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Germination Characters under Water Stress in Anatolian Black Pine Populations

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Abstract : ***Germination characters included germination percentage (GP%), germination speed (GS), germination period (GP), and germination value (GV) were investigated in seeds under 0 (control), -2.0, -4.0 and -6.0 water stresses by polyethylene glycol-6000 (PEG) solutions of eight seed stand and two seed orchard populations of Anatolian black pine [Pinus nigra Arn. subsp. pallasiana. (Lamb.) Holmboe.]. Variation among the populations was also examined for the characters. Average of germination percentage was the highest (76.5%) in control seeds, while it was the lowest (40.1%) in seeds of -6 bars. The control seeds germinated earlier (10 days) than that of other levels of water stresses. Germination speed was ranged from 3.6 (-4 bars) to 33.6 (control) in polled populations. The control seeds had the highest germination value (29.7) in polled populations. Statistically significant differences (0.05>p) were found for the germination characters among populations based on results of analysis of variance. Water stresses had significant (0.05>p) and negative effective on GP% (r=-0.685) and GS (r=-0.761), while it was significant and positive on GP (r=0.808).***
Keywords: Physiology, provenance, seed, variation, polyethylene glycol-6000 (PEG)

I. INTRODUCTION

Anatolian black pine [*Pinus nigra* Arn. subsp. *pallasiana*. (Lamb.) Holmboe.] is one of the most important forest tree species of "National Tree Breeding and Seed Production Programme" [1] and Turkish forestry. However, the species covers 4.2 million ha (19% of total forest area of Turkey), of which 1.52 million ha (36%) are considered to be unproductive forests [2]. Beside, 43% (9.6 million ha) of Turkish forest area has unproductive forests [2]. Seed quality included germination characters has important role in conversion of unproductive forest to productive forest especially by sowing method. Its importance is also emphasized in many studies [i.e., 3, 4].

The quality has also important roles in economical and biological successes of plantations and to produce quality seedlings [5], and selection and establishment of seed sources.

It is known that there can be many artificial (i.e., treatment) and natural (i.e., provenance) factors can be effective in the quality. We aim to evaluate germination characters, and to estimate variation among seed source populations for the characters to contribute seed science and technology of the species in the present study.

II. MATERIAL AND METHOD

Germination data was collected from ten seed sources/population of the species (Table 1). The water stress levels of the germination substrates 0 or also called control (C), -2.0 (-2B), -4.0 (-4B) and -6.0 (-6B) bars were carried out using PEG-6000 solution evaluated by Michel and Kaufman [6].

The seeds were tested in 11 cm diameter glass petri dishes by four replicates and 50 seeds for each stress level and provenance at 25°C during 21 days. Filter papers and solutions were changed every two days in order to keep the water stress during the test period.

For each provenance and water stress level the following registrations were assessed by ISTA-rules [7]:

Germination percentage (GP%), germination speed (GS), germination period (GP), and germination value (GV) were investigated as germination characters in the study. In these characters, GV was calculated by the formula of Djavanshir & Pourbeik [8], to give more reliable estimate of subsequent survival for the *Pinus* [9].

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Table 1. Locations of the populations.

Population	Location	Latitude (N)	Longitude (E)	Altitude (m)
1*	Beysehir- kurucaova	37° 34'	31° 22'	1320
2**	Afyon-Hocalar	38° 24'	30° 03'	1200
3*	Simav- Korcuk	39° 22'	29° 03'	1400
4*	Isparta- Sutculer	37° 32'	31° 08'	1600
5*	Adana-Pos	37° 41'	35° 15'	1350
6*	Isparta-Egirdir	37° 47'	30° 56'	1200
7*	Kutahya-Aksaz	39° 06'	28° 48'	1300
8*	Afyon-Hocalar	38° 40'	30° 33'	1350
9*	Kutahya-Kicir	39° 15'	28° 41'	1200
10**	Burdur-Golhisar	37° 15'	29° 30'	1150

*; seed stands, **; seed orchards.

Populations were compared for the germination characters by the following linear ANOVA model:

$$Y_{ij} = \mu + P_j + e_{ij}$$

Where Y_{ij} is the observation from the j^{th} germination character of the i^{th} population, μ is overall mean, P_i is the random effect of the i^{th} population, and e_{ij} is random error.

Provenances were grouped by Duncan's multiple range test [10]. Correlations among the characters were calculated by Pearson's correlation using SPSS statistical package program.

II. RESULTS AND DISCUSSION

Control seeds showed the highest germination performance for the characters, while it was the lowest in seeds of -6.0 bars (Table 2, Figure 1). For instance, average of germination percentage was the highest (76.5%) in control seeds, while it was the lowest (40.1%) in seeds of -6 bars (Table 2). Results of Pearson's correlation showed that water stress had significant and negative effective on GP% (*0.05>p, r=-0.685*) and GS (*0.05>p, r=-0.761*), while it was positive on GP (*0.05>p, r=0.808*). It was reported that GP% was decreased with the increasing water stress and it, being around 77.75% in control group, decreased to 62.3% at a -6.0 bars water stress in Black pine [9].

Table 2. Averages of the germination characters for the population and water stresses.

Populations	GP%				GS				GP				GV			
	C	-2B	-4B	-6B	C	-2B	-4B	-6B	C	-2B	-4B	-6B	C	-2B	-4B	-6B
1	75.0	60.0	44.5	19.5	28.5	14.5	4.5	2.0	11.8	12.8	15.0	15.0	24.3	12.0	5.3	1.0
2	83.0	72.5	63.5	30.5	39.3	21.5	6.0	1.0	11.0	12.3	14.5	15.5	30.5	20.0	13.3	3.0
3	75.5	69.0	62.0	39.5	34.5	27.5	11.0	4.0	10.8	11.3	13.8	14.8	27.0	19.5	12.5	4.8
4	72.7	83.5	65.0	35.5	36.0	33.0	5.5	2.0	10.8	12.0	14.5	15.5	29.8	28.3	11.8	4.3
5	89.0	93.5	86.5	72.5	50.0	39.0	10.0	4.0	9.5	11.3	13.5	15.0	40.8	38.0	24.8	16.8
6	68.5	58.5	45.0	29.5	25.0	12.0	7.5	1.5	11.3	13.5	14.0	16.0	21.3	11.8	6.5	2.3
7	60.5	58.0	46.0	33.5	19.5	9.5	6.0	4.0	12.0	14.3	14.5	14.8	14.5	10.5	6.8	3.3
8	89.0	86.5	74.0	55.0	55.0	39.0	25.0	11.0	9.0	10.8	12.0	13.5	46.5	33.5	22.0	10.8
9	79.0	75.5	49.0	46.0	34.0	21.0	9.5	4.0	10.3	12.5	13.5	15.0	36.8	21.8	8.0	5.8
10	71.5	52.5	48.0	39.0	14.7	11.0	8.5	2.0	12.8	13.8	13.8	15.5	25.5	8.3	7.5	4.3
Total	76.5	71.0	58.4	40.1	33.6	22.8	9.3	3.6	10.9	12.4	13.9	15.1	29.7	20.4	11.8	5.6

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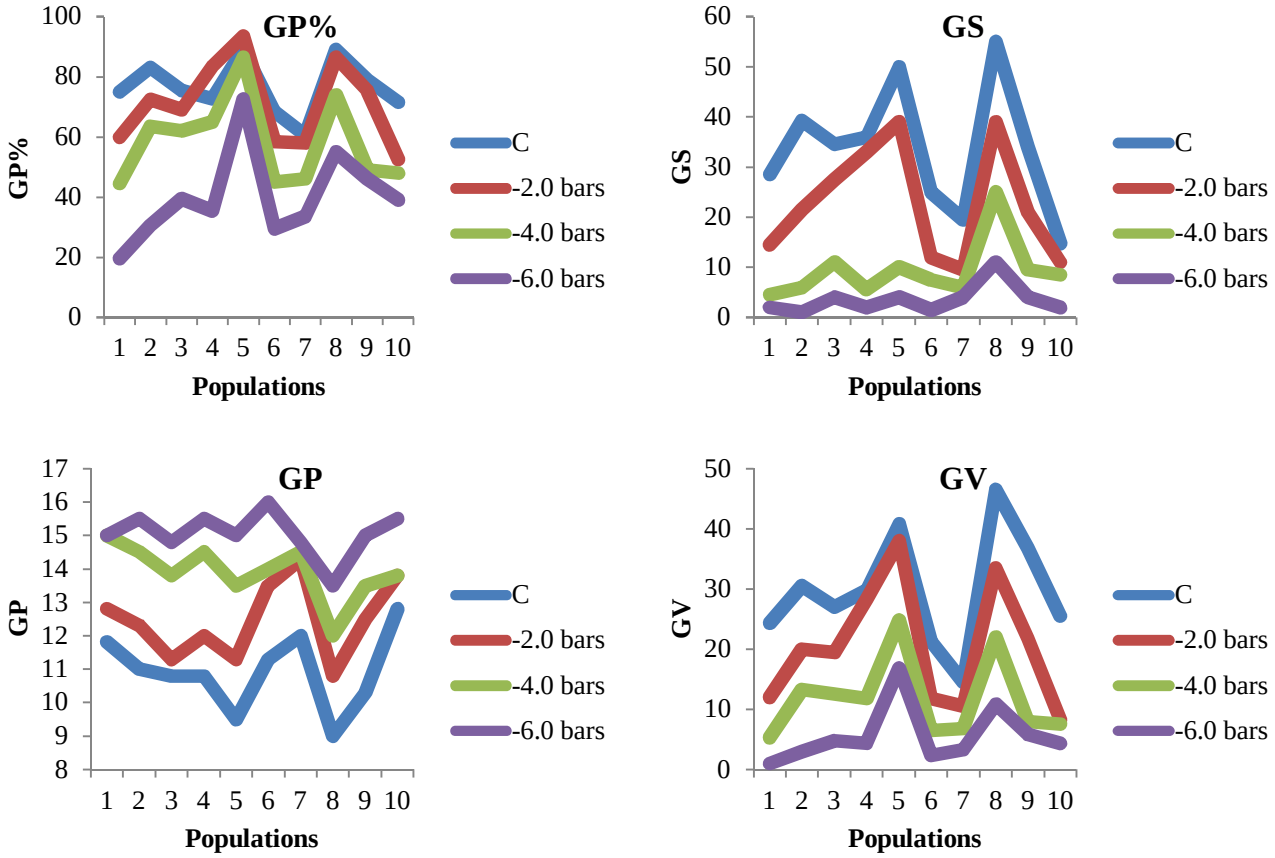


Figure 1. Averages of the germination characters for the population and water stresses.

Large differences were found among populations within the same water stress for the characters. For instance, GP% was ranged from 52.5% (population 10) to 93.5% (population 5) at a -2.0 bars (Table 2, Figure 1). Similar results were reported in different forest tree species [6, 9, 11-14]. Statistically significant ($0.05>p$) differences were also found among populations for the characters according to results of analysis of variance. After determination of significant ($0.05>p$) differences, populations were grouped by Duncan's multiple range test for each character (Table 3). Populations showed larger variation for GP% and GV than GS and GP according to Duncan's multiple range test (Table 3).

Table 3. Results of Duncan's multiple range test for each character.

Populations*	GP%	GS	GP	GV
1	a	b	cde	bc
2	d	c	cd	d
3	cd	c	b	d
4	d	c	c	d
5	f	d	b	f
6	ab	b	cd	bc
7	a	ab	de	ab
8	e	d	a	e
9	bc	ab	cde	c
10	a	a	e	a

*; the same letters are not significantly different ($p<0.05$).

Large differences were reported among provenances for germination characters at 0, -2.0, -4.0, -6.0, and -8.0 bars in Anatolian black

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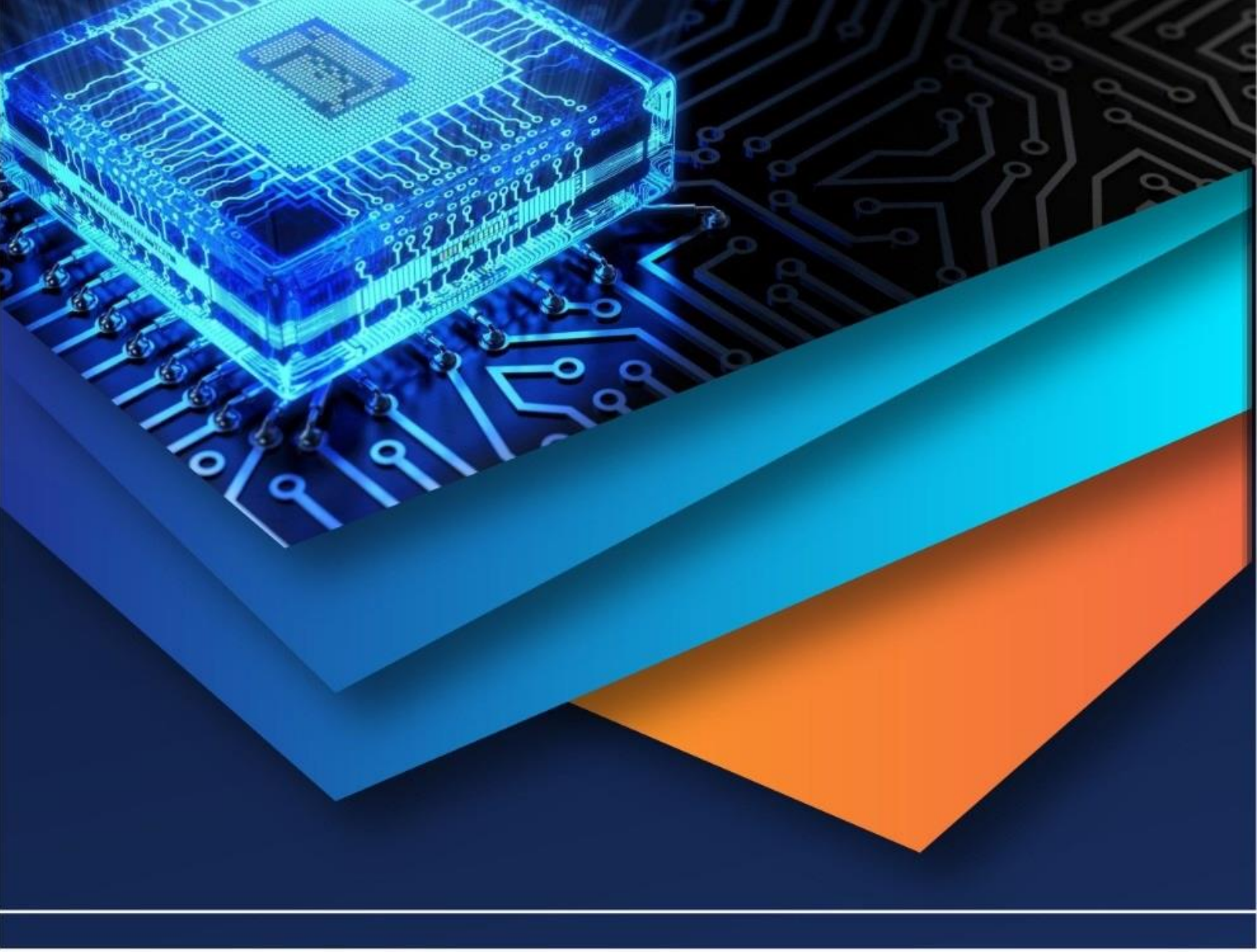
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pine [9]. They [9] found that GP% changed between 93.42 and 23.76 in provenances of the species. Variation among were also reported in provenances of *Cedrus libani* [15]. The results showed importance of seed sources in nursery practice and seed science for forest establishment especially by sowing. However, results of the present study emphasized that there were many environmental (e.g., water stress) and biological (e.g., provenance) effects in estimation of seed quality such as quality seedling produced from the seeds [i.e., 4, 16], nursery practice [16, 17]. It could be concluded that present results of the study should be combined by field performances of the water stresses levels.

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