Pak. J. Bot., 52(3): 901-908, 2020. DOI: http://dx.doi.org/10.30848/PJB2020-3(18)

EFFECTS OF SEED AGE, GERMINATION TEMPERATURE, GIBBERELLIC ACID AND STRATIFICATION ON GERMINATION OF *SILENE COMPACTA*

SELMA KOSA* AND OSMAN KARAGUZEL

Department of Landscape Architecture, Akdeniz University, Main Scientific Branch of Landscape Plants, Antalya 07070, Turkey
**Corresponding author's email: selmakosa@akdeniz.edu.tr*

Abstract

Natural populations of *Silene compacta*, native to South Anatolia, have ornamental potential for use in bedding plant design. However, some germination difficulties need to be overcome to meet industry needs. In the present study, the effects of seed age, germination temperature, gibberellic acid (GA_3), and stratification on germination characteristics of *S. compacta* seeds were investigated in two experiments. First, the effects of seed age (1 and 2 years), germination temperature (10, 15, 20, 25, and 30°C), and GA_3 treatment (soaking the seeds in distilled water as the control, and GA_3 solutions of 125 and 250 $mg.L^{-1}$ concentrations for 24 h) were tested. Second, the effects of seed age (1 and 2 years) and stratification (wet at 4°C) durations for 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, and 22 weeks on *S. compacta* seed germination characteristics at 25°C were investigated. Results from the first experiment indicated that seed age, germination temperature, and GA_3 treatments significantly affected *S. compacta* seed germination characteristics. Germination was higher in non-GA_3 treated 2-year-old seeds at germination temperatures of 25°C than in other experimental treatments. Consequently, the highest, but not adequate, germination (21.33%) was recorded in non-GA_3 treated 2-year-old seeds. In the second experiment, significant linear and quadratic relations were found with stratification durations and germination characteristics of *S. compacta* seeds with significant differences relating to the seed age. The highest germination percentage (82.67%) and most adequate germination characteristics were recorded in 2-year-old seeds stratified for 18 weeks. Results indicated that seeds of this *S. compacta* native population have deep physiological dormancy.

Key words: Catchfly, Propagation, Physiological dormancy, Native population, South Anatolia.

Introduction

Recently, there has been increasing interest in the use of native plant species in planting designs and landscaping (Brzuszek & Harkess, 2009; Nektarios *et al.*, 2011; Kösa & Karagüzel, 2012; Papafotiou *et al.*, 2013; Kokkinou *et al.*, 2016). This can create large opportunities for some countries, which are rich in plant taxa with high potential for ornamental use (Heywood, 2003; Wilkins & Anderson, 2007). Native flora of Turkey is relatively rich in *Silene* genus, including 147 native taxa comprising 129 species (52 endemic), 29 subspecies, and 9 varieties (Davis *et al.*, 1988). Furthermore, *Silene compacta* and *Silene armeria* have been found to be favorable for use as ornamental plants (Öztan & Arslan, 1993; Karagüzel &Taşcıoğlu, 2007; Yilmaz & Yilmaz, 2009; Draghia *et al*., 2011; Draghia *et al*., 2013).

Silene compacta (Caryophyllaceae) is completely glabrous, with erect stems up to 120 cm with numerous pink flowers on heads, and is a biennial or short-lived perennial species, native to West, South, Central, North, East, and South East Turkey at altitudes 0–2,100 m (Coode & Cullen, 1967). Yilmaz and Yilmaz (2009) stated that *S. compacta* with attractive flowers and a relatively long flowering period has considerable potential for use in bedding plant design, for instance as a bedding or ground cover plant for rock and roof gardens.

The use of native plant species or wild relatives of cultivated plants as ornamental plants is a complex process (von Henting, 1998; Brzuszek & Harkess, 2009) and propagation techniques are fundamental (Heywood, 2003; Wilkins & Anderson, 2007). In practice, most bedding plant species are propagated from seeds. However, previous studies on *Silene* germination indicated that seeds from some taxa have germination difficulties, mainly originating from physiological dormancy (Andersson & Milberg, 1998; Mondoni *et al.*, 2009) and similar difficulties have been determined in germination tests of fresh *S. compacta* seeds.

Numerous studies have suggested that the germination response of plant species depends on the ecological conditions for seed production and genetics, and on other environmental variables, such as light, water, humidity, and temperature, and endogenous variables, such as seed age, dormancy, hormonal activity, and biochemical or chemical substances (Hartmann *et al*., 2002; Conversa & Elia, 2009; Baskin & Baskin, 2014; Pipinis *et al.*, 2014).

Rees and Long (1993), and Valleriani and Tielbörger (2006) stated that ageing generally decreased germination rates, but germination percentage can increase with ageing in some cases for a certain age period. For instance, Micle (1985) reported that *S. compacta* seed viability decreased with ageing 3–10 years after harvesting. Caixinhas *et al.*, (1993) found that germination rates of 4-year-old *S. elegans* and *S. macrorhiza* seeds were 63% and 25%, respectively. In addition, germination ability may vary among species, and may even vary among different individuals of the same species in different years, different regions, and even in the same micro growth environment (Baskin & Baskin, 2014; Gülcü & Taramış, 2017).

Temperature has a very important role on seed conservation and can be used to overcome certain types of physiological dormancy and achieve final germination success (Bouwmeester & Karssen, 1992; Brändel & Jensen, 2005; Baskin & Baskin, 2014; Kellmann-Sopyla & Giełwanowska, 2015). It was found that 100%

germination occurred in *S. rhynchocarpa* seeds at a temperature of 20°C in the dark (Kırmızı *et al.*, 2013), and only 3.3% germination occurred in *S. vulgaris* at 5°C (Bencivenga *et al.*, 1987). In *S. armeria*, Karagüzel and Taşcıoğlu (2007) found that there was no physiological dormancy in seeds and the highest germination (95.6%) was recorded at 20ºC in the dark.

Gibberellic acid (GA_3, GA_4, and GA_7) has been used to determine the degree of dormancy or break physiological dormancy, and increase seed germination of several plant species (Baskin & Baskin, 2004; Tiawoun *et al*. 2017). In *S. elisabethae*, the effects of 250 $mg.L^{-1}$ GA_3 treatments on seed germination at 15/5, 20/10, and 25/15°C day/night temperatures under 12/12 h light/dark photoperiods were studied and the results indicated GA_3 treatment considerably increased germination rates (Mondoni *et al.*, 2009).

In *Silene* taxa, several studies on breaking dormancy using stratification treatments have been carried out. For instance, Giménez -Benavides *et al.*, (2005) stated that *S. ciliata* subsp. *elegans* seeds stratified for 12 weeks at 4°C had a 96% germination rate in 15°C. For *S. involucrate*, 99% of the seeds stratified for 8 months at 4°C germinated (Kellmann-Sopyla & Giełwanowska, 2015).

However, there is limited information on *S. compacta* germination characteristics. Öztan and Arslan (1993) directly sowed *S. compacta* seeds in landscaping areas and evaluated plant performance for landscaping under Central Anatolia climatic conditions. Draghia *et al.*, (2011) determined that 54% of *S. compacta* seeds germinated in greenhouse conditions within 8 days. In our pre-experiments and germination tests, it was revealed that there were serious difficulties in *S. compacta* seed germination and it is necessary to investigate seed response to ageing, temperature, gibberellic acid, and stratification duration. Therefore, the present study was conducted to determine the effects of seed age, germination temperature, gibberellic acid, and stratification on the germination characteristics of *S. compacta* seeds harvested from a native population in the Cevizli District of Antalya Province (South Anatolia), Turkey.

Materials and Methods

Plant material: In this study, 1- and 2-year-old seeds harvested from native populations of *S. compacta* grown in Cevizli District, Antalya Province (South Anatolia, Turkey), were used as plant material. Based on Hartmann *et al.*, (2002), seeds were sterilized for 10 min in a 10% hypochlorite solution, washed thoroughly, and dried at room conditions. Then, seeds were placed in a glass-jar and stored for 1 and 2 years at room temperature (25.3 ± 4.8ºC) and relative humidity (64.8 ± 7.4 %) until germination experiments were conducted.

Methods: In the present study, several germination tests were performed for two separate germination experiments and the same test procedures were applied in all germination tests in the dark. Based on Karaguzel *et al*., (2004) with limited differences, 50 seeds were placed in 11-cm Petri dishes containing two layers of blotting paper moistened with 15 mL distilled water. After the first watering, distilled water was used exclusively for moistening blotting paper and was applied as needed (Karaguzel *et al.*, 2004). All germination tests lasted for 21 days. Germination was defined by the presence of a radicle at least 2 mm long (Mackay *et al*., 1995) and germinated seeds were counted daily. In each germination test and experiment, the main germination characteristics, such as germination percentage (%), mean germination time (day), germination index, and germination energy were calculated according to Karaguzel *et al.*, (2004), Alvarado *et al*., (1987), and Ruan *et al*., (2002), respectively.

Experiment 1: In this experiment, effects of seed age, germination temperature, and gibberellic acid (GA_3) on *S. compacta* seed germination characteristics were determined. For the germination tests, 1- and 2-year-old seeds were soaked in GA_3 solutions for 24 h at 0 (control-distilled water), 125, and 250 $mg.L^{-1}$ concentrations, and placed in an incubator at germination temperatures of 10, 15, 20, 25, and 30°C. The experiment was conducted using a three factorial (germination temperature × age × GA_3) completely randomized design (CRD) with three (3 Petri-dishes, 50 seeds per Petri-dish) replications (Chitwood *et al.*, 2016).

Experiment 2: The aim of this experiment was to investigate the effects of seed age and stratification duration on *S. compacta* seed germination characteristics. Half the 1- and 2-year-old seeds needed for this experiment were reserved for stratification treatments, and the other half were stored at the room temperature and humidity conditions used for the controls. In the stratification duration treatments, adequate quantities of 1- and 2-year-old seeds were placed in a cheesecloth bag that was placed on a 5 cm thick perlite layer within a plastic-case, then the seed-bag was covered with 5 cm perlite, and finally the plastic case was completely moistened, and no leaching occurred. The plastic cases prepared for the stratification treatments were placed in a refrigerator at 4°C and the seed samples for the stratification duration treatments were taken from the refrigerator 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, and 22 weeks after beginning stratification, and the seeds used as the control were simultaneously prepared for germination tests at 25°C. The experiment was conducted using a two factorial (stratification duration × seed age) completely randomized design (CRD) with three (3 Petri-dishes, 50 seeds placed per Petri-dish) replications (Zhang, 2012).

Data analyses: Data relating to germination characteristics considered in the experiments were analyzed using analysis of variance (ANOVA) with general linear models (GLM) in SPSS 13.0 for Windows (SPSS Inc., 2004) software and means were compared using Duncan's multiple range tests at a significance level of 5% using data splitting where appropriate.

Results

Experiment 1: The ANOVA results indicated that seed age (SA), germination temperature (GT), and GA_3 treatment significantly affected *S. compacta* seed

germination (Table 1). Additionally, germination significantly differed with SA × GT and GT × GA_3 interactions (Table 1). Duncan's tests showed that germination means were higher in 2-year-old seeds, 25°C germination temperatures, and control seeds for GA_3 treatments than under other levels of the main treatment factors (Fig. 1abc). One and two year-old seeds treated with 125 and 250 $mg.L^{-1}$ GA_3 did not germinate at 30°C, and similar results were recorded for 1-year-old seeds at 10°C (Table 1). Finally, the highest germination (21.33%) occurred in 2-year-old and non-GA_3 treated (control) seeds at 25°C (Table 1).

S. compacta seeds were less sensitive to SA and GA_3 treatments and their interaction with respect to mean germination time than that of germination percentage (Table 1). Only the main effects of GT and GT × GA_3 interactions had significant effects on the mean germination time in *S. compacta* seeds. As results of these phenomena, the shortest mean germination times (about 13.0–14.0 days) were counted under 25°C germination temperatures with seeds that were either 1- or 2-year-old and non-treated or treated with GA_3 solutions (Table 1).

SA, GT and GA_3 treatments, and their interactions significantly affected the germination index values of *S. compacta* seeds (Table 1). The germination index means were higher in 2-year-old seeds at a 25°C germination temperature and control seeds than in those under other treatments, similarly to that of germination percentages (Table 1). For SA × GT × GA_3 treatment interactions, the highest germination index mean (16.37) was recorded for 2-year-old and non-GA_3 treated (control) seeds at a 25°C germination temperature (Table 1).

Results from the ANOVA analyses showed that SA, GT, and GA_3 treatments significantly affected general germination energy means, and these differed significantly with respect to GT × GA_3 interactions (Table 1). As in the germination percentage and index, the highest germination energy value (19.00) occurred in 2-year-old and non-GA_3 treated (control) seeds at a 25°C germination temperature (Table 1).

Table 1. Effects of seed age, germination temperature and GA_3 treatments on germination characteristics of *S. compacta* seeds.

Seed age (year)	Temperature (°C)	GA_3 ($mg.L^{-1}$)	Germination characteristics			
			Germination percentage (%)	Mean germination time (day)	Germination index	Germination energy
1	10	0 (control)	0.67 de[z]	14.500 bcd	0.35 de	0.67 c
		125	0.00 e	-	0.00 e	0.00 c
		250	0.00 e	-	0.00 e	0.00 c
	15	0 (control)	6.00 bc	15.10 bcd	2.34 cde	3.33 bc
		125	2.67 bcde	15.41 bcd	1.12 de	0.67 c
		250	1.33 cde	16.50 ab	0.44 de	0.67 c
	20	0 (control)	2.67 bcde	17.91 a	0.55 de	0.00 c
		125	5.33 bcd	16.63 ab	1.58 de	1.33 c
		250	6.67 b	15.30 bc	2.86 cd	2.67 c
	25	0 (control)	18.67 a	13.07 d	13.53 a	17.33 a
		125	14.67 a	13.45 cd	10.25 b	14.00 a
		250	7.33 b	13.72 cd	4.59 c	7.33 b
	30	0 (control)	0.67 de	13.50 cd	0.23 de	0.33 c
		125	0.00 e	-	0.00 e	0.00 c
		250	0.00 e	-	0.00 e	0.00 c
2	10	0 (control)	4.67 def	15.94 b	1.27 fgh	0.67 gh
		125	3.33 def	18.39 a	0.60 gh	0.00 h
		250	2.67 ef	14.53 bcd	1.30 fgh	2.00 fgh
	15	0 (control)	10.00 bcde	14.85 bcd	4.46 de	6.33 d
		125	4.00 def	14.71 bcd	1.89 fgh	3.33 defgh
		250	7.33 cde	15.33 bc	3.02 efg	5.33 def
	20	0 (control)	16.00 ab	14.83 bcd	6.46 cd	6.00 de
		125	12.00 bc	16.14 b	3.57 ef	2.67 efgh
		250	16.67 ab	16.10 b	5.36 cde	4.00 defg
	25	0 (control)	21.33 a	13.04 de	16.37 a	19.00 a
		125	10.67 bcd	13.45 cde	7.46 bc	10.67 c
		250	14.67 ab	13.72 cde	9.54 b	14.00 b
	30	0 (control)	0.67 f	12.00 e	0.72 gh	0.33 h
		125	0.00 f	-	0.00 h	0.00 h
		250	0.00 f	-	0.00 h	0.00 h
Significance *(P values)*						
Seed age (SA)			<0.001	0.270	<0.001	0.001
Germination temperature (GT)			<0.001	<0.001	<0.001	<0.001
GA_3			0.004	0.145	<0.001	0.001
SA×GT			0.001	0.218	0.010	0.096
SA×GA_3			0.082	0.712	0.003	0.059
GT×GA_3			0.016	0.019	<0.000	0.001
SA×GT×GA_3			0.466	0.102	0.016	0.080

[z]: Within each column (germination characteristic) and seed age, means followed by the same letter are not significantly different a the 5% level according to Duncan's multiple range tests

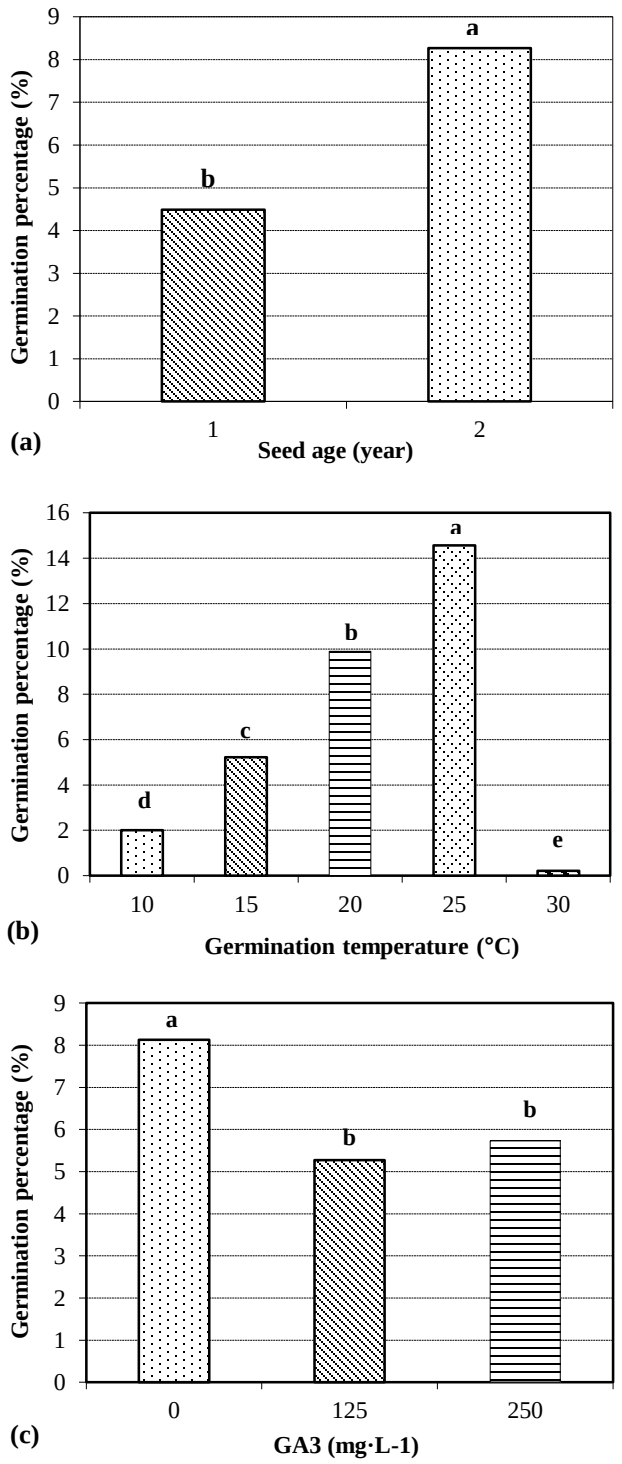

Fig. 1. Main effects of seed age (a), germination temperature (b) and GA_3 treatment (c) on germination percentages of *S. compacta* seeds. In graphs, means marked by the same latter are not significantly different at the 5% level according to Duncan's multiple range tests.

Experiment 2: Data and statistical analyses related to the effects of SA and stratification duration (SD) on germination characteristics of *S. compacta* seeds are included in Table 2, Figure 2, and Table 3. Generally, there were significant linear and quadratic relations between stratification durations and germination characteristics considered in this experiment for each seed age (Table 3).

SA, SD, and their interactions significantly affected germination (Table 2). The mean germination in 2-year-old seeds was about 2.5 times higher than that of 1-year-old seeds and a higher mean germination occurred in stratified seeds (Fig. 2ab). There were significant linear and quadratic relations between stratification durations and germination percentages for each seed age and germination significantly differed in relation to SA × SD interactions (Table 2; Table 3). The highest and most adequate germination (82.67%) was recorded for 2-year-old seeds stratified at 4°C for 18 weeks (Table 3).

SA and SD significantly affected the mean germination time of *S. compacta* seeds; however, SA × SD interaction had no significant effect on mean germination times (Table 2). The mean germination times in 2-year-old seeds were slightly shorter than that of 1-year-old seeds, and the longest mean germination times occurred in non-stratified seeds (Table 2; Table 3). Shorter mean germination times (~13 days) were recorded in seeds stratified for 14–22 weeks without significant differences regarding seed age and stratification durations (Table 3).

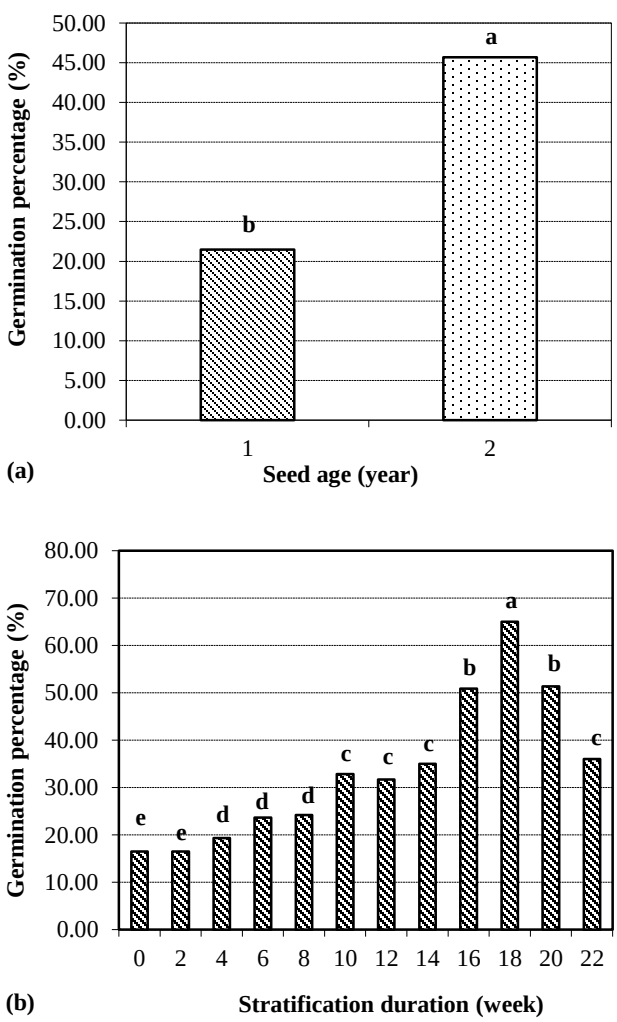

Fig. 2. Main effects of seed age (a) and stratification duration (b) on germination percentages of *S. compacta* seeds. In graphs, means marked by the same latter are not significantly different at the 5% level according to Duncan's multiple range tests.

Table 3. Effects of seed age and stratification duration on germination characteristics of *S. compacta* seeds.

Characteristic	Seed age (year)	Stratification duration (week)												Curve Estimation (*P value*)
		0	2	4	6	8	10	12	14	16	18	20	22	
Germination percentage (%)														
	1	14.33 Be	12.67 Be	14.33 Be	14.67 Be	15.67 Be	16.33 Be	18.67 Bde	24.00 Bcd	31.67 Bb	47.33 Ba	24.67 Bc	23.33 Bcd	L(*P<0.001*) Q(*P<0.001*)
	2	18.67 Ae	20.33 Ae	24.33 Ade	32.67 Ad	32.67 Ad	49.33 Ac	44.67 Ac	46.00 Ac	70.00 Ab	82.67 Aa	78.00 Aab	48.67 Ac	L(*P<0.001*) Q(*P<0.001*)
Mean germination time (day)														
	1	15.06 Aa	15.17 Aa	14.25 Aab	13.92 Aab	13.91 Aab	14.55 Aab	13.66 Aab	12.95 Abc	12.65 Ac	12.93 Abc	13.26 Abc	12.71 Ac	L(*P<0.001*) Q(*P<0.001*)
	2	15.37 Aa	13.13 Acde	13.42 Acd	13.74 Ac	14.56 Ab	13.82 Abc	13.47 Acd	12.98 Acde	12.09 Bf	12.51 Bef	12.63 Bdef	12.45 Aef	L(*P<0.001*) Q(*P<0.001*)
Germination index														
	1	10.B38 ef	9.18 Bf	11.40 Bef	11.34 Bef	12.00 Bef	12.33 Bef	13.56 Bdef	14.78 Bd	28.26 Bb	38.18 Ba	18.44 Bcd	20.81 Bc	L(*P<0.001*) Q(*P<0.001*)
	2	14.33 Ae	18.81 Ae	18.30 Ae	21.25 Ae	22.81 Ade	30.59 Acd	31.38 Acd	37.52 Abc	76.22 Aa	75.88 Aa	69.28 Aa	46.17 Ab	L(*P<0.001*) Q(*P<0.001*)
Germination energy														
	1	13.33 Ade	11.67 Be	12.33 Bde	13.67 Bde	14.67 Bde	14.00 Bde	17.33 Bcd	22.33 Bbc	23.33 Bbc	47.33 Ba	20.00 Bc	22.67 Bbc	L(*P<0.001*) Q(*P<0.001*)
	2	16.67 Ae	18.00 Ade	21.67 Ade	24.67 Ade	29.33 Ad	41.33 Ac	44.67 Ac	46.00 Ac	70.00 Ab	82.67 Aa	76.00 Aab	48.67 Ac	L(*P<0.001*) Q(*P<0.001*)

L: Linear, Q: Quadratic

[y]: Within each stratification duration (column) and germination characteristic, means followed by the same upper case are not significantly different at the 5% level according to Duncan's multiple range tests.

[z]: Within each germination characteristic and year (row), means followed by the same lower case are not significantly different at the 5% level according to Duncan's multiple range tests.

Table 2. Mean squares and significances from analysis of variance (ANOVA) for the effects of seed age and stratification duration on germination characteristics of *S. compacta* seeds.

Variation source	df	Mean squares			
		Germination percentage (%)	Mean germination time (day)	Germination index	Germination energy
Seed age (SA)	1	10536.681***	2.926 *	8573.930 ***	10296.125 ***
Stratification duration (SD)	11	1410.256***	4.290 ***	1445.452 ***	1454.347 ***
SA×SD	11	302.620***	0.678 NS	378.174 ***	395.852 ***
Error	48	21.986	0.460	17.676	25.250
Total	71				

NS, *,***: Not significant and significant at $p<0.05$ and $p<0.001$, respectively

Mean germination indexes significantly differed with SA and SD, and SA × SD interactions significantly affected the germination index of *S. compacta* seeds (Table 3). Similar to germination percentages, there were strong and significant linear and quadratic relations between stratification durations and germination indexes (Table 3). The highest germination index values (69.28, 75.88, and 76.22) without statistically significant differences occurred in the 2-year-old seeds stratified at 4°C for 20, 18, and 16 weeks, respectively (Table 3).

Significant differences in germination energy values had close similarities to that of germination percentages and indexes. SA and SD and their interactions significantly affected the germination energy of *S. compacta* seeds (Table 2). The highest mean germination energy values occurred in 2-year-old seeds and seeds stratified at 4°C for 18 weeks (Fig. 2). Similar to the other characteristics considered in this experiment, there were significant linear and quadratic relations between stratification durations and germination energy values (Table 3). In SA × SD interactions, the highest germination energy value (82.67) occurred in 2-year-old seeds stratified for 18 weeks (Table 3).

Discussion

In the present study, the effects of seed age, germination temperature, gibberellic acid (GA_3), and stratification on *S. compacta* seed germination characteristics were investigated in two experiments. Results from the first and second experiments showed that the duration of dry storage after ripening (harvest), i.e., certain ageing periods (one or two years), increased *S. compacta* seed germination, but did not completely overcome germination difficulties in seeds aged for 2 years. This could be an indication of deep physiological dormancy, according to the well-detailed dormancy classification described by Baskin and Baskin (2004; 2014). Viability in *S. compacta* seeds decreased with ageing; however, only 3–10 years after harvesting (Micle, 1985). Caixinhas *et al*., (1993) also stated that germination rates of 4-year-old *S. Elegans* and *S. macrorhiza* seeds were 63% and 25%, respectively.

GA_3 treatments had no increasing effects on germination characteristics of *S. compacta* seeds and soaking the seeds in 125 and 250 $mg.L^{-1}$ GA_3 solutions for 24 h slightly decreased their germination. Generally, gibberellic acid is a growth regulator that promotes germination (Hartman *et al.*, 2002; Machado de Mello *et al.*, 2009; Parvin *et al.*, 2015) and has been used to break physiological dormancy, and increase the seed germination in several plant species (Baskin & Baskin, 2014). In *S. elisabethae*, GA_3 treatments combined with different germination temperatures and light conditions considerably increased germination rates (Mondoni *et al.*, 2009). However, it was previously found that GA_3 did not affect germination rates, which were dependent on the kind of seed dormancy (Baskin & Baskin, 2014), and it also inhibited germination of some plants species (Villa *et al.*, 2016).

Results related to the first experiment also revealed that germination temperature significantly affected *S. compacta* seed germination characteristics and the highest germination percentage, index, and energy values were recorded at 25°C. As in many biological processes, temperature is fundamental for the success of final germination in most plant species (Bouwmeester & Karssen, 1992; Brändel & Jensen, 2005; Baskin & Baskin, 2014; Kellmann-Sopyla & Giełwanowska, 2015). However, optimal germination temperature requirements of plants can vary considerably between species, populations, or genotypes, and also the micro-ecological conditions that the mother plants were grown in (Baskin & Baskin, 2014; Gülcü & Taramış, 2017). In *Silene*, germination *S. rhynchocarpa* seeds was 100% at 20°C (Kırmızı *et al.*, 2013), and in *S. vulgaris* was 3.3% at 5°C (Bencivenga *et al.*, 1987). For *S. armeria* seeds, Karagüzel & Taşcıoğlu (2007) found no physiological dormancy and the highest germination (95.6%) was recorded at 20ºC. Therefore, it can be concluded that the optimal germination temperatures of the *S. compacta* populations used in the present study were slightly higher than that of other *Silene* species, such as *S. armeria*.

The most remarkable finding from the first experiment was obtaining low and inadequate germination percentages from all of the treatment factors and their combinations. Although seed age, germination temperature, and GA_3 significantly affected *S. compacta* seed germination, the highest, but inadequate germination (21.33%) was recorded in non GA_3 treated 2-year-old seeds germinated at 25°C. This could possibly have been a result of deep physiological dormancy in *S. compacta* seeds based on the classification criteria evaluated by Baskin and Baskin (2004; 2014).

Results related to the second experiment indicated seed age and stratification duration and their interactions significantly affected most germination characteristics considered in the experiment. Furthermore, there were significant linear and quadratic relations between germination characteristics and stratification duration. Germination percentages were higher in 2-year-old seeds and

increasing stratification duration up to 18 weeks resulted in increased germination, without eliminating differences originating from seed age. Hence, the highest and adequate germination (82.67%) for practice was recorded in 2-year-old seeds stratified at 4°C for 18 weeks. Several previous studies determined the effectiveness of stratification to overcome physiological dormancy in many plant species (Baskin & Baskin 2014). In *Silene*, Giménez -Benavides *et al.,* (2005) reported 96.0% germination in *S. ciliata* subsp. *elegans* seeds after 3 months cold-wet stratification at 4°C. Kellmann-Sopyla and Giełwanowska (2015) stated 99.0% germination occurred in *S. involucrate* seeds at different temperatures after 8 months storage at 4°C. In contrast, no dormancy occurred in *S. armeria* seeds harvested from a S1 generation of a native population from North East Anatolia (Karagüzel & Taşcıoğlu 2007), suggesting that *Silene* species could show different germination characteristics according to genetic content, and indigenous and environmental variables.

The information on *S. compacta* germination evaluated in this study using a certain population could not be used to explain the germination characteristics of all native populations. It is well-known that germination varies among species, and may even vary among different individuals of the same species in different years, in different regions, and even in the same micro growth environment (Anderson & Milberg, 1998; Baskin & Baskin, 2014; Gülcü & Taramış, 2017). However, observations from this study are valid in context with information pertaining to the germination characteristics of *S. compacta* species.

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(Received for publication 11 August 2018)