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Response of Fennel to Priming Techniques

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Authors' contributions

This work was carried out in collaboration between all authors. Author MH designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author SBK performed the statistical analysis and managed the analyses of the study. Author EJ did laboratory experiments and English editing. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: The aim is to study the effects of seed priming on germination and yield of Fennel in laboratory experiments and pot studies.
Study Design: The method used is CRD (Completely Randomized Design) with three replications.
Place and Duration of Study: Experiments were carried out at the Research Station of the Islamic Azad University, Tabriz Branch, northwestern Iran at June 2012. The climate of the research site is semiarid and cold with an average annual precipitation of 270 mm. The soil was sandy-loam with an electrical conductivity of 0.72 dS m–1, pH of 7.74.
Methodology: The treatments are gibberellic acid (GA3) with dosage of 500p.p.m, hydro-priming (HP) with 24 hours duration, nitrate potassium (KNO3) 3% and control that was performed on Fennel seeds. Then in laboratory with use of special paper and pure water the seeds were cultured in Petri-dishes and were putt in germinator with 19^0C temperature for 8 days and were counted daily. Some parts of primed seeds were stored in normal condition for 6 months and were cultured in laboratory condition. All the primed seeds were farmed in pots. Three months later the plants were harvested in first blooming level and dry weight and essential oil percentage were measured.
Result: The results of laboratory study showed that the influence of various treatments on germination percentage was significant. KNO3 showed the highest positive effect on

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germination percentage (87.83%). The seedling length and weight in KNO3 and GA3 treatments were the highest in comparision with other ones. The effect of different treatments on essential oil percentage was significant. KNO3 with (3.55%) and GA3 with (3.36%) had the most positive effect on essential oil percentage. But the effect of different treatments on dry weight was not significant.

Keywords: Essential-oil; fennel; germination; seed-priming.

1. INTRODUCTION

Fennel (*Foeniculum vulgare*) is aromatic perennial plant with soft, feathery, almost hair-like foliage that is native to coastal areas in the Mediterranean region and widely naturalized in Europe and North America. Fennel belongs to the *Umbelliferae (Apiaceae)* family, and is a medicinal plant used as anti-spasmodic, appetite stimulant, stomachic, diuretic, anti-inflammatory, anti-diarrheic, against colic and as a lactation promoter [11].

Seed priming is performed with various chemical and physical methods. To name a few, some are listed: gibberellic acid, cytokinin, chlorhydric acid, sodium chloride, potassium nitrate, thioredoxin, sulphuric acid, laser, seed scraping and generator [7]. Priming is a pre-emergence treatment in which seeds are treated in such a way that they absorb water and then they are dried in the next step. In fact the germination process is started but the radicle emergence is not allowed in the process [4]. In other words, in the priming process, the seed is incited to start cell division however it is dried afterward. If again the seeds absorb water; it will start emergence from the dried situation [10]. Using priming techniques the plant growth would increase, the same would happen for yield and quality. The main advantage of this technique is the plant protection against diseases and pests and also reduction in the use of fertilizers and pesticides. Therefore the farmer can reach a crop with more quality and quantity with expensing less time; cost and effort [4]. Priming increases antioxidant enzymes like cationeskorbate in the seed. These enzymes reduce lipid per oxidation in germination time. Therefore the germination percentage will rise [7]. A large number of research results are available in the literature for the application of different priming methods on plant production. Amooaghaie 2007; Baskin 1991; Schmitz 2001; Thomas and Sambrooks 1985; using GA3 as a biostimulator, showed effects on the growth and development of plants during their investigations [2]. Harris 1999; demonstrated that on-farm seed priming (soaking seeds overnight in water) markedly improved establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. This simple, low-cost, low-risk intervention also had positive impacts on the wider farming system and livelihoods and the technology has proved highly popular with farmers [3]. HP value has already been shown for many crops, for instance on wheat, chickpea, maize, mungbean, sunflower and Barley [3]. For the first time, Strogonov 1964; proposed that salt tolerance of plants could be enhanced by treatment of seed with salt solution prior to sowing. Successful results of KNO3 priming have been obtained for wheat, tomato, rice, melon and cucumber [6].

The aim of this researchis to study the effects of seed priming techniques on germination and yield of Fennel (*Foeniculum vulgare*) concurrently in laboratory experiments and pot studies.

2. MATERIALS AND METHODS

This study examines the effects of seed priming on germination and yield of Fennel (viability 85%), in the laboratory experiment in conjunction with pot study. The method used in the laboratory and pot is CRD (Completely Randomized Design) with three replications (210 seeds per replications). The treatments are gibberellic acid (GA3) with dosage of 500p.p.m, hydro-priming (HP) in 24 hours time interval at room temperature (12ºC, 30% humidity), potassium-nitrate (KNO3) 3% and control. Before the experiment, the seeds were disinfected in sodium hypochlorite5% solution for 3 minutes. In the next step, the seeds were transferred to aseptic dishes. GA3 and KNO3 solutions were added to dishes and the seeds are exposed to the solution in darkness for two hours period. Hydro-priming seeds were wetted for 24 hours in pure water. The final step in this process is the extraction of the seeds out of solutions and drying them at room temperature (12ºC, 30% humidity). Then in laboratory with use of special paper and pure water 25 seeds were cultured in Petri-dishes (20×30cm) and were put in germinator at 19ºC temperature for 8 days and the germination number were counted daily. After 24 hours seeds started to germination and radicle were observed. Finally, germination percentage (GP) was computed as the cumulative number of germinated seeds with normal radicles. After that seedling length (SL) and seedling weight (SW) were measured. Some parts of primed seeds were stored in normal condition for 6 months and then storage seeds germination percentage (SGP) were cultured in laboratory condition. Five of all the primed and control seeds were farmed in pots (24x24x40.5cm) in depth of 5 cm. Experiment were carried out at the Research Station of the Islamic Azad University, Tabriz Branch, north western Iran at June 2012. The climate of the research site is semiarid and cold with an average annual precipitation of 270 mm. The soil was sandy-loam with an electrical conductivity of 0.72 dS m–1, pH of 7.74.Pots irrigated 4 times a week. Three months later the plants were harvested in first blooming level and their dry weight (DW) were measured and their essential oil percentage (EOP) was extracted from dried plant. Essential oil was extracted by Clevenger device in two hours.

The statistical data were analyzed using MSTATC software. The means of the treatments was compared using the least significant difference test at $P < 0.05$.

3. RESULT AND DISCUSSION

As Table 1 indicates, there are significant differences among treatments in germination percentage (GP), seedling length (SL), seedling weight (SW), storage germination percentage (SGP) and essential oil percentage (EOP). But the effect of different treatments on dry weight (DW) was not significant.

The survey results of reference [1] confirms the obtained results of this research where the reference reveals that priming increase oxidative enzyme activity of the components that leads to improvement in germination and seedling growth. In other words, the treated seeds germinated faster and sprouted earlier than soil and less time exposed to soil pests and pathogens.

Table 1. Variance analysis of effects of priming techniques on Fennel

S.O.V	df	SL (mm)	SW (mg)	GP (%)	DW (g/plant)	EOP (%)	SGP (%)
Treatment	3	91**	1.01**	1328.11**	75.61^{ns}	0.55**	315.66**
Erorr	8	6.89	0.014	28.66	29.71	0.03	38.33
Cv%	-	9.70	18.7	12.3	13.7	14.5	12.9

*, **, ns: Indicate significant difference at 5%, 1% and not significant*

Analysis of variance of the laboratory data indicated that, the germination percentage was significantly affected by priming methods. The highest germination percentage was recorded for seeds primed with KNO3 (87.83%). After that GA3 has the most GP with 75.5% (Fig. 1).

Table 2 shows the positive effect of priming on seedling length (SL) and weight (SW) in majority of the treatments. The difference between primed and non-primed seed for SL and SW were statistically significant. The KNO3 treatment increased the length and weight of seedling more than other treatments. Maximum seedling length was depicted in KNO3 treatment (84.30mm) and minimum seedling length was noted in control and HP treatments. Also, Maximum seedling weight was noted in KNO3 treatment with 9.53 mg (Table 2). The positive effects of osmo-priming on seed germination and seedling growth were also reported for barley, cucumber, fennel and winter rapeseed in [5]. Analysis of variance of the laboratory data indicated that, the highest germination rate and seedling dry weight were recorded for seeds primed with KNO3 [6]. It might be due to early synthesis of nucleic acids, DNA, RNA and proteins during salt hydration process, which ultimately resulted in improved energy of germination of seeds. Rapid germination of seeds ultimately could lead to the production of larger seedlings [6]. GA3 treatment increased ion content in chloroplast and vacuole while there was no change in cytoplasm ion content [14]. *Kelussia odoratissima*Mozaff.is one of the endogenous plant species of Iran which is exposed to extinction during the recent decades. Results showed that seed priming with GA3 significantly improved seedling growth as compared to the control [2]. Seed priming with GA3 in Milk-thistle might cause the acceleration in metabolic reactions before germination and make germination of cultivated seeds possible under salinity stress [12]. Also, GA3 may activate the synthesis of proteins and other metabolites required by the embryo for germination. GA3 might have enhanced growth promoter levels that helped overcome the effect of the inhibitors (such as ABA), leading to seed dormancy release [2]. Hydro-priming generally improves grain yield of sesame cultivars through enhancing seed germination rate, seedling emergence rate and percentage, and grains per plant. The highest yield increase was obtained with 16 hr hydro-priming [3]. Hydro-priming clearly improved both rate of germination and mean germination time under salt stress conditions. Furthermore, hydro priming resulted in increase of normal germination [10]. Results showed that the effect of hydro and osmo-priming on germination percentage of fennel were significant [10]. Hydro-priming clearly improved rate of germination and mean germination time under salt stress conditions. Furthermore, hydro-priming resulted in increase of normal germination percentage [10]. The efficiency of seed hydro-priming for better seedling establishment, also reported in barley, lentil and chickpea [6]. The results showed that the effect of HP was significant on germination percentage, seedling vigor, seedling length and seedling dry weight in dill [8]. Kumar et al. 2002; found safe maximum lengths of time for which seed should be primed, beyond which it could be damaging to the seed or seedling. Recommended safe limits were 24 hr for maize and rice, 10 hr for chickpeas and 8 hr for pearl millet [5].

Analysis of variance in the present work revealed that there was significant difference between stored seeds germination percentage (SGP). The stored part of primed seeds showed decreasing in germination percentage. Among different treatments, KNO3 was observed to decrease germination percentage the most. Germination percentage in KNO3 (29%) was less than control (48%) as is illustrated in Table 2. Comparing the results provided for different priming techniques in Table 2 for stored seeds and Fig. 1 for no stored seeds revealed that how storing effect could jeopardize the viability of seeds. For example in the case of KNO3 storage the primed seeds reduced SGP from 87.83% to 29%. To discuss the physiological reason it worth to add that harmful effects of seed treatment while storage causes activation of DNA-repair due to development in cell cycle. Lipid per-oxidation increscent, due to active oxin agent while seed drying and lack of conservation mechanism is effective in reduction of seed preservation [7]. The germination test with wheat primed seeds that stored in general showed that 60 days after seed priming was better than other storage duration after seed priming [13].

The results of pot study are summarized in Table 2. The essential oil percentage (EOP) responded positively and significantly to seed priming methods. Priming the seeds in KNO3 had greatest effect on essential oil percentage (3.55%). In this regard, following this technique, other treatments like GA3 and HP affected positively on EOP (Fig. 2). A significant increase in essential oil yield due to seed priming, in comparison to those seeds that are not primed, was expected because the germination rate, uniformity in seed, seed yield, and oil content in primed seeds were high. Thus, all of these factors contribute to a higher essential oil yield. However, priming may increase yield directly through its effect on even stand establishment, because of the uniformity in the stand results in higher yield [9]. Feghenabi 2007; reported that GA3 increased oil percentage in safflower [4]. Different researchers found that micro-nutrient treatments increased the essence yield in Cumin from 1.72 kg/ha to 2.56 kg/ha. Also as addressed in [9], seed germination with iron and boron enhances germination and yield of Dill.

Table 2. Comparison of mean effects of seed priming on some traits of Fennel

	Storage germination percentage (%)	**Seedling weight (mg)**	**Seedling length (mm)**
KNO3	29	9.53	84.3
GA3	48	8.93	79.92
HP	51.66	8.45	74.79
Control	48	8.21	71.86

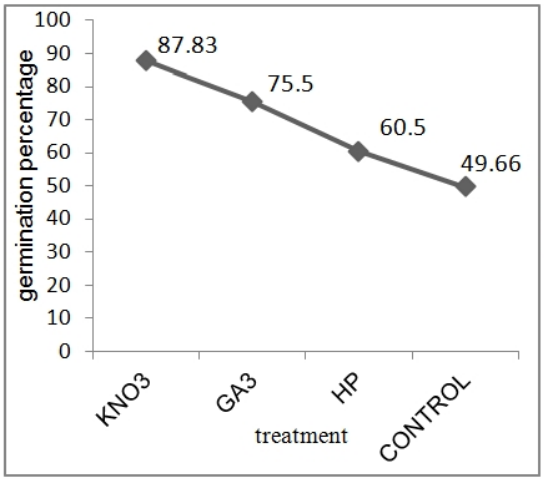

Fig. 1. Germination percentage (GP)

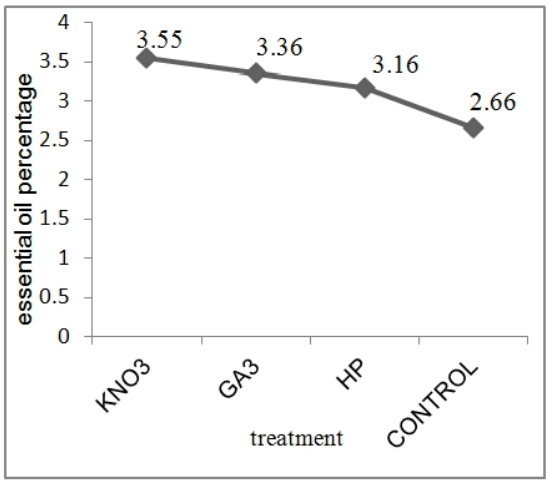

Fig. 2. Essential oil percentage (EOP)

4. CONCLUSION

1. It has been proven that between treatments of Fennel, the best effective method is KNO3.
2. Hydro-priming treatment has no environmental pollution so it is better than two previous methods.
3. The results obtained in this study can be used in the pharmacy, alimentary and sanitary industries.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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