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The influence of temperature and light on seed germination of mugwort (*Artemisia vulgaris* L.)

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Summary

It has been discovered that mugwort can occasionally produce viable seeds also in Turkey. Therefore, the objective of this study was to determine the effects of temperature and light on germination of mugwort seeds collected from five different locations of Turkey. Experiments were conducted under nine constant temperatures, and three light conditions.

Germination of mugwort seeds was influenced from temperature, but almost independent from light conditions. The highest germination percentages were achieved at temperatures ranging from 15 to 30 °C. In general, lower and higher temperatures resulted in reduction of germination percentages, and germination was totally inhibited at 45 °C. Time (day) required for final germination percentage decreased progressively with increasing temperature. It was estimated that optimum germination temperature was approximately 29 °C for three Black Sea Region lots, 30 °C for Aegean lot, and 33 °C for Mediterranean lot. The optimum temperature for means of all seed lots (Turkey) was 29 °C. The results of this study are important to understand germination requirements of mugwort, allowing development and improvement of management strategies specific to mugwort.

Keywords: Temperature, light, seed germination, mugwort, *Artemisia vulgaris*

Zusammenfassung

*Die Wirkung von Temperatur und Licht auf die Samenkeimung des Beifuß (*Artemisia vulgaris *L.)*

Es wurde festgestellt, dass der Beifuss in der Türkei zur Samenreife gelangt. Das Ziel dieser Arbeit ist es, die Samenkeimung dieser Pflanze an fünf verschiedenen Orten der Türkei unter dem Einfluss von Licht und Temperatur zu untersuchen. Die Versuche wurden unter neun festgelegten Temperaturbedingungen und drei Lichtkonditionen durchgeführt.

Die Samenkeimung von Beifuss wurde von der Temperatur beeinflusst, jedoch nicht vom Licht. Die höchste Samenkeimung wurde bei 15 bis 30 °C festgestellt. Temperaturen unter oder über diesen Werten haben die Samenkeimung vermindert. Bei 45 °C wurde die Samenkeimung verhindert. Die Keimzeit war bei höheren Temperaturen geringer. Für die drei aus dem Schwarzmeergebiet gesammelten Samenproben war die optimale Temperatur für die Keimung 29 °C, für die Proben aus der Ägäis 30 °C, und für die Population aus dem Mittelmeergebiet 33 °C. Für alle Samenproben der Türkei wurde eine optimale Keimtemperatur von 29 °C berechnet. Die Ergebnisse dieser Arbeit sind wichtig, um zu verstehen, unter welchen Umweltbedingungen der Beifuss keimt. Diese Information kann für die Entwicklung und Verbesserung von Bekämpfungsstrategien verwendet werden.

Stichwörter: Temperatur, Licht, Samenkeimung, Beifuss, *Artemisia vulgaris*

Introduction

Mugwort (*Artemisia vulgaris* L.) is a perennial weed that is found in almost all farming systems in all over the world. It was reported that mugwort has been associated with 25 crops in 56 countries (Holm *et al.* 1996). The extensive rhizome system of mugwort provides competition for water and nutrients with crops (HOLM *et al.* 1996). Furthermore, mugwort is an aromatic plant and contains numerous phytotoxic components (NANO *et al.* 1976, HOFFMANN and HERRMANN 1982). Thus, it was considered highly phytotoxic on seed germination and growth of a number of crops and weeds (MELKANIA *et al.* 1982, ÖNEN *et al.* 2002, ÖNEN and ÖZER 2002). Moreover, it is an alternative host for several crop diseases and pests, and pollens of mugwort are allergenic for human (KALYONCU *et al.* 1995). However, mugwort has been used for a long time in herbal medicine (MISRA and SINGH 1986, HOLM *et al.* 1996) and has also a potential source of pesticide (MISRA and SINGH 1986, DUKE *et al.*, 1988, ÖNEN and ÖZER 2002).

Temperature and light have a major role on controlling seed germination with water availability, oxygen and hormonal factors (PIMPINI *et al.* 1993). Therefore as other plants, weed seeds also require suitable temperature and light conditions before germination. With increasing temperature from minimum to optimum level the germination of weed seeds also increases. The effect of light on germination is variable, however the majority of weed seeds germinate equally well in light or dark conditions (GWYNNE and MURRAY 1985).

Weeds progress through a series of stages in their life cycles and management tactics generally apply to a particular stage (MOHLER 2001). Therefore, information on weed seed germination has great monetary value. Since, the knowledge of what controls the timing of seed germination enhances effective control of weeds (BASKIN and BASKIN 1998). Mugwort was thought to be regenerated only vegetatively due to the lack of viable seed production especially in Black Sea Region of Turkey (GÜNCAN 1982). However, rapid long-distance dispersal of wandering perennial weeds occurs via seeds (MOHLER 2001). It brought in the idea of seed production of mugwort. Further studies (ÖNEN 1999) indicated that mugwort could also occasionally produce viable seeds in Turkey. However, there was a need for detailed studies on seed germination requirements of different mugwort populations in order to improve and develop specific weed management strategies for mugwort in Turkey. Therefore, this research was conducted to investigate the effect of temperature and light on germination of mugwort seeds collected from 5 different geographic regions of Turkey.

Materials and methods

The mugwort seeds were collected from very diverse geographic regions in Turkey, and each location has different climatic conditions in 2001. Three of the locations were located at Black Sea region (Rize, Giresun and Tokat provinces), one at Mediterranean region (Antalya), and one at Aegean region (Denizli) (Fig 1).The seeds were air-dried and stored in glass containers at room temperature. The experiments were conducted in 60 mm diameter petri dishes containing two layers of Whatman No.1 filter paper. Each petri dish contained 50 seeds (seeds were 2 years old). The filter papers were kept moist by adding distilled water as required. Petri dishes for each seed lot were completely randomized within each growth chamber (NK System, Biomulti incubator LH 30 8CT) with three replications. Seed germination was recorded at 24 h interval for 21 days. The seeds produced at least 1-mm radicle was considered germinated. Germinated seeds were counted and removed.

Effects of temperatures

In order to evaluate the effect of temperature and estimation of optimum temperatures for seed germination, petri dishes of each seed lot were kept at nine different (5, 10, 15, 20, 25, 30, 35, 40 and 45 °C) constant temperatures in dark. All five seed lots were used in the experiment.

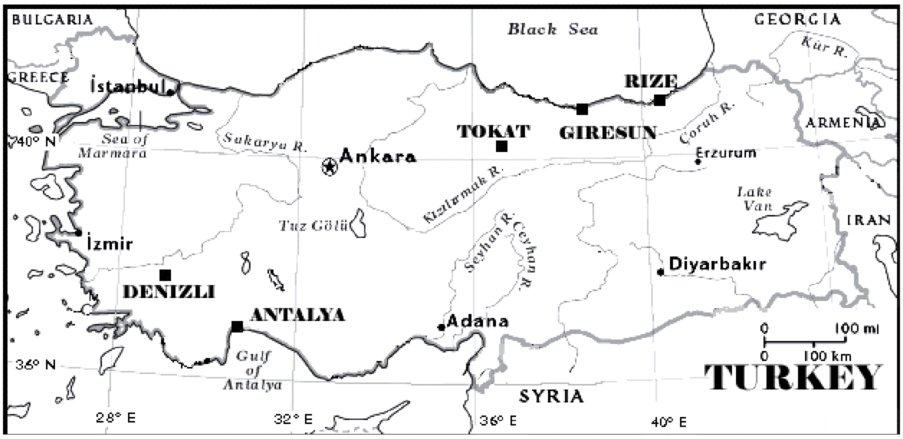

Fig. 1: Sampling locations of mugwort seeds in Turkey.
Abb. 1: Orte in der Türkei, von denen Beifußsamenbeispiele gesammelt wurden.

Effects of light conditions
Antalya and Tokat seed lots were only used in this experiment. Seeds were placed in the growth chamber under three light conditions (constantly dark and 12 hours/day or 24 hours/day light) at three different constant temperatures (20, 25, and 30 °C). Each growth chambers were illuminated by one 8 W fluorescent lamp (Nec FL8W-F).

At the end of experiments, final germination percentages (FGP) and seed germination rates were calculated. The rate of seed germination was estimated using the index of germination velocity (IGV) (LABOURIAU 1970 cit. by ANDRADE *et al.* 2003): $IVG = \Sigma n_i / \Sigma n_i \, . \, t_i$, where n_i is the number of seeds germinated between t_i -1 and t_i where t_i is the number of days between the beginning of the experiment and the $_i$th observation. The final germination percentage values were previously arcsin transformed (GOMEZ and GOMEZ 1984) and analyzed by ANOVA. When significant ($P<0.05$) F ratios occurred, least significant differences (LSD) test was used to separate the means of treatments.

Results

Effect of temperature
Final germination percentage and germination rate of all seed lots were affected by temperature. The highest germination percentages were achieved at temperatures ranging from 15 to 30 °C, and both lower and higher temperatures caused reduction in germination percentages. Although there were differences between seed lots, the highest germination percentage was observed at 25 °C temperature for mean of all seed lots. However, germination percentages were statistically same from 10 °C to 30 °C temperatures (Tab. 1). The temperature of 45 °C was lethal for all seed lots. At 5 °C, germination of seeds occurred only in two coastal Black Sea seed lots (Rize and Giresun). The final germination percentages in Rize and Giresun seed lots were statistically in the same group in a wide temperatures range. This situation was conflicting to the rest of the populations studied. Final germination percentage of Antalya lot was lower than that of the others (Tab. 1).

Germination rate of seeds accelerated up to 30 °C, and then slightly decreased with increasing temperature for all seed samples. However, it accelerated up to 35 °C temperature for Mediterranean population (Antalya). Temperatures lower than 25 °C and higher than 35 °C retarded the germination by increasing the time lag to onset of germination or reducing germination rate (Fig. 2).

The estimation of optimum temperatures for seed germination was possible using the linear regression relationship between constant temperatures and germination rate; those correspond to the intersection of two regression lines (ANDRADE *et al.* 2003). Two linear regression lines were constructed depending on the temperature that peak occurred for germination rate. Germination rates (IVG) up to each peak occurrence was used to construct the upward trend line and the downward trend line was formed using peak germination rates and IVGs obtained above each peak temperature. Peak for germination rate was happened at 35 °C for Antalya lot, and at 30 °C for the rest of the seed samples investigated. The optimum germination temperature was estimated around 29 °C for Black Sea lots (costal regions Rize and Giresun and inner region Tokat), 30 °C for Aegean lot (Denizli), and 33 °C for Mediterranean lot (Antalya). Optimum temperature of mean for all seed lots (Turkey) was estimated 29 °C (Fig. 2).

Tab. 1: Effect of temperature on the seed germination (%) of mugwort.
Tab. 1: Einfluss der Temperatur auf die Keimung der Samen (%) von Beifuss.

	Temperature (°C)									
Seed lot	5	10	15	20	25	30	35	40	45	Mean
Antalya	0.0 cE	47.3 cD	55.3 cC	54.7 dC	70.0 cA	63.3 bB	54.7 bC	43.6 bD	0.0 aE	43.2b
Denizli	0.0 cG	82.0 bD	92.0 abB	95.3 bA	95.3 aA	88.0 aC	70.0 aE	51.3 bF	0.0 aG	63.8ab
Tokat	0.0 cE[1]	94.0 aB	94.7 aAB	98.7 aA	94.0 aB	84.7 aC	78.7 abC	53.3 bD	0.0 aE	66.4a
Rize	38.7aD	92.7 aAB	93.3 aAB	91.3 bAB	96.0 aA	88.0 aB	76.0 aC	28.7 cD	0.0 aE	67.2a
Giresun	7.3 bD	76.0 bAB	83.3 bA	78.7 cAB	80.0 bAB	82.0 aAB	74.0 aB	64.0 aC	0.0 aE	60.6ab
Mean	9.2 D[2]	78.4 AB	83.7 A	83.7 A	87.1 A	81.2 AB	70.7 B	48.1 C	0.0 E	

[1]Means in the same column followed by different lower case letters (to compare sites for the same temperature) and within same row followed by different upper case letters (to compare temperatures for same seed lot) are significant different (P<0.05). [2]Means of temperatures within same row followed by different upper case letters are significant different (P<0.05).

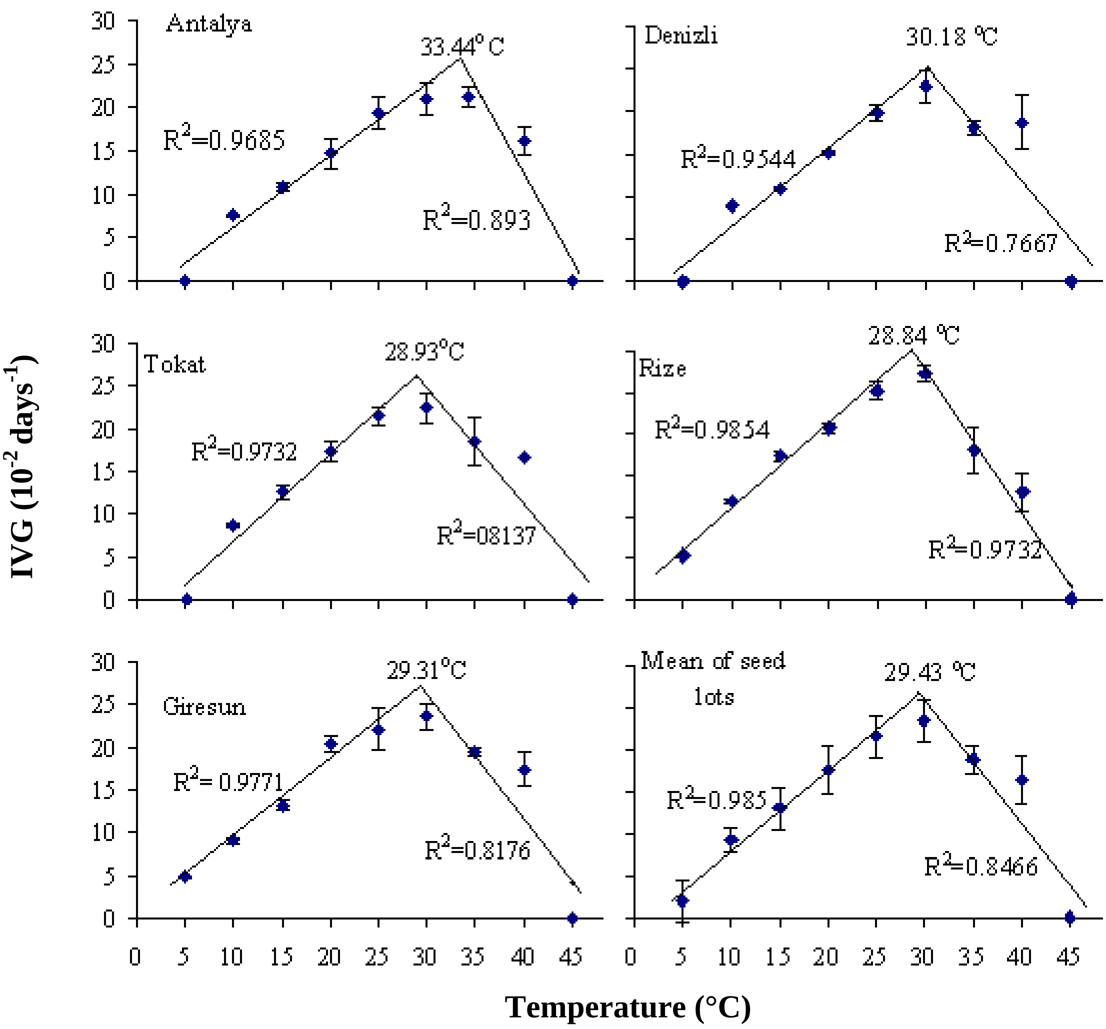

Fig. 2: Germination rates depending on different temperatures for mugwort seed samples and optimum germination temperatures of the samples.
Abb. 2: Keimungsrate unter verschiedenen Temperaturbedingungen der verschiedenen Beifusssamen-herkünften und optimale Temperatur für die Keimung.

Effect of light conditions

Final seed germination percentage of both populations (Antalya and Tokat) was not significantly different from the light conditions at each of the temperatures tested. However, means of temperatures in the same seed lot and general means of seed lots were significantly different (P<0.05) (Tab. 2). Germination rate of seeds was not also affected by light conditions. But, as observed in temperature experiment, with increasing temperature germination rate of seeds accelerated (results were not given).

Tab. 2: Germination percent of mugwort seeds under different lights and temperatures conditions.
Tab. 2: Prozentsatz der Samenkeimung von Beifuss bei verschienen Licht- und Temperaturbedingungen.

		Temperature (°C)			
Seed lot	Light (h/day)	20	25	30	Mean
Antalya	0	54.7ns	69.3ns	63.3ns	62.4 ns
	12	57.3	62.0	54.0	57.8
	24	58.0	58.0	52.0	56.0
	Mean[2]	56.7b	63.1a	56.4b	58.7B[1]
Tokat	0	98.7	94.0	84.7	92.4
	12	98.7	96.7	92.0	95.8
	24	98.0	96.0	76.7	90.2
	Mean	98.4a	95.6a	84.4b	92.8 A

[1] Genaral means of two seed lots are significant different (P<0.05). [2] Means of temperatures in the same column followed by different lower case letters are significant different (P<0.05). ns Light conditions were not significantly different in the same column (P<0.05).

Discussion

The final germination percentage and germination rate of all seed lots were influenced by temperature. Time (day) required for final germination percentage decreased progressively with increasing temperature. The optimum temperature changed among seed lots. Optimum temperature of mean of all seed lots (Turkey) was estimated 29 °C, but it was reported as 25 °C for Germany (LAUER 1953). The differences were possibly because of environmental differences of growing conditions of the seed samples and/or genetic differences of seeds. But it was not possible to distinguish the variations in temperature responses occurred due to whether the differences in genotype or environment (ELLIS *et al.* 1986). This was also in agreement with previous studies on a number of weeds (ÖZER 1996). On the other hand, species from a wide range of plant families, life cycle types, and plant communities exhibited the differences in germination characteristics of seeds collected from different locations (BASKIN and BASKIN 1998).

The germination percentage was almost independent from light conditions. In general, the germination values obtained from light conditions were similar at the same incubation temperatures. Therefore, it was supposed that presence or absence of light has no effect on both germination percentage and germination speed of mugwort seeds. However, the fresh achenes germinated in room temperature under daily light were 14 percent higher than that of under the dark condition (ÖNEN 1999). But, a brief exposure to low intense light was found sufficient to stimulate germination of achenes, and as seeds aged, they became less dependent on light and eventually could germinate also in darkness (CRESCINI and SPREAFICO 1953 and CRESCINI *et al.* 1956 cit. by HOLM *et al.* 1996). Similarly, the light sensitivity was lost with storage in *Dioscorea composita* seeds (VIANA and FELIPPE 1986). Thus, since seeds used in experiment were aged, it was possible for seeds to become independent to light as time progressed. It is also known that nondormant seeds of many species germinated equally well in light and dark (BASKIN and BASKIN 1988).

No differences were observed among germination rates of mugwort seed lots at different temperatures. However, the final germination percentage of Antalya population was lower than that of the others. Seeds of Antalya might lose its germination ability more than other seed lots. This may be a result of differences in germination capacity of seed lots, since variations were also observed previously in germination capacity of fresh seeds (ÖNEN 1999).

In conclusion, the mugwort seeds collected from different regions were found very sensitive to temperature, but not sensitive to light. Weeds in general, require certain environmental conditions for seed production and seedling establishment subsequent to germination. In particular, differences between weeds and crops in germination characteristics such as seed size, growth rate, and susceptibility of different life stages to stress provide weed management options (MOHLER 2001) to weed scientists. However, perennial species do not only depend on sexual reproduction but also survive and spread through clonal growth. But, seeds are the main agents of long-distance spreading of perennial weeds such as mugwort. Therefore, further studies to determine the conditions affecting seed production and germination of mugworth will be useful for management and contribution of valuable information to understand the biology of perennial weeds.

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