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Seed germination of three *Ulmus* species from Turkey as influenced by temperature and light

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Abstract: *The effect of temperature and light on the germination performance of Ulmus minor, Ulmus glabra and Ulmus laevis were studied in this research. Seeds were germinated under constant temperatures of 20 and 25 °C and alternating temperatures of 25/15 and 30/20 °C. Within each temperature regime, seeds were subjected daily to the following photoperiods: total darkness and 8 hr photoperiod. Temperature and light affected seed germination percentage (GP) and germination rate expressed as peak value (PV) in Ulmus minor and 25 and 30/20 °C under light gave the highest GP (>95%) and PV (>23). The temperatures of 25/15 and 30/20 °C gave the highest GP (>89%) in Ulmus glabra and light did not significantly affect GP. But the highest PV in Ulmus glabra was found at these temperatures under light. Germination percentage of Ulmus laevis was not affected by temperature and light, but the alternating temperature of 30/20 °C produced the highest germination rate under darkness.*

Key words*: Elm, Seed, Germination performance, Photoperiod*

Introduction

There are three native elm species (*Ulmus minor* Mill., *Ulmus glabra* Huds. and *Ulmus laevis* Pall.) in Turkey (Davis, 1982; Ansin and Ozkan, 1993; Yaltirik, 1998). Though elms are widespread in Turkey and Europe, yet they have been neglected and scarcely studied and so relatively little is known on population dynamics, seed biology and seedling production of these species. Elms are valuable for their hard, tough wood and ornamental value, and they have been planted for environmental purposes though habitat destruction and the bark beetles have caused enormous damage to elm populations in Turkey and in Europe (Ansin and Ozkan, 1993; Collin, 2002, 2003).

Although seeds of most elm species require no presowing treatment but seeds of some species (*U. rubra, U. americana and U. crassifolia*) may show dormancy. Stratification at 4°C for 1-2 months before spring sowing improves germination of these species. Under natural conditions, elm seeds that ripen in the spring usually germinate in the same growing season; seeds ripening in the fall germinate in the following spring (Brinkman, 1974). Among several environmental factors, temperature is one of the most important factors governing the maximum germination performance (Heydecker, 1977; Tilki and Cicek, 2005) and temperature and light requirements vary among species in elms (Brinkman, 1974; ISTA, 1985; Phartyal *et al.*, 2003). Germination performance usually remains constant over a wide range of temperatures (20°C) and declines sharply on either side of this range (Thompson, 1970). The rate of germination usually increases linearly with temperature, at least within a well defined range (Hegarty, 1977).

Little is known about temperature and light requirements for germination of some *Ulmus* sp. Thus, the aim of the present study was to determine the effects of temperature and light on the germination percentage (GP) and germination rate (PV) of the species of *U. minor*, *U. glabra* and *U. laevis.*

Materials and Methods

Mature samaras of *Ulmus minor* (40°51'N, 30°23'E, 30 m), *Ulmus laevis* (40°52'N, 30°36'E, 30 m) and *Ulmus glabra* (40°46'N, 31°25'E, 800 m) were collected from western Black Sea Region of Turkey in May 2004. Samaras were de-winged manually, cleaned and upgraded by separating empty seeds from the filled ones (Phartyal *et al*., 2002). Germination tests were carried out under constant temperatures of 20 and 25°C and alternating temperatures of 25/15 and 30/20°C. Within each temperature regime, seeds were subjected to the following photoperiods: total darkness and 8 hr photoperiod with 1000 lux. A total of 400 seeds, 4 replicates of 100 seeds, each were used in all treatments for *U. laevis* and *U. glabra* seed germination and 4 replicates of 50 seeds were used for *U. minor* seed germination.

The seeds were put in petridishes of 20 cm diameter on a moist filter paper and then placed in the germination chambers. Seeds were monitored every day and moistened periodically. The appearance of a 5 mm radicle long was the criterion for germination. Germinated seeds were counted every day until the 14th day (ISTA, 1985).

For all experiments germination percentages (GP) at the 14 day were calculated as the average of the four replicates for each species separately. Germination rate was also measured and expressed as peak value (PV), an index of germination speed which is calculated as the quotient of the highest value of the cumulative germination percentage, divided by the number of days from the beginning of the test (Czabator, 1962).

Data were analyzed by analyses of variance (ANOVA), germination percentages were arcsine transformed before analysis. The means were separated according to Duncan's multiple range test at the $p<0.05$ level of probability.

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Table - 1: Analyses of variance for the effect of temperature and light on germination percentage (GP) and on peak value (PV) of three *Ulmus* species

Species	Germination parameters	Source	Sum of squares	df	Mean square	F
U. minor	GP	Temperature	331.264	3	110.421	17.626***
		Light	54.080	1	54.080	8.632**
		Temperature x Light	14.313	3	4.771	0.762N.S.
		Error	150.356	24	6.265	
		Total	550.013	31		
	PV	Temperature	513.211	3	171.070	24.935***
		Light	63.563	1	63.563	9.265**
		Temperature x Light	87.918	3	29.306	4.272*
		Error	164.653	24	6.861	
		Total	829.345	31		
U. glabra	GP	Temperature	327.500	3	109.167	15.024***
		Light	19.360	1	19.360	2.664N.S.
		Temperature x Light	12.032	3	4.011	0.552N.S.
		Error	174.384	24	7.266	
		Total	533.275	31		
	PV	Temperature	24.226	3	8.075	31.629***
		Light	6.390	1	6.390	25.029***
		Temperature x Light	0.438	3	0.146	0.572N.S.
		Error	6.128	24	0.255	
		Total	37.182	31		
U. laevis	GP	Temperature	95.289	3	31.763	1.987N.S.
		Light	3.050	1	3.050	0.191N.S.
		Temperature x Light	39.972	3	13.324	0.833N.S.
		Error	383.747	24	15.989	
		Total	522.059	31		
	PV	Temperature	131.883	3	43.961	150.134***
		Light	1.853	1	1.853	6.328*
		Temperature x Light	22.536	3	7.512	25.655***
		Error	7.028	24	0.293	
		Total	163.300	31		

N.S.: Non significant, * p<0.05, ** p<0.01, *** p<0.001

Table - 2: Germination percentages (GP) and peak values (PV) under the four temperature regimes for three *Ulmus* species (averaged for two light regimes)

Species	Temperature	GP	PV
U. minor	20	87.3[a]	14.4[a]
	25	93.7[b]	25.2[c]
	25/15	94.4[b]	20.4[b]
	30/20	95.1[b]	22.7[bc]
U. glabra	20	82.7[a]	7.0[a]
	25	84.1[a]	7.7[b]
	25/15	89.8[b]	8.6[c]
	30/20	91.4[b]	9.2[cd]
U. laevis	20	93.7[a]	9.1[a]
	25	95.2[a]	11.3[b]
	25/15	96.2[a]	9.6[a]
	30/20	97.4[a]	14.3[c]

Means within each species followed by the same letters are not significantly different at p<0.05

Results and Discussion

Germination percentage and germination rate were significantly affected by temperature in *U. minor* (Table 1). Temperature of 20°C produced the lowest germination percentage and germination rate in *U. minor* when averaged for two light regimes, and there were no significant differences among the other temperature regimes in terms of germination percentage (Table 2). Temperature of 25 and 30/20°C produced the highest germination rate (PV>22) in this species. Germination percentage and germination rate were significantly affected by light when averaged over four temperatures. The highest germination percentage and germination rate were found at a constant temperature of 25°C and an alternating temperature of 30/20°C under light (Table 3).

Germination percentage was significantly influenced by temperature in *U. glabra* and was the highest at 25/15 and 30/20°C when averaged for two light regimes (GP>89%) (Table 1 and 2). When averaged over four temperatures, germination percentage was not affected by light. Germination rate was

Table - 3: Germination percentages (GP) and peak values (PV) under the combination of four temperature and two light regimes for three *Ulmus* species

Species	Temperature	Light	GP	PV
U. minor	20	Dark	86.2 a	10.2 a
	25	Dark	91.6 bc	25.2 d
	25/15	Dark	93.6 bc	20.0 bc
	30/20	Dark	94.7 c	21.6 bcd
	20	8 hr light	88.4 ab	18.6 b
	25	8 hr light	95.7 c	25.3 d
	25/15	8 hr light	95.2 c	20.7 bc
	30/20	8 hr light	95.5 c	23.8 cd
U. glabra	20	Dark	82.0 a	6.5 a
	25	Dark	81.1 a	7.2 ab
	25/15	Dark	89.6 bc	8.0 bcd
	30/20	Dark	91.2 c	9.0 cde
	20	8 hr light	86.1 ab	7.4 ab
	25	8 hr light	84.2 a	8.2 bcd
	25/15	8 hr light	90.0 bc	9.2 de
	30/20	8 hr light	91.5 c	9.5 e
U. leavis	20	Dark	93.7 a	8.0 a
	25	Dark	95.0 a	10.4 c
	25/15	Dark	95.5 a	9.8 bc
	30/20	Dark	98.5 a	15.2 f
	20	8 hr light	93.7 a	10.2 bc
	25	8 hr light	95.3 a	12.3 d
	25/15	8 hr light	97.0 a	9.4 b
	30/20	8 hr light	96.4 a	13.5 e

Means within each species followed by the same letters are not significantly different at $p<0.05$

significantly affected by temperature, and light also increased germination rate significantly when averaged over four temperatures (Tables 1 and 3). When seeds were germinated at 25/15 or 30/20°C, germination was not significantly affected by light (Table 3). The highest germination percentage and germination rate were found at 25/15 and 30/20°C under light or dark. Temperature and light did not significantly affect germination percentage in *U. laevis* although germination percentage was the highest at 30/20°C under darkness and the lowest at 20°C (Table 1 and 2). But germination rate was significantly affected by temperature and light and their (temperature x light) interactions (Table 1). Germination rate was the highest at 30/20°C under darkness (PV=15.2) (Table 3).

According to Brinkman (1974) and ISTA (1985) 20 or 30/20°C under 12 hr photoperiod is optimal for germination of some elm species (*Ulmus americana, Ulmus parviflora, Ulmus pumila, Ulmus rubra and U. laevis*). Phartyal *et al.* (2003) found that 24-26°C was the optimal temperature for seed germination of *Ulmus wallichiana* depending on the seed lots. The influence of temperature on seed germination rate seemed to differ slightly for all the three seed lots. *Ulmus americana* seed germination was also affected by temperature and light, and light significantly increased germination rate (McDermott, 1973). According to Bey (1994) germination is best with night temperatures at 20°C and day temperatures of 30°C in *U. americana*. The seeds can germinate in darkness, but germination increases in light.

In conclusion this study demonstrated that temperature and light affected seed germination performance of *Ulmus* species. Temperature of 25°C and 30/20°C produced the highest germination percentage and germination rate for *U. minor* and 25/15°C and 30/20°C for *U. glabra* seed germination. Germination rates were always higher under light in these two species. Temperature did not significantly affect germination percentage of *U. laevis,* but the alternating temperatures of 30/20°C produced the highest germination rate under darkness followed by 30/20°C under light.

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