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Influences of presowing treatments on the germination and emergence of fig seeds (*Ficus carica* L.)

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ABSTRACT. Seed germination of fig seeds is important for obtain seedlings with high variability in breeding studies, and for producing mosaic virus-free seedlings. This experiment was carried out to evaluated the effects of several treatments (priming with water for 24h, GA_3 at 500 and 1000 ppm for 24h, 3% KNO_3 for 24h, and stratification at 4°C for 7, 14 and 21 days) on seed germination and emergence of 'Bursa Siyahı' and 'Sarılop' fig cultivars. The application of GA_3 increased the germination and emergence of these fig seeds. The highest percentages of germination and emergence were obtained with GA_3 at 500 or 1000 ppm for both cultivars. The seed germination and emergence of the cultivar 'Bursa Siyahı' were higher than observed with the 'Sarılop'. The application of GA_3 at 500 ppm or 1000 ppm reduced the time to germination and emergence from the seeds of both cultivars. In summary, the GA_3 treatments showed efficacy to overcome the dormancy of these fig seeds.

Keywords: *Ficus carica* L., fig, seed germination, seedling emergence, seed treatments.

Influências de tratamentos pré-semeaduras na germinação e na emergência de sementes de figo (*Ficus carica* L.)

RESUMO. A germinação de sementes de figo é muito relevante para obter mudas com alta variabilidade e para a produção de mudas livres de vírus. O experimento avaliou os efeitos de vários tratamentos (com água durante 24h, GA_3 a 500 e 1000 ppm durante 24h, 3% KNO_3 durante 24h, e estratificação numa temperatura de 4°C durante 7, 14 e 21 dias) na germinação e emergência de sementes de cultivares de figos 'Bursa Siyahı' e 'Sarılop'. A aplicação de GA_3 aumentou a germinação e a emergência destas sementes. As mais altas porcentagens de germinação e emergências foram obtidas com GA_3 a 500 ou 1000 ppm para os dois cultivares. A germinação e a emergência de sementes do cultivar 'Bursa Siyahı' foram maiores das obtidas com 'Sarılop'. GA_3 a 500 ppm ou 1000 ppm reduziu o tempo de germinação e emergência para as sementes de ambos os cultivares. Os tratamentos com GA_3 tiveram mais eficácia para superar a dormência de sementes de figo.

Palavras-chave: *Ficus carica* L., figo, germinação de semente, emergência de mudas, tratamentos de semente.

Introduction

Ficus is a botanical genus that contains over 700 different species, and characterized by a particular reproductive system (BERG, 2003) Functionally, it is dioecious plant which has male and female fig cultivated for fruit production, and the female trees produces syconia with only female flowers that are containing of the seeds (VALDEYRON; LLOYD, 1979).

Genetic variability in fig is enhanced by the obligatory outcrossing within species that results in the production of new individuals with favorable characteristics such as productivity, fruit size, and fruit colour. As the fig plants are easily and repeatedly propagated through cuttings, there is opportunity for phenotypic variability from natural mutations and environmental factors within a cultivar (FLAISHMAN et al., 2008). Although the fig propagation is made by rooting the cuttings, genetically different plants can be developed from seeds produced in female trees. Currently, unknown genes still determine whether a seed from a single syconium will be a caprifig or an female fig. (BECK; LORD, 1988).

Seeds are important for propagating the seedling rootstocks and for obtaining hybrid plants (HARTMANN et al., 2002), but the seed germination is influenced by internal factors as the seed coat, undeveloped embryo or chemical inhibitors (AGRAWAL; DADLANI, 1995) that induces seed dormancy. There are different methods to eliminate the seed dormancy as, for example, seed soaking in water (CETINBAS; KOYUNCU, 2006), stratification, scarification (AL ABSI, 2010), KNO_3 (FURUTANI; NAGAO, 1987) and the application of gibberellin (CETINBAS; KOYUNCU, 2006).

In breeding programmes, fig seeds are most important material for producing hybrid plants, and these seeds have generally been used for producing mosaic virus-free seedlings in the last decade (CAGLAYAN et al., 2010). Currently, there is no information about the germination and seedling emergence of fig seeds, but Ellis et al. (1985) stated that high percentages of *F. carica* seed germination is more difficult to achieve under laboratory conditions. The objectives of the present study were to determine the influences of presowing treatments on the germination and seedling emergence of two fig cultivars. The 'Bursa Siyahı' cultivar with black peel is the most important fresh fig with high quality, for exportation. The 'Sarılop' with yellow peel is the best cultivar to produce dried fig fruit. According to this results, germination of all fig seeds to be obtained from the hybridization could be provided as soon as possible, and could be obtained uniform seedlings.

Material and methods

The cultivars 'Bursa Siyahı' and 'Sarılop' were cultivated under field conditions (36°54′N, 36°13′E, altitude 198 m) at the Department of Horticulture, in the Faculty of Agriculture, University of Mustafa Kemal, Hatay, Turkey. Fruit of both cultivars were collected in the full ripening period in August 2009 and 2010. For each cultivars, 50 main crop fruits were randomly collected. These fruit were manually macerated, the seeds were extracted, and dried under shade conditions for two days.

Eight treatments were used for germination and emergence tests. The seeds in these treatments were control, priming with water (10 mL) for 24h, 3% KNO_3 (10 mL) for 24h (DEMIR; MAVI, 2004), GA_3 at 500 ppm (10 mL) and 1000 ppm (10 mL) (Gibberelex, Valent BioSciences) for 24h, and stratification at +4°C for 7, 14 and 21 days. All the priming treatments were moistened on top of filter paper in Petri dishes (80 mm, Isolab Inc.). All priming applications were exposed for 24h at 25°C in an incubator. For stratification treatments were used a refrigerator. Germination tests were conducted in petri dishes using filter paper moistened with distilled water. The Petri dishes were wrapped with plastic bags to minimize water losses during the test period. These dishes were placed in a seed germinator (ES120 Nüve Cooled Incubator, TR) at 25°C for germination. In the emergence experiments, the seeds were sown in plastic trays (container number, 12 x 16; volume 15 cc) filled with peat (Potground P, 70 L, Klasmann, Germany), and placed under room conditions (minimum of 21°C and maximum temperature of 27°C). The seed germination was recorded for 30 days and the seedling emergence was recorded for 40 days.

All the seedlings with the radicle at least 2 mm in length were considered as germinated. Seedling emergence was recorded when the hypocotyls raised above the surface of the growing media. Germination percentages were calculated as the average of three replicates of 100 seeds, and the emergence were calculated as the average of three replicates of 50 seeds. The mean germination time (MGT) was calculated according to Ellis and Roberts (1980):

$$MGT = \Sigma\,(t.n)/\Sigma n,$$

where:

t is the time in days from 0 to the end of the germination test, and n is the number of germinated seeds on the day t.

Time to 50% (T_{50}) of germination and emergence were evaluated according to the formula suggested by Coolbear et al. (1984):

$$T_{50} = ti + \left[\frac{\frac{(N+1)}{2} - ni}{nj - ni}\right](tj - ti)$$

where:

N is the final number of seeds germinated, and ni and nj are total number of seeds germinated by adjacent counts at time ti and tj, where $ni < (N+1)/2 < nj$.

The percentage values were transformed by the angle transformation before submitting the data to the analysis of variance. Differences among means were analyzed by the Tukey's Honestly Significant Difference (HSD) method ($p < 0.05$) using SAS program (SAS INSTITUTE, 2005).

Results and discussion

For all the germination and emergence parameters, the main effects, two way interaction mean squares with their significance levels were displayed on the ANOVA (Table 1).

Table 1. Analysis of variance for the mean squares of germination (G), mean germination time (MGT), time to 50% of germination (GT_{50}), emergence (%), mean emergence time (MET), time to 50% of emergence (ET_{50}) of fig cultivars as affected by treatment and cultivar.

Source	df	G (%)	MGT (day)	GT_{50} (day)	E (%)	MET (day)	ET_{50} (day)
Cultivar (C)	1	7876.2**	254.3**	151.6**	1643.1**	117.7**	70.94**
Treatment (T)	7	2060.9**	23.5**	58.0**	1874.5**	72.1**	64.6**
C x T	7	106.3*	0.50ns	18.7**	236.9**	10.1**	2.43ns
Error	32	24.9	1.48	2.90	27.86	1.12	2.90
CV (%)		9.33	9.37	10.35	10.32	6.03	9.22

**Significant at $p < 0.01$; *Significant at $p < 0.05$, ns: non significant.

According to results of variance analysis, several germination and emergence parameters were significantly affected by cultivar and treatment, cultivar x treatment, whereas MGT and ET_{50} were non significant affected by cultivar x treatment.

Analysis of the two years average data indicated that effects of different treatments on seed germination, seedling emergences, MGT, MET, and T_{50} in both 'Bursa Siyahı' and 'Sarılop' cultivars statistically varied ($p < 0.05$). Some of seed traits of 'Bursa Siyahı' and 'Sarılop' cultivars were given Table 2. The mean of seed number per a fruit and seed weight were 772 and 1.05 g for 'Bursa Siyahı', respectively, while mean of seed number per a fruit and seed weight were 420 and 0.54 g for 'Sarılop'. 1000 seed weights were 1.25 g for 'Bursa Siyahı' and 1.28 g for 'Sarılop'.

Table 2. Seed characteristics of fig cultivars.

Cultivar	Seed Number per fruit	Seed weight per fruit	1000 seed weight (g)
Bursa Siyahı	772±5.29	1.05±0.10	1.25±0.03
Sarılop	419±5.03	0.54±0.06	1.28±0.01

The highest germination percentage was found in 500 ppm and 1000 ppm GA_3 treatments for both 'Bursa Siyahı' (100%) and 'Sarılop' cultivars (85%) (Table 3). 'Bursa Siyahı' and 'Sarılop' had the lowest germination percentages in primed in water (45 and 14%, respectively) and control (48 and 11%, respectively) treatments. There was lowest germination percentage for control seeds. The results indicated that the fig seeds have dormancy. Also, our results showed that seed germination of one old seeds in control was higher (60-70%) than fresh seeds (data not shown). The results showed that afterripening may be positive affect on fig seeds. Afterripening is defined as the progressive loss of dormancy in mature dry seeds. The efficacy of afterripening depends on the environmental conditions such as moisture, temperature, and oxygen. Dormant seeds, when dry, slowly lose their dormancy by the process of afterripening. Also, afterripening is well known to alleviate physiological dormancy and promotes germination of many species (BASKIN; BASKIN, 2004). Similar to our results, the previous studies on various species declared that GA_3 treatments could be stimulate the germination and shorten afterripening periods (FEURTADO et al., 2004; LEUBNER-METZGER, 2002; SCHMITZ et al., 2002).

Table 3. Germination percentage (G), mean germination time (MGT), time to 50% of germination (GT_{50}), emergence percentage (E), mean emergence time (MET), time to 50% of emergence (ET_{50}) in eight treatments of Bursa Siyahı and Sarılop cultivars.

Treatment	G (%)	MGT (day)	GT_{50} (day)	E (%)	MET (day)	ET_{50} (day)
			Bursa Siyahı			
Control	48 e[1]	13 a	20 a	32 d	20 a	18 b
24 hrs Water	45 e	12 ab	20 a	67 b	16 b	18 b
3% KNO_3	81 dc	12 ab	18 ab	74 b	16 b	18 b
7 day Stratification	64 de	12 ab	16 abc	38 cd	17 b	23 a
14 day Stratification	88 bc	11 abc	14 bcd	59 bc	18 ab	19 ab
21 day Stratification	95 ab	9 bc	12 cd	71 b	18 ab	17 b
500 ppm GA_3	100 a	8 c	9 d	98 a	12 c	13 c
1000 ppm GA_3	100 a	8 c	9 d	95 a	11 c	13 c
$HSD_{0.05}$	13.5	3.1	5.0	14.5	2.5	3.5
			Sarılop			
Control	11 e[1]	16 abc	20 ab	14 d	22 a	19 b
24 hrs Water	14 de	17 ab	18 abc	28 d	20 ab	21 b
3% KNO_3	59 b	18 a	22 a	71 bc	17 bc	19 b
7 day Stratification	20 cde	17 ab	20 ab	21 d	20 ab	27 a
14 day Stratification	33 cd	16 abc	17 bc	32 d	18 bc	22 ab
21 day Stratification	37 bc	14 bcd	14 c	48 c	18 bc	19 b
500 ppm GA_3	85 a	12 d	17 bc	87 ab	16 c	16 b
1000 ppm GA_3	85 a	13 cd	18 abc	93 a	15 c	16 b
$HSD_{0.05}$	14.7	3.7	4.5	14.8	3.3	5.8

[1]Mean comparisons within each column were compared by Tukey test at $p < 0.05$.

The seed dormancy may be caused by an inadequate development of embryo (KARAM; AL-SALEM, 2001). In addition, physiological dormancy in seeds is related to the amount of inhibitors (ABA) and growth regulators (gibberellins) (HARTMANN et al., 2002). Powell (1987) indicated that stratification in cold directly stimulates to the structural GA synthesis. According to our results, stratification not enough for remove dormancy in fig seeds such as 'Sarılop' cultivars. The treatments of 500 and 1000 ppm of GA_3 has been successful in breaking dormancy. Other studies in several species were reported that GA_3 or stratification was found to be effective in increasing germination percentages (GERCEKCIOGLU; CEKIC, 1999; KARAM; AL-SALEM, 2001; KOYUNCU, 2005). Also, 21 days for stratification and 3% KNO_3 treatments for 'Bursa Siyahı' were higher germination (> 80%) than 'Sarılop'. This can be because of difference in the genetic variation of cultivars on germination and emergence. The seed germination showed no significant differences among priming in water for 24h and control treatments.

The emergence percentages of 'Bursa Siyahı' and 'Sarılop' seedlings were showed in Table 3. While the highest emergence percentages were found in 500 ppm and 1000 ppm GA_3 treatments for 'Bursa Siyahı' (98 and 95%, respectively), the lowest were found in 7 days stratification (38%) and control (32%). 'Sarılop' had the highest emergence in 1000 ppm (93%) and 500 ppm GA_3 (87%) treatments. The lowest emergence rate was 14% (control) for 'Sarılop'. The emergence of KNO_3 treatment had the above 70% for both 'Bursa Siyahı' and 'Sarılop'. Stratification periods increased emergence percentages for both 'Bursa Siyahı' and 'Sarılop', but not as enough as GA_3 and KNO_3. Demirsoy et al. (2010) showed that treatments of GA3 or stratification in strawberry tree seeds increased of seedling emergence. Also, our study demonstrated that KNO_3 treatment was found better results than stratification. Derkx and Karssen (1993) stated that effects of KNO3 on seed germination are related to sensitivity of seed. Previous studies suggested that effects of KNO_3 treatments on germination and seedling growth were positive (AGRAWAL; DADLANI, 1995; CETINBAS; KOYUNCU, 2006; FURUTANI; NAGAO, 1987). Our data were similar to these results.

The MGT and MET of both 'Bursa Siyahı' and 'Sarılop' cultivars had the shortest in GA_3 treatments (Table 3). The shortest MGT was obtained from 1000 ppm GA_3, 500 ppm GA_3, and 21 day stratification (8,8 and 9 day, respectively) for both 'Bursa Siyahı' and 'Sarılop'. 'Bursa Siyahı' and 'Sarılop' had the shortest MET for 1000 ppm GA_3 (11 and 15 days, respectively) and for 500 ppm GA_3 (12 and 16 days, respectively) treatments. The longest MET was found in control for 'Bursa Siyahı' (20 days) and for 'Sarılop' (22 days). The treatments of GA_3 on seeds of 'Bursa Siyahı' reduced of MGT to 5 days and MET to 10 days compared to the control. Also, the treatments of GA_3 on 'Sarılop' made less of MGT to 4 days and MET to 6 days contrast to control. Similar studies showed that MGT decreased with increasing duration of stratification and concentration of GA_3 (EL-REFAEY; EL-DENGAWY, 2005; KOYUNCU, 2005) The short of MGT was showed more seed germination ratio in the beginning of germination whereas the long of MGT was showed more seed germination ratio in the end of germination (HARTMANN et al., 2002).

The shortest of time of total 50% (GT_{50}) obtained from GA_3 treatments for 'Bursa Siyahı' with 9 day, followed by 21 days and 14 days stratification The longest GT_{50} was 20 days in control and primed in water. The shortest GT_{50} was obtained from 21 days stratification (14 days), followed by 500 ppm GA_3 (17 days) and 14 days stratification (17 days) for 'Sarılop'. The GT_{50} was longest in KNO_3 and control (22 and 21 days, respectively). As a similar of the germination results, the shortest ET_{50} of emergence was 13 days in 500 and 1000 ppm GA_3 treatments for 'Bursa Siyahı' whereas ET_{50} for emergence was the longest in 7 days stratification (23 days). The shortest ET_{50} for emergence was 16 days in 500 ppm and 1000 ppm GA_3 treatments while the longest was 27 days in 7 days stratification for 'Sarılop'. Similarly, Frutani and Nagao (1987) suggested that soaked in KNO_3 or GA_3 increased emergence percentage, and reduced T_{50} of papaya emergence in comparison to seeds soaked in water. El-Refaey and El-Dengawy (2005) explained that stratification or GA_3 in loquat seeds increased emergence percentage, and reduced T_{50}. Rawat et al. (2010) reported that early germination in wild pomegranate seeds may results into longest radicle, which helps in early establishment of new seedling to produce maximum food material with the help of photosynthesis that resulted into the maximum survival of seedlings.

Conclusion

The current experiment showed that the fig seeds have physiological dormancy. Determination of seed germination and emergence of Bursa Siyahı and Sarılop cultivars is considerable for next fig hybridization studies. In this study, the seeds of the cultivar 'Bursa Siyahı' had more germination and emergence percentages than those of 'Sarılop'. GA_3 treatments significantly enhanced the germination and emergence of these fig seeds.

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