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PHYSIOLOGICAL EFFECTS OF DIFFERENT ENVIRONMENTAL CONDITIONS ON THE SEED GERMINATION OF *RUMEX SCUTATUS* L. (*POLYGONACEAE*)

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ABSTRACT

Effects of temperature, time after harvest, light, pH and depth of soil on germination of *Rumex scutatus* L. (*Polygonaceae*) were investigated. The optimal for germination percent temperature for seeds was found to be at 25 ^{0}C. Furthermore, the germination percentage increased with light. Seeds showed the greatest response germination in the alternating light / dark regimes. The optimal seed germination percent was observed at soil surface and 2 cm soil depth (100 % and 97 %, respectively). Deeper than 2 cm, the germination percent of *R. scutatus* was reduced due to lower penetration of light and the influence of several other factors. The optimal pH for seed germination of *R. scutatus* was 6 (98 %) so in lower than pH 6 (especially, in pH 4) seed germination was inhibited. A negative relationship between germination rate and seed age was obtained. Maximal germination percent (99 %) of seeds occurred for seeds that were new harvested.

Keywords: Germination, Ecophysiology, Seed longevity, Rumex scutatus, Temperature, Ph.

RUMEX SCUTATUS L. (*POLYGONACEAE*) TOHUMLARININ ÇİMLENMESİ ÜZERİNE FARKLI ÇEVRESEL ŞARTLARIN FİZYOLOJİK ETKİLERİ

ÖZET

Rumex scutatus L. (*Polygonaceae*) tohumlarının çimlenmesi üzerine sıcaklık, tohum yaşı, ışık, pH ve toprak derinliğinin etkisi araştırılmıştır. Tohumlar için optimum çimlenme sıcaklığının 25 C^{0} olduğu bulunmuştur. Bunun yanı sıra , çimlenme yüzdesinin ışıkla birlikte arttığı belirlenmiştir. Tohumlar değişen ışık / karanlık uygulamasına karşı oldukça iyi bir cevap oluşturmuştur. Optimum tohum çimlenme yüzdesinin toprak yüzeyinde ve toprağın 2 cm derinliğinde olduğu gözlenmiştir (sırasıyla, % 100 ve % 97). 2 cm'den daha derinde düşük ışık şiddeti ve diğer çevresel faktörlerin etkisi ile *R.scutatus* tohumlarının çimlenme yüzdesi azalmıştır. *R. scutatus* tohumlarının çimlenmesi için optimum pH değerinin 6 (% 98) olduğu pH 6'nın altında (özellikle pH 4'de) tohum çimlenmesinin engellendiği belirlenmiştir. Tohum çimlenme oranı ile tohum yaşı arasında negatif bir ilişkinin olduğu tespit edilmiştir. Maksimum çimlenme yüzdesi (% 99) yeni toplanan tohumlardan elde edilmiştir.

Anahtar Kelimeler: Çimlenme, Ekofizyoloji, Tohum ömrü, *Rumex scutatus*, Sıcaklık, Ph.

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1. INTRODUCTION

Successful establishment of plant species is often dependent on the timing for germination resulting from seed responses to environmental cues [1]. Seeds often respond to a combination of different environmental factors such as light, temperature and soil moisture that are most favorable to their establishment [2]. Plant species have various temperature ranges over which their seeds will germinate, so very high and very low temperatures can cause the prevention of seed germination. In general, alternating temperature regimes can be more effective in stimulating germination than one constant temperature [2]. This sensitivity differs between species. For survival of a species, it is important that seeds should germinate only when the environmental factors are likely to be satisfactory for growth of the seedling. The seeds may display the dormancy phenomenon which is the period for maturation to germination [2].

It is also well established that many seeds are sensitive to light [3]. The pH of the soil can control the distribution and abundance of plants. At highly acidic pH ($\lesssim 3$) and alkaline pH (< 9) values, toxic concentrations of H^+ and OH^- ions damage the protoplasm of root cells. Long term burial studies suggested that *Polygonaceae* seeds can be viable after storage of 4-15 years in the soil [3].

Ecophysiological studies of seed germination have suggested that temperature, light, distribution of minerals, its changes, and its fluctuation can be the most reliable environmental signals to indicate the appropriate timing for germination [2].

The aim of this study was to investigate and evaluate the effects of pH, seed longevity, temperature, soil depth, light and in particular the interactions between among these factors on final germination in *Rumex scutatus*, an important vegetable, which is being cultivated for salad dressing purposes. *Rumex scutatus* L. (*Polygonaceae*) can survive under a wide temperature and grow in almost all types of soil. This plant is native to Europe, Crime, a Caucasian and Northwest Iran and Turkey and it is a widely distributed perennial species. It grows slopes, hillside and field from 300 to 2200 m [4]. This species has a more delicious acid than *Rumex acetosa* therefore preferred for kitchen use in soups, especially by the French.

2. MATERIALS AND METHODS

Mature seeds of *Rumex scutatus* were harvested from plants growing on wild and garden soil in Kayseri (34^0 56’ and 36^0 59’ E, 37^0 45’ and 38^0 18’ N) Turkey. Plants bearing ripe capsules were collected and the seeds were removed from the capsules. After being removed from the capsules, the seeds were rinsed in tap water and then dipped into a sodium hypochlorite solution (1 % v/v) for sterilization. The seed samples were dried and then stored in plastic bags for 4 months, without sealing at room temperature. The standard germination tests used involved counting out one hundred seeds onto Whatman filter paper moistened with 4 ml distilled water in a Petri dishes which was then placed in a temperature and light controlled growth cabinet.

To determine the optimal temperature for germination mature seeds collected and tested for germination at 5, 10, 15, 20, 25 or 30 ^{0}C. Germination was monitored every 24 h until no further changes were observed (generally 21 days). Radicle protrusion of greater than 1 mm in seeds was considered as the criterion for germination. All non-germinated seeds were assessed visually for viability, fungal damage and emptiness. Furthermore, the seeds of *R. scutatus* were germinated on filter paper moistened with mineral nutrient that contain different kinds of minerals in Petri dishes to determine the effect of minerals. Additionally, five different (4, 5, 6, 7 and 8) pH values were tested, for this treatment the pH values of solutions were adjusted by the addition of either HCl or NaOH. Another experiment was designed to estimate the influence of seed age on the ability of germination rate, so three different seed groups (new harvested, after 12 or 36 months storage) were used for this purpose.

Finally, in order to estimate the proportion of seed lost due to germination in deeper depths, we set up a small experiment in which seeds of *R. scutatus* were buried in soil at five different depths (0, 2, 4, 6 and 8 cm). 100 seeds were placed in plastic pots containing garden soil. Each test was carried out in five replicates during the 4 weeks.

The SPSS (Statistical Package for the Social Sciences) statistical program was used to calculate standard errors, mean and other statistical analyses (one- way ANOVA). Analysis of variance (ANOVA) was used to determine if significant differences were present among means. When significant differences were found among means, a Bonferroni post hoc test was carried out to determine if significant ($P<0.05$ or $P<0.01$) differences occurred among individual treatments.

3. RESULTS AND DISCUSSION

The mean germination values of *Rumex scutatus* under different kind of environmental stress are given in Figures 1-5. The germination percent of *R.scutatus* are quite variable such as; temperature (89-100 %), light (89-99.8 %), pH (91-98.7 %) and seed age (78.3-99.3 %). Although, the lowest germination percent (89 %) was obtained at 5 ^{0}C, the highest germination percent (100 %) was obtained at 25 ^{0}C however, this rate decreased to 95 % at 30 ^{0}C (Figure 1).

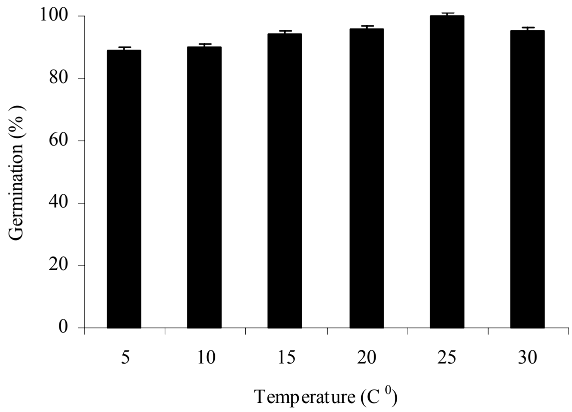

Figure 1. Effect of different temperature on the seed germination of *R.scutatus*. Data are means ± 1 S.E. (for 100 seeds). Bars with the same letter for each temperature range are not significantly different ($P<0.05$) from one another.

Neuffer and Hurka [5] and El- Habibi and Youssef [6] stated that seeds are exposed to alternating temperature can cause increasing of germination rate of seeds from different plants. However, the results obtained from this study showed that a range of alternating temperatures produced lower germination percentage for seeds of *R.scutatus*. The results obtained from this study are shown to be in good agreement with the data obtained from *Capsella bursa-pastoris* by Aksoy et. al [7] and from *Inula viscosa* (L.) by Pirdal and Öztürk [8].

In the light conditions, maximum germination percent of seeds was obtained at 25 ^{0}C (Figure 2).

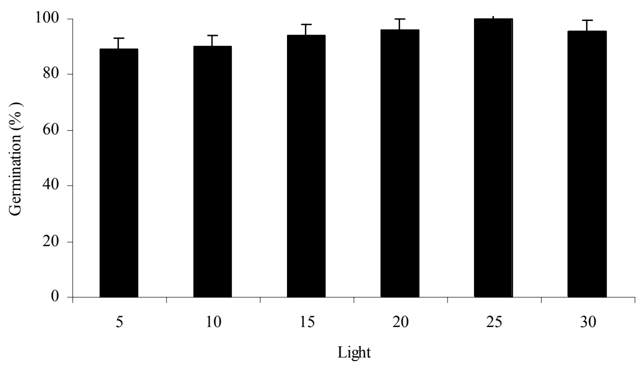

Figure 2. Effect of ligth on the seed germination of *R.scutatus* at a day /night temperature of 25 ^{0}C. Data are means ± 1 S.E. (for 100 seeds). Bars with the same letter for light are not significantly different ($P<0.05$) from one another.

However, germination was slightly lower than those in light reduced by darkness. Furthermore, seeds showed the greatest response germination percentage in the alternating light / dark regimes than total darkness. These values are nearly similar to those obtained by Pirdal and Öztürk [8]. They stated that the maximum germination percentage (90 %) is obtained from light treatment for seeds of *Asphodelus aestivus*.

The highest germination percent was observed in pH 6 (98 %) however, it was inhibited by pH 4 (91 %). Germination percent of seeds was enforced by low pH levels (Figure 3)

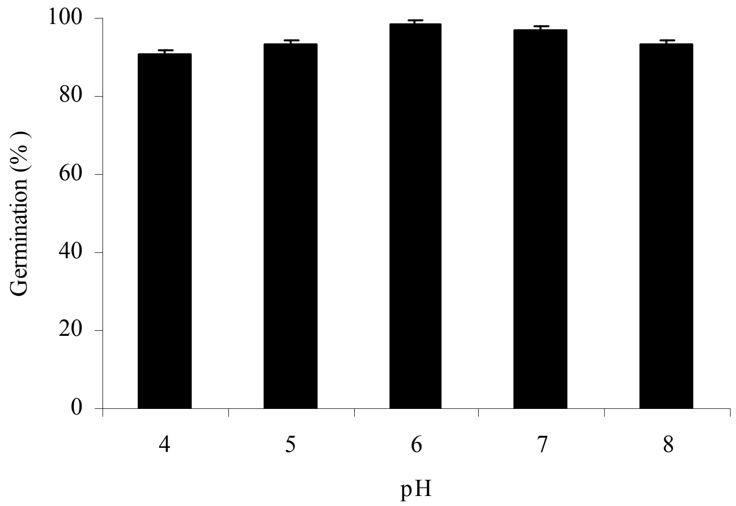

Figure 3. Effect of pH on the seed germination of *R.scutatus* at a day /night temperature of 25 ^{0}C. Data are means ± 1 S.E. (for 100 seeds). Bars with the same letter for each pH range are not significantly different (P<0.05) from one another.

and this may be due to at the low pH values the mobility of various elements which may lead to a partial supply of seeds and plants is somewhat reduced. It seems likely that most of the soil 10 cm depth has a pH values between five and just over six. According to Parkpain et al. [9], average suitable pH values for general plant growth were 6.5-7.5. Low pH may cause some problems for plants especially for seeds such as heavy metal toxicity since solubility of metal ions is pH dependent [10, 11]. Furthermore, for this phenomenon, Görransson and Eldhuset [12] proposed a possible explanation that germination starts by the passive process of water imbibition, swelling of existing tissue and rupture of the seed coat, followed by cell division and tissue elongation in the embryo. Additionally, potential effects of the extremely low pH on germination were recorded for several species by different investigators [13, 14].

Seed germination for various plant species tends to increase within the first few months after dispersal as a result of breaking dormancy, remains maximal for up to several years and then eventually decreases [2]. A general statement can be made that percent of germination or percent of viable seeds drops over time. For example, if they are exposed to moulds, a greater percentage of the seed can become non-viable through disease; excessive heat or cold or an extremely dry surrounding can also cause reduction of germination percentage for seeds of a particular species.

In this study, results obtained seed age treatment indicated that the germination percent of seeds of *R.scutatus* was reached to 84 % between 12 and 36 months storage (Figure 4). As a result, reduced germination percent may result from seed deterioration or secondary dormancy [15]. The two principal factors influencing seed deterioration are seed moisture content and storage temperature [16], however; other factors such as disease organisms, insects, atmospheric gases, pre-storage history and genotype can all have an impact on the rate of deterioration. Temperature and relative humidity of the storage environment have a key role in maintaining longevity of seeds stored under ambient conditions.

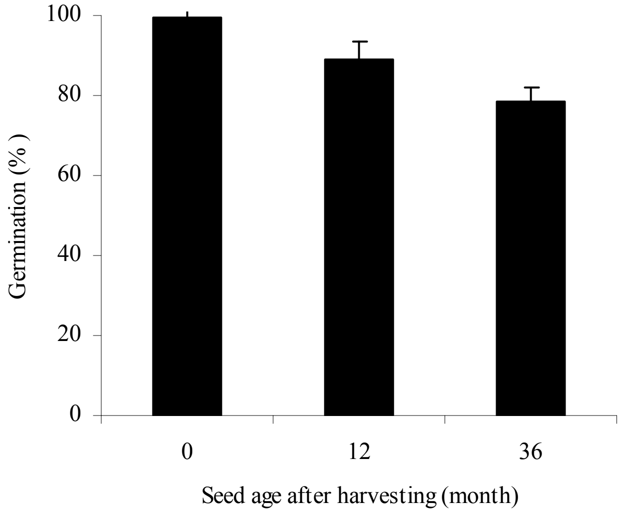

Figure 4. Effect of seed age on the seed germination of *R.scutatus* at a day /night temperature of 25 ^{0}C. Data are means ± 1 S.E. (for 100 seeds)

Seedlings of most plant species arise from seeds in the surface layers of the soil. This has been incorporated of population biology of species [17]. According to Figure 5, the germination was declined with increasing depth of soil cover. The results obtained also emphasized that the heterogeneities of a soil surface may determine the chance of a seed finding a suitable gap for germination.

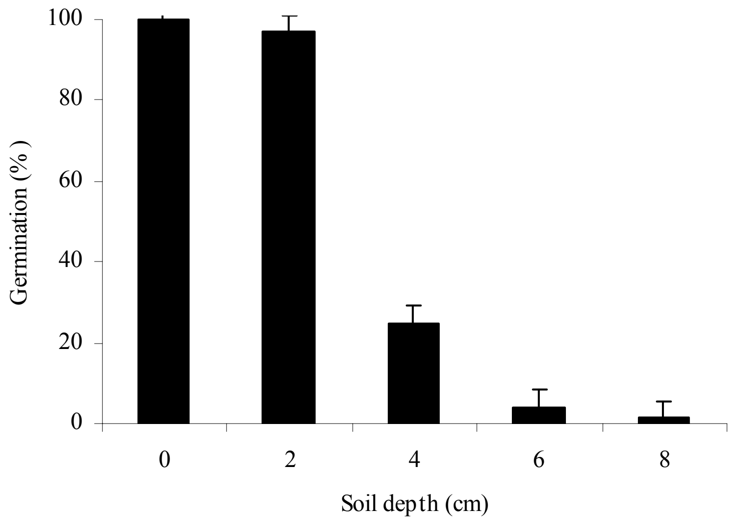

Figure 5. Effect of different soil depth on the seed germination of *R.scutatus* at a day /night temperature of 25 ^{0}C. Data are means ± 1 S.E. (for 100 seeds). Bars with the same letter for each soil depth are not significantly different ($P<0.05$) from one another.

A one-way ANOVA of the germination responses at each environmental conditions revealed that most of them significantly effected seed germination such as; the various temperatures had a significant effect on germination of seeds of *R. scutatus*. (For temperature, F= 121.76; df=5; P<0.000; for light, F=175.656; df=5; P<0.000; for dark, F= 131.81; df=5; P<0.000; for pH, F= 172.84; df=4; P<0.000).

Additionally, a least square linear regression was obtained among temperature, light, pH, seed longevity and soil depth in germination. Results show that correlations between different environmental conditions and germination percent are significant at the p<0.01 and the p<0.05 level. Among these environmental influence - germination relationships, the correlation between temperature and light is the most significant (r = 0.931). Other high correlations in germination were recognized for the groups of pH- seed longevity (r = - 0.93), depth- light (r= - 0.918) and depth- seed longevity (r = 0.877).

In conclusion, the germination rate and physiology of seeds of *Rumex scutatus* were not significantly affected by environmental factors. Germination rate at 5 C^0 had significantly decreased. Furthermore, results showed that germination was slightly lower than those in light reduced by darkness. Additionally, germination rate of seeds was not significantly affected by dormancy.

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