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Germination biology of Field Bindweed seeds collected from different provinces

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Abstract

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Field bindweed (*Convolvulus arvensis* L.) is one of the most harmful weeds in the world. It is a common and problematic perennial weed in many crops such as corn, sunflower, cotton, vegetables and orchards in Turkey. Field bindweed has strong seed dormancy and its germination is delayed. A good understanding of the mechanism of seed dormancy is important for plant reproduction and control of field bindweed. This study was carried out in laboratories in order to determine the dormancy breaking methods (sulfuric acid, gibberellic acid, hydrochloric acid, microwave, cold-hot applications) 20°C and 27°C seeds from the Malatya Province and germination temperatures of seeds from different ecological regions where are the Adana, Ankara, Canakkale, Denizli, Erzurum, Hatay, Karaman, Kayseri, Konya, Malatya, Samsun, Sanliurfa, Tekirdag and Usak Provinces. The highest dormancy breaking happened in sulfuric acid 60 or 120 min (20°C) and keeping seeds 5 s in 90°C hot water (27°C). It has been determined that at germination temperature is between 10-40°C depending on the provinces where it was collected. The highest germination rate (96.3%) was observed in seeds of Erzurum province at 20°C. While there was no germination at 2 and 45°C, the highest germination rate (80%) at 40°C was also observed in the seeds of Erzurum province.

Keywords: Convolvulus arvensis; dormancy breaking; germination temperature; different provinces

Introduction

Field bindweed (*Convolvulus arvensis* L.), which is considered among the worst weeds worldwide, perennial agricultural weeds with euroasian origin and seen in temperate, tropical and Mediterranean type of climatic areas of all continents (Lyons, 1998; Holm et al., 1977). Field bindweed is one of the most harmful weeds in the world and has been detected in 32 different agricultural crops in 54 countries (Holm et al., 1991). In studies conducted in Turkey, it has been reported that field bindweed has a high prevalence and density in industrial plants which have economic importance, fruit and vegetable gardens, ornamental and forage plants, cereals and greenhouse cultivation (Kordali & Zengin, 2011; Arikan et al., 2015). Field bindweed belongs to the Convolvulaceae family and Convolvulaceae family includes 57 genera and about 1600 species and was first classified by Linneaus in 1753 (Guncan, 1979; Yadav et al., 2018). In our country, 4 genus and 40 species show natural distribution (Ozturk, 2019). It reduces the water present in the soil depth of 60 cm and causes the product to fade as a result of lack of water and causes difficulty in pruning by winding the bush and small trees (Vogelgsang, 1998). It creates a breeding ground for pests in cultivated plants and it is an alternative host to viruses that cause plant diseases (Tamaki et al., 1975). Field bindweed contains convolvulin glycosides in seeds, leaves and especially roots. This glycoside is a resinous, water-insoluble composition that causes severe hyperemia (blood attack), peristalsis and diarrhea in animals' stomach and intestinal tract (Lubenov, 1985). In studies conducted in Turkey, it has been reported that field bindweed has a high prevalence and density in industrial plants which have economic importance, fruit and vegetable gardens, ornamental and forage plants, cereals, lentil and greenhouse cultivation (Uludag, 1993; Kordali & Zengin, 2011; Arikan et al., 2015; Ustuner, 2016; Hancerli & Uygur, 2017; Karabacak & Uygur, 2017; Ozkil & Uremis 2019).

Field bindweed propagates by seeds and rhizomes an average plant can produce up to 550 seeds in one growing season (DeGennaro &Weller, 1984). The seed coat of field bindweed is impervious to water, and over 95% of mature seeds have hard seed coats (Brown & Porter 1942). Due to the hard and impermeable seed coat, field bindweed can remain dormant and remain viable in the soil for more than 60 years, which makes its generations continuous (Bond et al., 2007; Wright et al., 2011). The rest period in which the growth activities decrease and stop in seeds or some plant parts is called dormancy and is of great importance in terms of the destruction of weeds and adaptation to the environment and is a life insurance policy (Guncan, 2001). and it occurs in growth organs such as bulbs. For seeds to germinate, factors such as heat, light and water in the environment must be at a sufficient level. Also, there should be no harmful or inhibiting chemicals in the environment. Although these conditions are present, seeds may not germinate again (Iskenderoglu et al., 1993). The event that we call getting rid of drowsiness or breakage is that both internal and external conditions are appropriate and the state of sleep ends with external intervention (Kocacaliskan, 2002).

Some biological properties (moisture, temperature, elevation etc.) in weeds may differ according to ecological values. This means that the seeds of plants grown in different ecological environments have different germination properties (Ozer, 1995; Uremis & Uygur, 1999).

Although different researchers (Brown & Porter, 1942; Rolston, 1978; Jayasuriya et al., 2008; Xiong et al., 2018) find different methods, other methods investigated in this study are not available. Especially, there is no study on the different temperature ranges of field bindweed seeds collected from different ecological conditions. It has been reported by many researchers (Brown & Porter, 1942; Callihan, 1961; Tanveer et al., 2013; Ozkil & Uremis, 2019) that the germination temperature of field bindweed is 15-40°C. However, there is no study on how germination temperatures of field bindweed seeds may change in different ecological conditions. Therefore, this study was conducted to find the effects of different dormancy breaking methods (sulfuric acid, gibberellic acid, hydrochloric acid, microwave, cold-hot applications) on germination at 20°C and 27°C and germination temperatures of seeds collected from different ecological regions.

Materials and Methods

Sites and plant materials

Seeds of bindweed were collected from agricultural areas (orchards, vegetable and field areas) in different provinces of Turkey in 2018 (Table 1 and Figure 1). Seeds collected from different provinces were extracted by manually cracking capsules, cleaning, and removing insect or others damaged

Table 1. The altitutes, climate and soil characteristics of the provinces where the field bindweed seed (*Convolvulus arvensis*) are collected (Anonymous, 2019a)

Provinces	Altitudes (m)	Regions	Climatic properties
Malatya	966 m	Eastern Anatolia	Terrestrial
Erzurum	1900 m		Terrestrial
Diyarbakir	673 m	Southeastern Anatolia	Terrestrial
Sanliurfa	510 m		Terrestrial
Ankara	858 m	Central Anatolia	Terrestrial
Karaman	1058 m		Terrestrial
Kayseri	1060 m		Terrestrial
Konya	1023 m		Terrestrial
Samsun	10 m	Black Sea	Temperate
Adana	26 m	Mediterranean	Mediterranean
Hatay	89 m		Mediterranean
Denizli	390 m	Aegean	Temperate
İzmir	10 m		Mediterranean
Usak	911 m		Terrestrial
Tekirdag	25 m	Marmara	Mediterranean
Canakkale	12 m		*Transition climate* of *Mediterranean and Black Sea*

Fig. 1. Provinces where field bindweed (*Convolvulus arvensis* L.) seeds were collected (Anonymous 2019b)

seeds and then, collected was stored at +4°C until they were used in the experiments. All the experiments reported in this study were carried out at Malatya Turgut Ozal University, Malatya, Turkey 38.27°N, 38.21°E) in 2018-2019. Before all seed experiments, to perform surface sterilization, seeds were soaked in 1% NaClO for 1 min and then washed thoroughly with tap water for 1 min.

Experimental conditions

Dormancy breaking studies in field bindweed seeds

Five different dormancy breaking methods were studied under 20 ± 1°C and 27 ± 1°C temperatures in the dark using one or two years old seeds of field bindweed collected from Malatya province. Germination experiments were carried out in the dark environment, since light has no stimulated on the germination of fresh field bindweed (Weaver & Riley, 1982). The methods for breaking dormancy as following:

Sulfuric acid application: In this application, the seeds (25 seeds for each petri dish and 100 seeds per application) were soaked with 96% sulfuric acid for 1, 2, 15, 30, 60 and 90 minutes (Ates, 2017) and then thoroughly washed with tap water for 1 min.

Gibberellic acid application: For the application, 3 ml solution was applied to each petri dish from 200 ml of gibberelic acid (GA_3) solution prepared in different doses (250, 500, 1000 and 2000 ppm) (Ates, 2017). Then the seeds were taken to the climate cabinet and petri dishes were added for each dose of gibberellic acid as needed.

Microwave application: In this application, the seeds (25 seeds for each petri dish) were exposed to microwaves of 100 watts at different times (10, 20, 45.90 and 180 seconds) (Ates, 2017). Then, the seeds were taken into petri dishes prepared with 9 cm diameter double layer filter paper and 3 ml of distilled water was added and placed in the climate cabin.

Hydrochloric acid application: To evaluate the effect of hydrochloric acid on seed dormancy, the seeds were soaked with 37 % hydrochloric acid for 5, 15, 30 and 60 and then thoroughly washed with tap water for 1 min.

Cold/hot application: To evaluate the effect of cold/hot application on seed dormancy, there were a total of 10 applications in the experiment. These applications;

- control (seeds were directly applied to 3 ml of distilled water and transferred to petri dishes)

-1 day -86°C (seeds were kept at -86°C for 1 day)

-2 days -86°C (seeds were kept at -86°C for 2 days)

-4 days -86°C (seeds were kept at -86°C for 4 days)

-7 days -86°C (seeds were kept at -86°C for 7 days)

- 90°C (seeds were kept in 90°C water for 5 s)

-1 day -86/90°C (seeds were kept at -86°C for 1 day, then kept in 90°C water for 5 s)

-2 days -86/90°C (seeds were kept at -86°C for 2 days, then kept in 90°C water for 5 s)

-4 days -86/90°C (seeds were kept at -86°C for 4 days, then kept in 90°C water for 5 s)

-7 days -86/90°C (seeds were kept at -86°C for 7 days, then kept in 90°C water for 5 s)

After the applications are carried out, the petri dishes are placed in the climate cabin. The seeds in the climate cabin were subjected to germination count the following day of applications and the seeds forming 0.5 cm radicle were considered germinated. The total count lasted 14 days (Tiryaki & Topu, 2014).

Seeds were placed in a 9 cm-wide petri dish with two layer of Whatman No 1 filter paper. The experimental design was completely randomized plots with four replications and 25 seeds were placed in petri dishes, in each replication. Only distilled water was applied to the control application to be used in the study. Until the last day of germination, irrigation with distilled water (except for the application of gibberelic acid) has been carried out in order to ensure the humidity of the environment, when it is needed. The experiment continued until the 14^{th} day in dark when germination was stable and germinated seeds were taken out of the petri dish depending on the findings of daily counting and the seeds forming the 0.5 cm radicle were considered as germinated. The experimentt was repeated twice.

Seed germination percentage was calculated by multiplying the ratio of germinated seeds to a total number of viable seeds in a single petri dish by 100. Germination rate (GR) was calculated: with the formula:

$$GR = \sum_{i}^{n} \frac{Si}{Di},$$

where Si is the number of germinated seeds on day i, Di is the incubation days of the seeds, and GR is the germination rate expressed as seeds per day (Xiong et al., 2018).

Determination of germination temperatures of field bindweed seeds

The experiment was carried out in dark environment climate cabins with 4 replications and 2 repetitions. After surface sterilization of field bindweed seeds obtained from different provinces (Adana, Ankara, Canakkale, Denizli, Erzurum, Hatay, Karaman, Kayseri, Konya, Malatya, Samsun, Sanliurfa, Tekirdag and Usak) (Table 1 and Figure 1) was applied, sulfuric acid 90 min application, one of the most suitable dormancy breaking methods at 20°C, was done to break the hard seed coat dormancy of the seeds. After the dormancy breaking application, 25 seeds were placed in sterile petri dishes with 9 cm diameter double filter paper and then 3 ml of distilled water was added, they were left in at 2, 5, 10, 15, 20, 25, 30, 35, 40 and 45°C temperatures to climate cabins in dark conditions. In order to determine the germination rates, the counts continued for 21 days every day and the seeds forming 0.5 cm radicle were considered to be germinated. The above formula was used to calculate the germination rates (Xiong et al., 2018).

Data analysis

The results were combined and the mean value was used, since no statistically significant difference was found in the results of the trials repeated twice, Furthermore, using IBM SPSS 25 package program, the results obtained regarding the effect on germination rates of field bindweed (*Convolvulus arvensis* L.) at different temperatures and in the dormancy breaking studies were subjected to GLM model One-way (ANOVA) variance analysis. The difference between the applications was calculated using Duncan multiple comparison test ($p \leq 0.05$).

Results

Effect of dormancy breaking studies on field bindweed (*Convolvulus arvensis* L.) seeds

Statistical differences between dormancy breaking methods were found to be significant at 20°C and 27°C ($p < 0.05$). While the best dormancy breaking applications at 20°C were obtained from sulfuric acid 60 (65%) and 90 (63%) minutes; 0 days in 90°C (57%), 7 days in -86°C /90°C (56.7%), 1 day-86°C /90°C (54.2%), 4 days in -86°C/90°C (50.8%) and 2 days in -86°C /90°C (44.8%) followed these applications. Increasing the time in the microwave application has increased the germination even a little. It was observed that there was no difference between hydrochloric acid, gibberellic acid and -86°C cold applications compared to control (4.5%) (Figure 2). While the best application of dormancy breaking applications at 27°C was found 0 days 90°C (87.5%); 4 days in -86°C/90°C (86.7%), 2 days in -86°C/90°C (83.3%), 1 day in -86°C/90°C (80%) and 7 days in -86°C/90°C (78.3%), sulfuric acid (1, 2, 15, 30, 60 and 90 min), microwave 90 and 180 s. Followed this application. It was observed that there was no difference between hydrochloric acid, gibberellic acid and -86°C cold applications compared to control (6.7%) (Figure 3). The difference between the applications was found statistically significant in dormancy breaking studies.

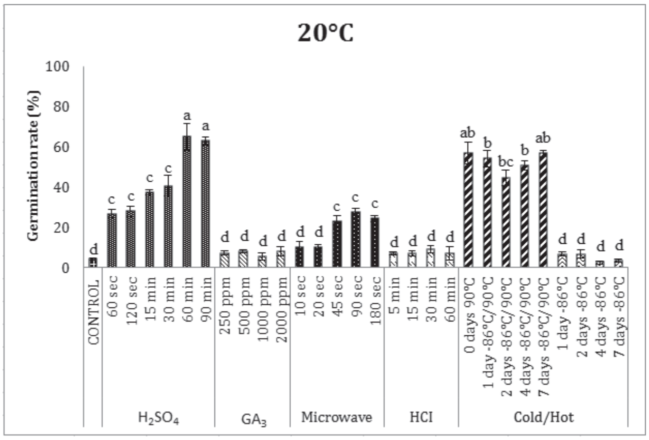


Fig. 2. The effect of dormancy breaking applications carried out at 20°C on germination of field bindweed seeds

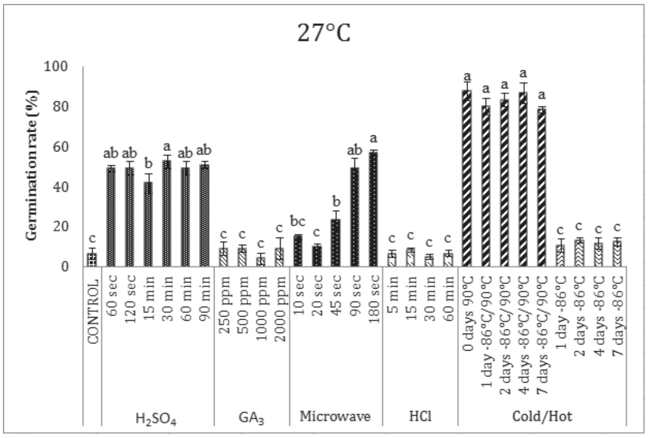


Fig. 3. The effect of dormancy breaking applications carried out at 27°C on germination of field bindweed seeds

Determination of germination temperatures of field bindweed (*Convolvulus arvensis* L.) seeds collected from different provinces

Statistical differences between germination temperatures were found to be significant ($p < 0.01$). In the germination temperature studies, it was observed that the appropriate germination temperatures of the field bindweed of different provinces differ according to the provinces and they were between 10-30°C (Canakkale), 10-35°C (Adana, Ankara, Erzurum, Karaman, Kayseri, Konya, Malatya, Tekirdag and Usak) and 15-35°C (Denizli, Hatay, Samsun ve Sanliurfa). In the study, there was no germination at 2 and 45°C (Table 2 and Figure 4). The germination temperature graphs of the provinces are given separately (Figure 4). The highest germination rate was obtained from Erzurum with 96.3% at 20°C. It was followed by Ankara, Karaman, Sanliurfa and Usak provinces between 25-30°C. When considered statistically, it was determined that these temperature values represent a wider range.

Discussion

Effect of dormancy breaking studies on field bindweed seeds

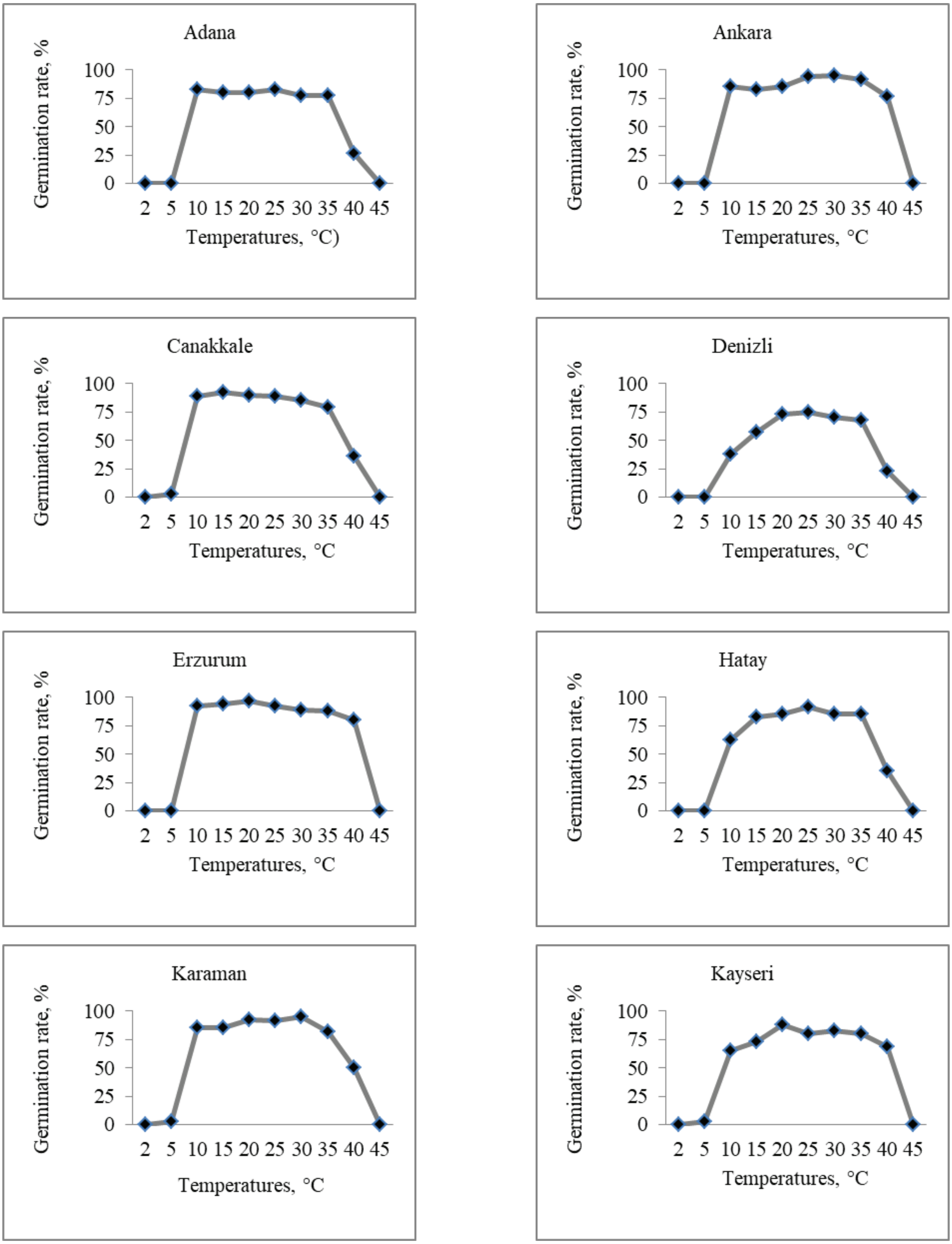
As a result of studies on field bindweed seeds, it is known to have dormancy (Callihan, 1961; Americanos, 1994; Jayasuriya et al., 2008; Jayasuriya et al., 2009; CABI, 2019; Ozkil & Uremis, 2019). It is very important to know the biological features of weeds such as dormancy, reproductive abilities and germination temperatures in order to make correct applications in the control of weeds (Ates, 2017).

Jayasuriya et al. (2008) found that germination of the field bindweed seeds was kept in boiling water for certain periods and the germination increased significantly. With the

Table 2. The effect of different temperatures on germination of field bindweed (*Convolvulus arvensis* L.) seed from different provinces

Provınces	2°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C	45°C	F
Adana	$0.0\pm0.0_{a}^{C}$	$0.0\pm0.0_{a}^{C}$	$82.5\pm4.8_{abcd}^{A}$	$80.0\pm7.1_{abc}^{A}$	$80.0\pm4.1_{bc}^{A}$	$82.5\pm4.8_{ab}^{A}$	$77.5\pm7.5_{ab}^{A}$	$77.5\pm7.5_{ab}^{A}$	$26.3\pm5.5_{c}^{B}$	$0.0\pm0.0_{a}^{C}$	58.60***
Ankara	$0.0\pm0.0_{a}^{C}$	$0.0\pm0.0_{a}^{C}$	$85.0\pm4.6_{abcd}^{AB}$	$82.5\pm2.5_{abc}^{B}$	$85.0\pm5.4_{abc}^{AB}$	$93.8\pm1.3_{a}^{A}$	$95.0\pm5.0_{a}^{A}$	$91.3\pm1.3_{a}^{AB}$	$76.3\pm1.3_{a}^{B}$	$0.0\pm0.0_{a}^{C}$	208.86***
Canakkale	$0.0\pm0.0_{a}^{D}$	$2.5\pm2.5_{a}^{D}$	$88.8\pm3.1_{ab}^{AB}$	$92.5\pm4.3_{a}^{A}$	$90.0\pm3.5_{ab}^{A}$	$88.8\pm3.8_{ab}^{AB}$	$85.0\pm2.9_{ab}^{AB}$	$78.8\pm5.2_{ab}^{B}$	$36.3\pm3.8_{c}^{C}$	$0.0\pm0.0_{a}^{D}$	156.14***
Denızlı	$0.0\pm0.0_{a}^{D}$	$0.0\pm0.0_{a}^{D}$	$37.5\pm9.5_{e}^{BC}$	$57.5\pm4.8_{d}^{AB}$	$72.5\pm6.3_{cd}^{A}$	$75.0\pm10.4_{b}^{A}$	$70.0\pm14.7_{b}^{A}$	$67.5\pm6.3_{b}^{A}$	$22.5\pm9.5_{c}^{CD}$	$0.0\pm0.0_{a}^{D}$	17.15***
Erzurum	$0.0\pm0.0_{a}^{C}$	$0.0\pm0.0_{a}^{C}$	$92.5\pm3.2_{a}^{A}$	$93.8\pm4.7_{a}^{A}$	$96.3\pm2.4_{a}^{A}$	$92.5\pm2.5_{a}^{A}$	$88.8\pm1.3_{ab}^{AB}$	$87.5\pm7.5_{a}^{AB}$	$80.0\pm3.5_{a}^{B}$	$0.0\pm0.0_{a}^{C}$	166.53***
Hatay	$0.0\pm0.0_{a}^{D}$	$0.0\pm0.0_{a}^{D}$	$62.5\pm7.8_{cd}^{B}$	$82.5\pm6.6_{abc}^{A}$	$85.0\pm4.1_{abc}^{A}$	$91.3\pm4.3_{a}^{A}$	$85.0\pm4.6_{ab}^{A}$	$85.0\pm3.5_{ab}^{A}$	$35.0\pm4.1_{c}^{C}$	$0.0\pm0.0_{a}^{D}$	83.72***
Karaman	$0.0\pm0.0_{a}^{C}$	$2.5\pm1.4_{a}^{C}$	$85.0\pm4.1_{abcd}^{AB}$	$85.0\pm6.8_{abc}^{AB}$	$92.5\pm1.4_{ab}^{AB}$	$91.3\pm4.3_{a}^{AB}$	$95.0\pm2.9_{a}^{A}$	$81.3\pm7.2_{ab}^{B}$	$50.0\pm5.4_{bc}^{C}$	$0.0\pm0.0_{a}^{C}$	99.23***
Kayserı	$0.0\pm0.0_{a}^{C}$	$2.5\pm2.5_{a}^{C}$	$65.0\pm16.6_{bcd}^{B}$	$72.5\pm2.5_{bcd}^{AB}$	$87.5\pm6.3_{abc}^{A}$	$80.0\pm4.1_{ab}^{AB}$	$82.5\pm4.8_{ab}^{AB}$	$80.0\pm7.1_{ab}^{AB}$	$68.8\pm5.5_{ab}^{AB}$	$0.0\pm0.0_{a}^{C}$	30.93***
Konya	$0.0\pm0.0_{a}^{D}$	$0.0\pm0.0_{a}^{D}$	$77.5\pm2.5_{abcd}^{AB}$	$67.5\pm8.5_{cd}^{B}$	$90.0\pm4.1_{ab}^{A}$	$85.0\pm2.9_{ab}^{AB}$	$85.0\pm6.5_{ab}^{AB}$	$76.3\pm6.9_{ab}^{AB}$	$45.0\pm11.4_{bc}^{C}$	$0.0\pm0.0_{a}^{D}$	45.70***
Malatya	$0.0\pm0.0_{a}^{D}$	$0.0\pm0.0_{a}^{D}$	$60.0\pm12.2_{d}^{B}$	$57.5\pm2.5_{d}^{BC}$	$62.5\pm5.2_{d}^{AB}$	$76.3\pm3.8_{b}^{A}$	$78.8\pm5.5_{ab}^{A}$	$78.8\pm4.3_{ab}^{A}$	$43.8\pm5.9_{bc}^{C}$	$0.0\pm0.0_{a}^{D}$	39.56***
Samsun	$0.0\pm0.0_{a}^{D}$	$2.5\pm2.5_{a}^{D}$	$68.8\pm7.5_{abcd}^{B}$	$77.5\pm8.5_{abc}^{AB}$	$77.5\pm6.3_{bc}^{AB}$	$81.3\pm5.2_{ab}^{AB}$	$90.0\pm3.5_{a}^{A}$	$91.3\pm2.4_{a}^{A}$	$45.0\pm10.8_{bc}^{C}$	$0.0\pm0.0_{a}^{D}$	44.03***
Sanlıurfa	$0.0\pm0.0_{a}^{D}$	$2.5\pm2.5_{a}^{D}$	$72.5\pm6.0_{abcd}^{B}$	$90.0\pm0.0_{ab}^{A}$	$90.0\pm6.1_{ab}^{A}$	$95.0\pm2.0_{a}^{A}$	$95.0\pm2.0_{a}^{A}$	$91.3\pm2.4_{a}^{A}$	$27.5\pm5.2_{c}^{C}$	$0.0\pm0.0_{a}^{D}$	155.29***
Tekırdag	$0.0\pm0.0_{a}^{C}$	$2.5\pm2.5_{a}^{C}$	$87.5\pm2.5_{abc}^{A}$	$85.0\pm6.5_{abc}^{A}$	$83.8\pm2.4_{abc}^{A}$	$86.3\pm3.8_{ab}^{A}$	$92.5\pm3.2_{a}^{A}$	$91.3\pm3.8_{a}^{A}$	$40.0\pm5.4_{c}^{B}$	$0.0\pm0.0_{a}^{C}$	134.76***
Usak	$0.0\pm0.0_{a}^{C}$	$0.0\pm0.0_{a}^{C}$	$85.0\pm6.5_{abcd}^{A}$	$87.5\pm2.5_{ab}^{A}$	$92.5\pm4.8_{ab}^{A}$	$95.0\pm2.9_{a}^{A}$	$93.8\pm3.1_{a}^{A}$	$91.3\pm3.1_{a}^{A}$	$48.8\pm19.5_{bc}^{B}$	$0.0\pm0.0_{a}^{C}$	38.69***
F		0.70ns	3.97***	4.64***	3.68***	2.33*	1.74ns	1.98*	4.75***		

(+ Capital letters represent groups between temperatures. small letters represent groups between provinces + ns = Not statistically significant (Duncan $p > 0.05$) + * = Statistically significant at the significance level of Duncan $p < 0.05$ + *** = Statistically significant at the significance level of Duncan $p < 0.01$)


Adana
Germination rate, %
100
75
50
25
0
2 5 10 15 20 25 30 35 40 45
Temperatures, °C)
Ankara
Germination rate, %
100
75
50
25
0
2 5 10 15 20 25 30 35 40 45
Temperatures, °C
Canakkale
Germination rate, %
100
75
50
25
0
2 5 10 15 20 25 30 35 40 45
Temperatures, °C
Denizli
Germination rate, %
100
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0
2 5 10 15 20 25 30 35 40 45
Temperatures, °C
Erzurum
Germination rate, %
100
75
50
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2 5 10 15 20 25 30 35 40 45
Temperatures, °C
Hatay
Germination rate, %
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Temperatures, °C
Karaman
Germination rate, %
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Temperatures, °C

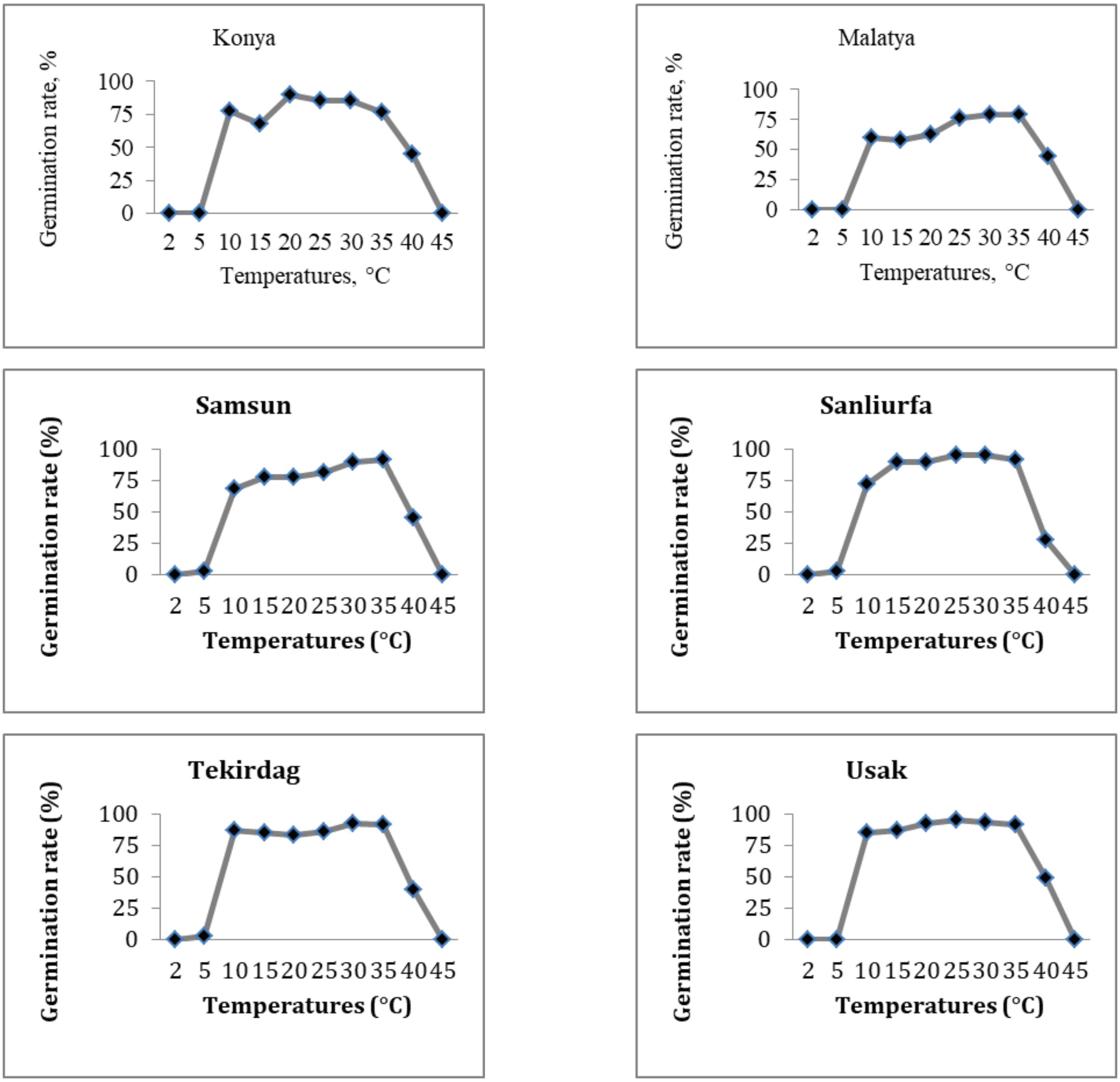

Fig. 4. The effect of different temperatures on germination of field bindweed (*Convolvulus arvensis* L.) seed from different provinces

hot water method applied to field bindweed, an increase in germination rate is observed with the cracking of the seed coat and consequently increased water permeability. Jayasuriya et al. (2008), clarified our work by determining that hot water application has a positive effect on seeds with their study. The positive effect of hot water application in our study confirmed the study of Jayasuriya et al. (2008). Callihan (1961), determined that the application of sulfuric acid in field bindweed encourages germination. Ozkil & Uremis (2019), tried 60, 90 and 120 minutes dormancy breaking methods in sulfuric acid applications in their dormancy and germination temperature study on the germination of field bindweed seeds at 25°C and found the best dormancy application in 90 and 120 min. In our study, the sulfuric acid application of the best germination rate at 20°C has similar characteristics with Ozkil & Uremis (2019).

It is thought that the germination rates after application differ due to the temperature and the structure of the seeds. In the same study, the observation that the effect of seeds on germination rates was very low in the application of gibberellic acid is similar to our study. Xiong et al. (2018), gibberellic acid has no effect on germination in field bindweed breaking dormancy study, whereas sulfuric acid and hot water soaking applications have significant effects on germination and this study shows similarity with our study. In addition, the reason why gibberellic acid and HCl acid applications do not affect the field bindweed seeds sufficiently at both temperatures is due to the hardness of the seed coat of the plant. Ozkil & Uremis (2019), determined that the extension of the time in microwave application had a negative effect on the germination of the seeds, but in our study, the extension of the times showed a positive effect. The differences in studies are thought to be due to the seed's maturity, general structure and the region where it is collected is different.

In another study, Uludag & Ozer (1999) tried H_2SO_4 and GA3 applications in breaking the dormancy of different weed seeds (*Cerastium dichotomum* L., *Galium tiricornutum* Dandy., *Scandix pecten-veneris* L., *Asperula arvensis* L.) and found that the most effective method for breaking the dormancy of *G. tiricornutum* seed was H_2SO_4 application. We can say that *G. tricornutum* seeds, which have a hard seed shell like field bindweed, can achieve better germination by eroding the seed coat with sulfuric acid application. Bozdogan et al. (2018), applied ethanol, sodium hypochlorite, distilled water, sulfuric acid, hydrochloric acid, gibberellic acid, microwave, -80°C, -80°C and + 80°C (one minute hold) dormancy methods on *Rumex crispus* L. (curly dock) seeds. In the study, sulfuric acid 60 s application has a high germination rate, but increasing the time has reduced the germination rate. Due to the curly dock seed coat is thinner than that of field bindweed, it is thought that the seed embryo is damaged as a result of increasing the time of sulfuric acid application. Due to field bindweed seed coat has a hard structure, increasing the time in sulfuric acid application did not harm the embryo and it made the germination easier by cracking the seed coat. As a result of the study, applications that will erode or crack the seed coat are seen to be effective in breaking the dormancy since the field bindweed has a hard seed coat.

Compared to the studies performed at 20°C in the dormancy breaking studies, increases in the germination rates were observed at 27°C in general (Figure 2 and Figure 3). Especially with the increase in temperature, the germination rates increased in cold hot applications and the best germination rates were obtained. This is due to the optimum germination temperatures of seeds obtained from Malatya used in the dormancy study are between 25-35°C. Bewley & Black (1994) states that many biochemical events that increase seed germination such as membrane permeability, activity of membrane proteins and cytosol enzymes can be affected by temperature changes. This situation can be explained by the emergence of a higher germination rate at 27°C in our study.

Determination of germination temperatures of field bindweed (*Convolvulus arvensis* L.) seeds collected from different provinces

It has been determined that field bindweed seeds can germinate at 5-40°C in studies that are collected from different ecological conditions and whose germination temperature was performed. Especially from the seeds obtained from Erzurum, a very high germination was obtained between 10-40°C. Erzurum is the province with the highest altitude among the places where samples were collected (about 1900 m) (Table 1). In addition, summer plants have a growing period of about 5 months in Erzurum, which has a cool and cold climate structure. In this case, it reveals that field bindweed shows the ability to germinate at any temperature in this region in terms of temperature. Germination temperatures vary in terms of other provinces.

Brown and Porter, (1942), determined the germination temperature of field bindweed as minimum 0.5°C, optimum 30, 20-30 and 20-25°C and maximum 40°C. Callihan (1961), the field bindweed has germinated between 5-15°C, 15-25°C and 20-30°C and it has determined that the most suitable germination is between 15-25°C in the dark environment and 20-30°C in the light environment. Tanveer et al. (2013) used temperatures between 15°C and 45°C to determine the germination temperature of field bindweed. It was determined that there was no germination at 45°C while germination occurred in field bindweed seeds between 15-40°C and determined the optimum germination at temperatures between 20-25°C. In these studies, the optimal germination temperature of the field bindweed at different temperatures proved that the field bindweed could germinate in a wide temperature range by showing similarity with the temperature values in our study. In the germination temperature study carried out in the laboratory environment, it was determined that the field bindweed seeds collected from different provinces generally adapt to the lowest 10°C and showed high germination rates. During the germination temperature study in field bindweed, temperatures between 5 and 10°C (6, 7, 8 and 9°C) were not used. In the future germination temperature study, it is stated that the germination of field bindweed will be at the lowest level between 5 and 10° C. It has been determined that seeds of Ankara, Erzurum and Kayseri proved to have high germination rates at 40 °C, but germination rates of seeds in all provinces decreased after 35°C (Table 2 and Figure 4). The field bindweed, which is a perennial weed, has been observed to germinate in a wide temperature range as a result of the study. Field bindweed seeds were observed to germinate at 5°C, but this germination had no effect on the development of the radicle. Ozkil & Uremis (2019), found that the optimum germination temperature of the field bindweed is between 20-30°C. Ozkil and Uremis (2019), determined that there was no germination in field bindweed at 2 and 45°C, Tanveer et al. (2013), at 45°C and it paralleled our study. It is thought that the most favorable germination temperatures differ in the germination temperature study, the seeds are collected from different regions and the environment is adapted to the temperature change. On the other hand, changing the appropriate germination temperatures in the germination temperature study of the field bindweed collected from different provinces shows that the field bindweed, which is a perennial weed, adapts to different environments and it is thought that the temperature studies on seeds will differ.

As a result, it is expected that the results obtained in the study of field bindweed related to seed biology will play an important role in the management the damage caused by this weed species to agricultural production and the natural ecosystem and to create a substructure for scientific studies.

Conclusions

It has been determined that field bindweed, which is a harmful and invasive weed in agricultural areas, has a strong dormancy and the most effective methods of breaking this dormancy have been sulfuric acid and hot water application. In breaking dormancy in field bindweed, the temperature increase affected the applications and some applications increased, while some decreased. In the germination temperature studies, it was found that field bindweed germinated between different germination temperatures according to the provinces. In addition, it has been observed that field bindweed germinates in a wide temperature range of 10-40°C. Due to its germination property in a wide temperature range, the field bindweed has strengthened its invasive feature and has revealed that it will appear anytime and anywhere. As a result, we see that the field bindweed weed has a cosmopolitan structure.

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References

Americanos, P. G. (1994). *Convolvulus arvensis* L. weed management for developing countries. Labrada. R. Caseley. J. and Parker. C. (eds.). FAO Publications, Rome, Italy, *No 120*, 95–99.

Anonymous (2019a). https://www.mecitalbayrak.com/ranked-of-provinces-by-altitude/. (Access date: 03/02/2020)

Anonymous (2019b). https://paintmaps.com/tr/ map-graphics / 217 / Turkey-map-graphic. (Access date: 03/02/2020)

Arikan, L., Kitis, Y., Uludag, A. & Zengin, H. (2015). Determination of observation frequency and density of weed species in citrus orchards of Antalya Province. *Turkish Journal of Weed Science* , *18 (2)*, 12-22.

Ates, E. (2017). Determination of some biological properties of weeds and wild mustard (*Sinapis arvensis* L.) and sterile wild oats (*Avena sterilis* L.) In Batman and Sanliurfa wheat fields. Mustafa Kemal University, Institute of Science, Plant Protection Department, Master Thesis.

Bewley, J. D. & Black, M. (1994). Seeds physiology of development and germination. 3rd Edition, Plenum Press, New York, 445.

Bond, W., Davies, G. & Turner, R. (2007). The biology and non-chemical control of field bindweed (*Convolvulus arvensis* L.). http://www.gardenorganic.org.uk./ organicweeds /downloads / convolvulus%20arvensis.pdf. Accessed: May 2017 (URL no longer active).

Bozdogan, O., Karaman, Y., Uyar, F., Evli, S., Akkaya, F. & Tursun, N. (2018). Effects of different application methods on the dormancy breaking in *Rumex crispus* L. (Curly dock) seeds. *Journal of Agricultural Faculty of Mustafa Kemal University*, *23(2),*188-196. ISSN:1300-9362

Brown, E. O. & Porter, R. H. (1942). The viability and germination of seeds of *Convolvulus arvensis* L. and other perennial weeds. *Research Bulletin,* Iowa Agriculture and Home Economics Experiment Station, *25 (294),* 477–504.

CABI (2019). Crop protection compendium online data sheet *Convolvulus arvensis* (bindweed). CABI Publishing 2019. www.cabi.org/ISC (Access date: 04.06.2019).

Callihan, R. H. (1961). The hard seed mechanism in *Convolvulus arvensis* L. and the influence of environmental variables upon germination. A Master Thesis, Oregon State University, ABD, 89.

DeGennaro, F. P. & Weller, S. C. (1984). Differential susceptibility of field bindweed (*Convolvulus arvensis*) biotypes to glyphosate. *Weed Sci., 32,* 472–476.

Guncan, A. (1979). Investigations on biology of Field Bindweed (*Convolvulus arvensis* L.) and management possibilities in wheat. Ataturk University Publishing, No 515. Department of Agriculture Publishing, No 234, Research Series, No 151.

Guncan, A. (2001). Weeds and management principles. Selcuk University, Faculty of Agriculture, Konya.

Hancerli, L. & Uygur, F. N. (2017). Weed species infesting corn growing areas in Çukurova Region. *Turkish Journal of Weed Science, 20 (2),* 55-60.

Holm, L. G., Plunknett, D. L., Pancho, J. V. & Herberger, J. P.

(1977). The world's worst weeds. University Press of Hawaii, Honolulu, Hawaii, USA, 98-104.

Iskenderoglu, N., Uygur, S. & Uygur, F. N. (1993). Research on breaking dormancy in some weed seeds. *Turkey I. Herbology Congress*, 109-116.

Jayasuriya, K. M. G. G., Baskin, J. M. & Baskin, C. C. (2008). Dormancy. germination requirements and storage behaviour of seeds of *Convolvulaceae* (*Solanales*) and evolutionary considerations. *Seed Science Research, 18 (4),* 223-237.

Jayasuriya, K. M. G. G., Baskin, J. M., Geneve, R. L. & Baskin, C. C. (2009). Phylogeny of seed dormancy in *Convolvulaceae*. subfamily *Convolvuloideae* (*Solanales*). *Annals of Botany, 103,* 45–63.

Karabacak, S. & Uygur, F. N. (2017). The most troublesome weed species infesting sunflower fields and their abundance in Çukurova Region. *Turk. J. Weed Sci., 20,* 46-54.

Kocacalıskan, I. (2002). Plant Physiology. ISBN: 975-8201-39-5, 420.

Kordali, S. & Zengin, H. (2011). Studies on weeds and their density, frequency and association in barley fields in Bayburt Provinces. *J. of Agricultural Faculty of Atatürk Univ., 42 (2),* 117-131.

Lubenov, Y. (1985). Harmful weeds are the source of death and life. Trans. B. Makakl, M. Dinçer, Ankara.

Lyons, K. E. (1988). Element stewardship abstract for *Convolvulus arvensis* L. In: Field bindweed. Arlington: The Nature Conservancy, 1-21.

Ozer, Z. (1995). Researches on the effects of different ecological environments on germination temperatures of some weed seeds. *VII. Phytopathology Congress of Turkey, 26-29 Sep. Adana*.

Ozkil, M. & Uremis, I. (2019). Research on the germination biology of field bindweed (*Convolvulus arvensis* L.) and three-lobe morning glory (*Ipomoea triloba* L.). *Plant Protection Bulletin, 59 (4),* 3-10.

Ozturk, D. (2019). Taxonomic investigations on Convolvulus L. (Convolvulaceae) species distributed in Eskişehir Province. *Eurasian J. Bio. Chem. Sci, 2(2),* 61-66.

Rolston, M. P. (1978). Water-impermeable seed dormancy. *Bot. Rev*. (Lancaster) *44,* 365.

Tamaki, G., Moffitt, H. R. & Turner, J. E. (1975). The influence of perennial weeds on the abundance of the redbacked cutworm on asparagi. *Environmental Entomology*, *4*, 274-276.

Tanveer, A., Tasneem, M., Khaliq, A., Javaid, M. M. & Chaudhry, M. N. (2013). Influence of seed size and ecological factors on the germination and emergence of field bindweed (*Convolvulus arvensis*). *Planta Daninha*. Viçosa-MG, *31(1),* 39-51.

Tiryaki, I. & Topu, M. (2014). A Novel method to overcome coat-imposed seed dormancy in *Lupinus albus* L. and *Trifolium pratense* L. *Journal of Botany, 1,* 6-6.

Uludag, A. (1993). Weed survey in cereal-lentil rotation crops in Diyarbakır and some biological aspects of important weeds. Cumhuriyet University, Institute of Science, MSc thesis, 50.

Uludag, A. & Ozer, Z. (1999). The effects of some chemical or mechanical tretments under varying temperatures on the germination of *Cerastium dichotomum* L., *Galium tricornutum* Dandy, *Scandix pecten-veneris* L. and *Asperula arvensis* L. *Turkish Journal of Weed Science, 2 (1),* 6-16.

Uremis, I. & Uygur, F. N. (1999). Minimum, optimum and maximum germination temperatures of some important weed seeds in Cukurova Region. *Turkish Journal of Weed Science, 2 (2),* 1-12.

Ustuner, T. (2016). Determination of weed density, frequency and general coverage areas in chickpea fields in Kahramanmaras. *Turkish Journal of Weed Science, 19(2),* 38-48.

Vogelgsang, S. (1998). Pre-emergence elficacy of phomopsis *C. arvensis* ormeno to control Field Bindweed (*C. arvensis* L.). Ph.D. thesis. Department of Plant Science. Macdondd Campus of McGU University Montr6al. QC. Canada.204.

Weaver, S. A. & Riley, W. R. (1982). The biology of Canadian weeds. 53. *Convolvulus arvensis* L. *Canadian Journal of Plant Science, 62,* 461-472.

Wright, S. D., Elmore, C. L. & Cudney, D. W. (2011). Field Bindweed. http://ipm.ucanr.edu/PMG/PESTNOTES/pn7462.html (accessed: May 2017)

Xiong, R.. Wang, Y., Wu. H., Ma, Y., Jiang, W. & Ma, X. (2018). Seed treatments alleviate dormancy of field bindweed (*Convolvulus arvensis* L.). Weed Science Society of America, *Weed Technology, 32(5),* 564-569. https://doi.org/10.1017/wet.2018.46

Yadav, S., Atul, H. & Umekar, M. (2018). Convolvulaceae: A morning glory plant. *International Journal of Pharmaceutical Sciences Review and Research, 51 (1),* 103–117.

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