonica* and *Cupressus arizonica* in -8 bar water stress level. However, these numbers are related to the natural biology of the species and the very low percentage of germination in some kinds, which probably stems from the germination impediment of the seeds. The real indicator of a species' water stress resistance is the change of occurred decrease in relation with the control group. The calculations made by accepting the proportion of germination occurring in the control group as 100% are given in Table 2, and the graphics made for understanding the values given in Table 2 more clearly are given in Fig. 2.

Table 2 and Fig. 2 show that the percentage of germination decreased when compared to the control group in all species for which -4, -6, and -8 bar water stress were applied, and there is no germination for *Ailanthus altissima* in -6 bar water stress level and for *Sophora japonica* and *Cupressus arizonica* in -8 bar water stress level. It has also been identified that the species affected by the remaining water stress least are *Pinus nigra,* which shows germination proportion with 65% of the control group, *Cupressus sempervirens,* which shows germination proportion with 36.5%, and *Pinus brutia,* which shows germination proportion with 65% of the control group. In all the other seeds, the proportion of germination was less than 30% of the control group in -8 bar water stress level and the germination proportion of *Thuja orientalis* seeds, which has the highest germination among these seeds has been calculated as 28.6% of the control group.

Discussion

All studies conducted until now have proved that the increasing water stress decreases the germination propor-

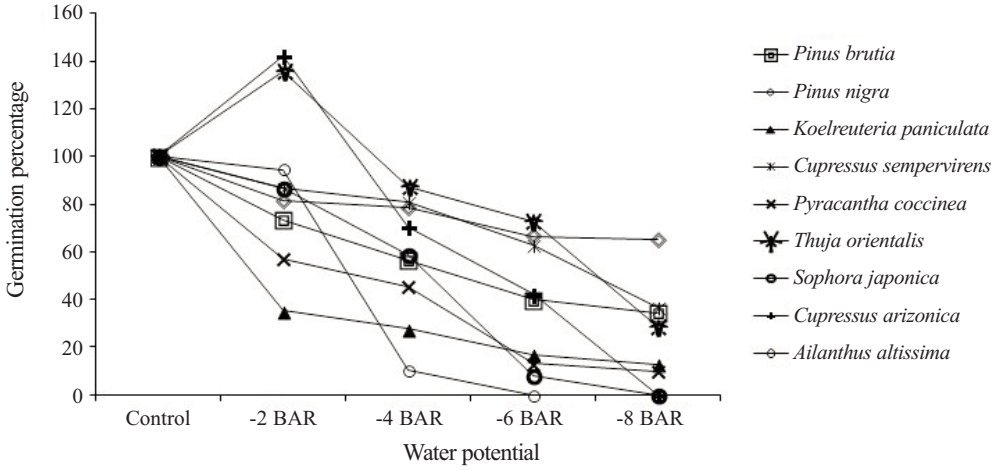

Fig. 2. Effects of water potential on cumulative germination percentage.

tion in many species, including Aleppo pine [18], *Pinus brutia* [19], Taurus cedar [20, 21], Scotch pine [22, 23], and Anatolian black pine [24, 25].

Kaufmann and Eckard [26] indicate that water stress of -8 bar can decrease the germination percentage of *Pinus contorta* and *Picea engelmanii* seeds with a proportion of 50%. However, Djavanshir and Reid [27] have found that the germination percentage decreases to 22% at -8 bar water stress for *Pinus ponderosa* and also to 36% for *Pinus elderica*. Falusi and Calamassi [28] have found that there is a decrease in the germination percentage of *Pinus brutia* seeds in -4 bar water stress and they have proven that the germination drops approximately to 5% at -8 bar stress level. In their study they conducted with *Pinus brutia* seeds of Turkey with different origins, Boydak et al. [19] found that the germination proportionally drops in a significant way after -4 bar stress level, and they also detected that the proportional germination percentage drops meanly to 30% in -8 bar. Falusi et al. [18] found that the germination percentage of Aleppo pine seeds drops approximately to 25% at -8 bar water stress level. In a similar study conducted with Taurus cedar, it was found that the germination percentage meanly decreases to 75% in a proportional way in -6 bar water stress level [29].

The studies that have been conducted show that the factor of origin is also an important factor that determines the tolerance for drought stress in addition to the species. In his study, Buyurukcu [29] states that the germination levels of the clones changes depending on the drought stress in *Pinus nigra* seed orchard, where germination in only the seeds of only five pieces out of 30 in the seed garden at -8 bar water stress level, and the highest germination percentage is 5%. However, in this study the germination percentage was found to be 46.3% in *Pinus nigra* seeds at -8 bar water stress level. This factor also indicates how important the origin factor is in addition to the factor of species. The effect of origin factor on tolerance for drought stress also has been mentioned in different studies [19, 21, 30].

Especially in landscaping designs made in arid zones, the usage of plant species resistant to drought decreases the costs of both maintenance and watering, and it increases the plants' holding and survival successes. The results of our study show that the use of species subject to studies in such fields, especially *Ailanthus altissima, Sophora japonica,* and *Cupressus arizonica,* are not appropriate. We also found that the species most resistant to drought stress among the species that have been studied are *Pinus nigra, Pinus brutia, Cupressus sempervirens,* and *Thuja orientalis*. In addition, it has also been proven in the previously conducted studies that the tolerances of different origins to drought stress are different. Conducting similar studies on different species and the different origins of the species determined to be resistant to drought in wider fields carries great importance in terms of identifying the species most resistant to drought and in this way preparing healthy landscaping planning in arid fields.

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