How does the Seed Size of the Fennel (*Foeniculum vulgare* Mill.) affect its Germination?

Samira Hashemirad, Elias Soltani, Ali Izadi Darbandi and Iraj Alahdadi

***Abstract*— In this study, the type of dormancy, seed size and its effect on germination in the fennel plant, a native species to the Mediterranean coast, has been investigated. We investigated seed length, embryo length and embryo to seed ratio (E/S), the role of different seed sizes in germination. The embryo contains differentiated organs, however it is small (underdeveloped) and must develop inside the seed, growing to a critical size, seed length ratio (E/S) was 0.24–0.28, before germination occurs. Seeds were stratified at 5°C for < 4 weeks for embryo growth, dormancy break and seed germination. Thus, seeds have morphological dormancy (MD). In this study, it was concluded that seed size also affects seed germination. In large seeds, dormancy was less, resulting in better germination.**

***Keywords*—Cold stratification, embryo, morphological dormancy.**

I. INTRODUCTION

Plant germination plays a significant role in the establishment and growth of seedlings (Chien et al., 2011; Baskin and Baskin, 2014). In regions with a cold winter, seeds disperse in the autumn, whereas seeds germinate in the spring (Baskin and Baskin, 2014), since mature seeds are dormant during winter and they will not germinate. As a result of cold stratification, dormancy is alleviated during winter, and seeds become non-dormant and can germinate in the spring (Washitani and Masuda, 1990). Thus, dormancy plays a crucial role in regulating germination and seedling emergence. Additionally, understanding how to overcome dormancy and stimulate germination is required for propagation protocols in wild species, which can potentially be applied to the horticultural and industrial crops (Lee et al., 2015).

Apiaceae seeds exhibit underdeveloped (small, but differentiated) embryos, which can lead to morphological or morphophysiological dormancy (Baskin and Baskin, 1990; Baskin et al., 2000, 2004; Vandelook et al., 2007; Vandelook and Van Assche, 2008; Baskin and Baskin, 2014). MPD is classified into twelve levels based on the temperature regime required for the pretreatment.

The purpose of this study was to determine the interaction effect of seed size and cold stratification on seed germination of fennel seeds.

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E. Soltani, Department of Agronomy and Plant Breeding Sciences, College of Aburaihan, University of Tehran, Iran.

II. MATERIAL AND METHODS

A factorial experiment (5 × 2 × 3) was conducted to examine the effects of cold stratification and seed size in which factors included five periods of cold stratification (0, 2, 4, 6, and 8 weeks), two genotypes (Chahestan and Fasa), three seed sizes (large, medium, and small) in four replicates (total 120 Petri dishes).

Seeds of two genotypes were classified into three groups which were large (>4.7 mm), medium (2.7–4.7 mm), and small (2–2.7 mm). Approximately 31% of the seeds in Fasa were small, 46% were medium, and 23% were large. In Chahestan, 29% of the seeds were small, 56% were medium and 15% were large. Three groups of seed sizes were cold stratified for 0, 2, 4, 6, and 8weeks at 5°C. For cold stratification, seeds were placed on double layers of filter paper on Petri dishes with 150 mm diameters. Filter papers were moistened with deionized water and Petri dishes were sealed with parafilm to prevent contamination and loss of water during incubation. Germination of treated and control seeds were tested at 10 °C for 30 days. In germination test, fifty seeds of each genotypes were placed on top of two filter papers in 90-mm diameter petri dishes for each replicate. In germination test, seeds were soaked in 6 ml of distilled water and incubated at 10°C. The incubators had a daily photoperiod of 12 hours of light and 12 hours of darkness. Seeds were monitored with a 3-day interval for germination until no further germination was observed over two consecutive weeks. At the end of the experiment, germination percentage was calculated for each treatment.

III. RESULTS

Results showed that there was a significant difference in seed size in both genotypes, but stratification did not significant change on seed size (Fig 1). A significant increase in embryo length occurred with increasing stratification period and reached its maximum in the fourth week. Across all stratification periods, large seeds had longer embryos than medium and small seeds. In addition, the embryo to seed ratio (E/S) also peaked in the fourth week of stratification, and after four weeks of stratification, the difference between seed sizes was not significant. Seed germination was significantly higher in large seeds than in small seeds (Fig 1). More than 70% of large seeds in both genotypes germinated without stratification. The germination of seeds increased with increased stratification time by four weeks, however, increasing the germination time by six and eight weeks reduced the germination (Fig 1).

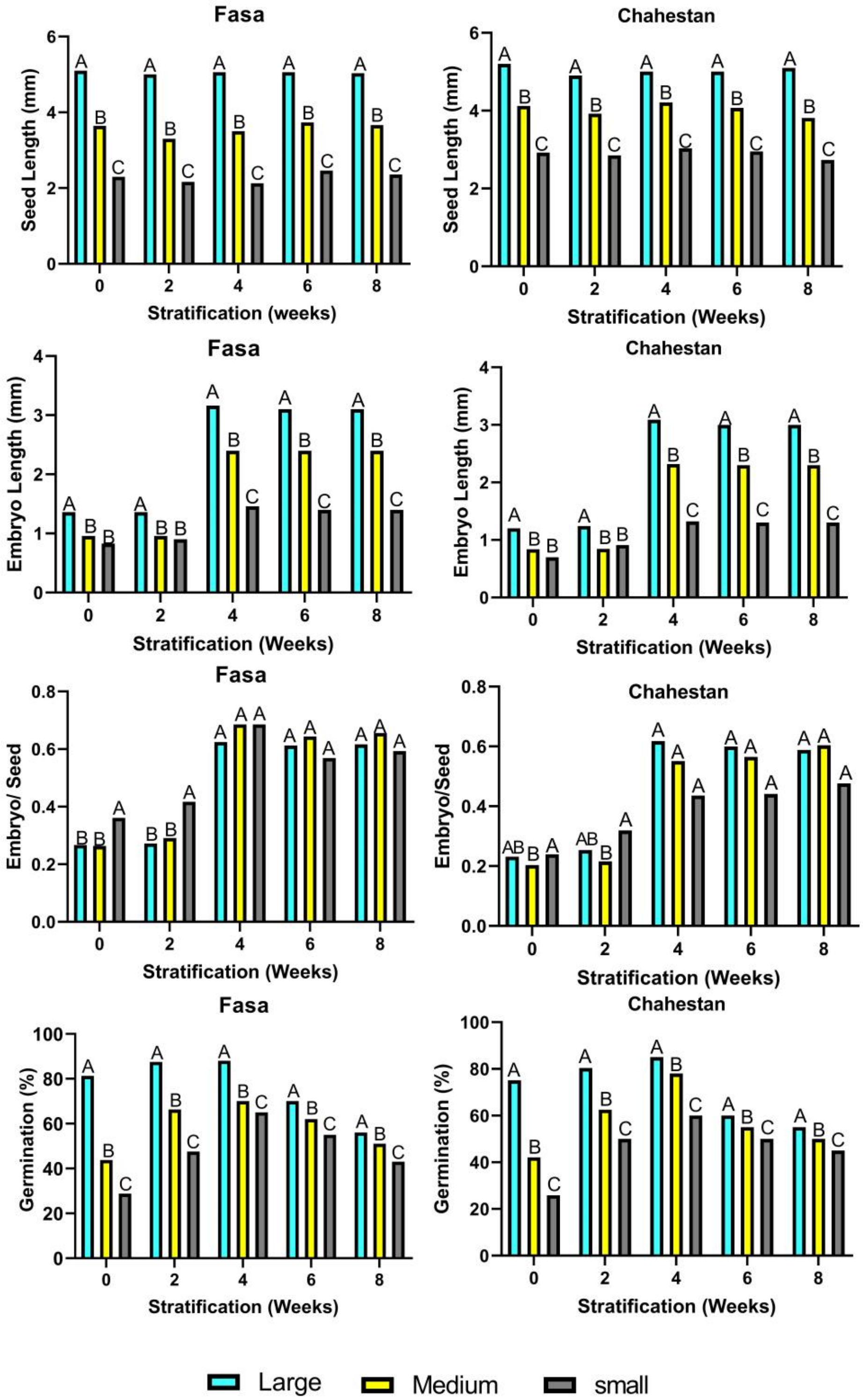

Fig. 1. Effects of cold stratification and seed size and their effect on seed length (S), embryo (E) length, E/S ratio, and germination.

IV. Discussion

In nature, cold stratification, which occurs naturally in winter, delays embryo growth and germination until warm temperatures of spring (Rhie et al., 2016). When embryo growth and germination of freshly matured seeds occur over a wide range of temperature during incubation for about 4 weeks, the seeds are dormant morphologically, i.e. absence of physiological dormancy (PD) and germination occurs after embryonic development (Nikolaeva 1977; Baskin and Baskin 2014). Since in the present study, seed embryos reached the germination threshold for growth during 30 days of stratification, it seems that dormancy of fennel seeds is morphological. Due to the cessation of embryo growth after 4 weeks, it is possible that the prolongation of the cold period has caused damage to the embryo and cold stress. MD/MPD require an underdeveloped embryo to grow inside the imbibed seeds before radicle emergence can complete germination (de Farias et al., 2015; Homrichhausen et al., 2003; Jacobsen and Pressman, 1979; Jacobsen et al., 1976; Porceddu et al., 2017; da Silva et al., 2008; Van der Toorn and Karssen, 1992; Zhang et al., 2019).

When the temperature, moisture, and light conditions are right, the embryos begin to grow (elongate) within 1 to 2 weeks, germination occurs approximately 30 days later (Baskin & Baskin 1998). Embryos in simple subclasses grow well at temperatures higher than those suitable for cold stratification (Baskin and Baskin, 2014). In this case, dormancy in fennel seeds must be morphological dormancy. The large seeds germinated the best compared to the other two sizes, possibly because they were less dormant.

Seeds with MD don't have physiologically dormant, therefore they do not require dormancy breaking treatments. Incubation at suitable conditions for a short time is all that is necessary for the embryo to reach full size, and the radicle appears immediately afterward (Nikolaeva 1977; Baskin & Baskin; 2004).

V. Conclusion

In conclusion, freshly matured seeds of fennel contain a differentiated but underdeveloped (small) embryo with morphological dormancy (MD) at maturity time. Cold stratification breaks MD in fresh funnel seeds, and the embryo begins to grow. Seed germination improved after cold stratification under warm temperatures. Larger seeds, even without stratification, had a higher germination percentage than smaller seeds, and their embryo size was significantly greater than small and medium-sized seeds. Thus, it can be concluded that larger seeds have less morphological dormancy than smaller seeds. To cultivate this medicinal plant, it would be beneficial to use large seeds to ensure better germination and seedling establishment. It is recommended for farmers to plant large seeds for an appreciate plant stand since large seeds have less MD than small seeds.

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