

Evaluation of cardinal temperature for three species of medicinal plants, Ajowan (*Trachyspermum ammi*), Fennel (*Foeniculum vulgare*) and Dill (*Anethum graveolens*)

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Abstract

In order to evaluate cardinal temperatures and optimum thermal range of germination of three medicinal plants including Ajowan, Fennel and Dill an experiment was conducted in a Completely Randomized Design with three replications. Temperatures considered for this study were: 5, 10, 15, 20, 25, 30 and 35 °C. Results indicated that temperature affected germination rate and percentage of these crops. Optimum thermal range for Ajowan and Fennel seeds were determined as 10-20 °C and 10°C for Dill. The basic optimum and maximum temperatures were 2.88, 20 and 38.35 for Ajowan, 3.86, 20 and 34.98 for Fennel and 5, 13 and 33.7 for Dill. In general, as it is expected, germination response of these crops to temperature was correlated with the nature of growth of these plants. At higher temperatures, Dill as a winter crop showed a lower germination percentage compared to Ajowan and Fennel.

Key words: germination, temperature, Ajowan, Fennel, Dill, Iran

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Introduction

Ajowan, Fennel and Dill are plants from Apiaceae family with a wide range of usage in traditional medicine. Ajowan seed is considered as hot medicine and is used for relief of pain in human digestive track and as an antidiarrhoeal (Mirheidari, 1993). Dill seeds contain 3-3.5 % essential oil and are used for stomach unrest particularly for children (Singh and Randhawa, 1991). Active ingredients of Fennel are used for prevention of cough and stomachache and enhancement of food digestion. Essential oil of Fennel is used in beverage cosmetics and hygienic industry (Omid beigi, 1997).

Germination is a complex physiological process which is affected by temperature and water potential of the soil (Alvarado and Bradford, 2002). This process includes the events in which embryo activates from a dormant stage to a dynamic form (Koocheki and Zarif, 1996). Germination is an important process in the final stand establishment of the crop and optimum density is achieved when the seeds are healthy and germinated completely in an appropriate rate (Koocheki and Zarif, 1996).

Temperature is also an important factor in seed germination and affects dormancy and germination rate (Alvarado and Bradford, 2002). The effects of temperature on germination are considered in terms of cardinal temperatures (Sarmadnia, 1996, Yan and Hunt, 1999). Cardinal temperature

(minimum or basic temperature, optimum and maximum) is the range of temperature in which seeds of a particular species are able to germinate. Minimum temperature (T_b) is the lowest temperature in which a seed is able to germinate. Optimum temperature (T_o) is a temperature in which the highest percentage of the seed germinate at the shortest period of time and finally maximum temperature (T_c) is the highest temperature in which seed can germinate. Generally, cardinal temperature of a particular seed depends on environmental conditions in which it is adapted and seeds normally germinate when environmental condition for growth and development of seedling is assured (Alvarado and Bradford, 2002). As a general rule, seeds need lower temperature in temperate environment compared with tropical conditions and wild species also need lower temperature compared with domesticated plants (Sarmadnia, 1996). Optimum temperature for most of the seeds is between 15 and 30 °C and the maximum temperature is between 30 to 40 °C.

Since cardinal temperature is important for germination and this temperature has not been determined for medicinal plants, the purpose of present investigation is to evaluate the effect of this temperature for three important medicinal species including Ajowan, Fennel and Dill.

Materials and Methods

In order to determine cardinal temperature for Ajowan, Fennel and Dill, seeds of these species were exposed to a wide range of temperature as 5, 10, 15, 20, 25, 30 and 35°C in a germinator. Before starting of the experiment, the seeds were disinfected by Sodium Hypochlorite for one minute followed by washing through distilled water. Fifty disinfected seeds were located in Petri dishes on Watman paper and 10 cc of distilled water was added to each Petri dish. Petri dishes were placed in a germinator. Each temperature treatment was repeated three times. After 24 hours, germinated seeds were counted and this was continued for 15 days. At the end, the percentage and rate of germination were calculated.

Rate of germination was determined by the following formula:

$$R_s = \sum_{i=1}^n \frac{S_i}{D_i}$$

where R_s is rate of germination, S_i : number of germinated seed/day and D_i : number of days seeds were monitored.

For determination of cardinal temperatures, a linear regression was used between temperature as an independent variable and rate of germination as a dependent variable and regression lines were drawn separately for temperatures lower and higher than optimum temperature. The intersection point of this regression line with X axes was considered as basic and maximum

temperature. Data were analyzed on the basis of Completely Randomized Design MINITAB software and means were compared according to Duncan's test. Graphs were drawn by SigmaPlot.

Results and Discussion

In table 1, the rate and percentage of germination are presented. As it is shown, temperature has a pronounced effect on rate and percentage of germination. In general, by increasing temperature up to 20 °C, germination rate for all three species was increased and declined afterwards. This was only significant for Ajowan and Fennel while there was no difference between temperature regimes at 10, 15 and 25°C for Dill. By increasing temperature beyond 20 °C, the rate of germination for all three species was decreased significantly and the extent of this reduction was more pronounced for Dill compared with Ajowan and Fennel (71% for Dill compared with 30.87% for Ajowan and 24.13% for Fennel). In general, rate of germination for Dill in all temperature levels, particularly temperatures higher than 10°C, was lower compared with Ajowan and Fennel. These findings have also been confirmed elsewhere (Ali et al, 2003). Alvarado and Bradford found that with increasing temperature up to optimum level, rate of germination was increased and declined thereafter (Alvarado and Bradford, 2002).

Table 1: Rate and percentage of germination for three species in different temperatures

Temperature (°C)	germination rate (seed/day)			germination percentage		
	Dill	Fennel	Ajowan	Dill	Fennel	Ajowan
5	0 ^b	0.142 ^d	1.147 ^d	0 ^d	4.667 ^d	24 ^c
10	3.311 ^a	3.910 ^c	4.978 ^c	70 ^a	78.667 ^a	67.33 ^a
15	3.571 ^a	5.556 ^b	6.274 ^{bc}	56 ^b	82 ^a	64.667 ^a
20	3.448 ^a	8.176 ^a	10.735 ^a	30.667 ^c	80 ^a	69.333 ^a
25	0.989 ^b	6.203 ^b	7.421 ^b	10 ^d	66.667 ^b	54 ^{ab}
30	0.645 ^b	3.058 ^c	5.922 ^{bc}	6.67 ^d	40.667 ^c	39.333 ^{bc}
35	0 ^b	0 ^d	1.495 ^d	0 ^d	0 ^d	7.333 ^d

In each column values with the same letter are not significant

The results of regression relationships are shown in figure 1 and table 2. It is clear that Ajowan seeds are capable to germinate in a wider range of temperature and its basic and maximum temperature are lower than the corresponding temperatures for two other species.

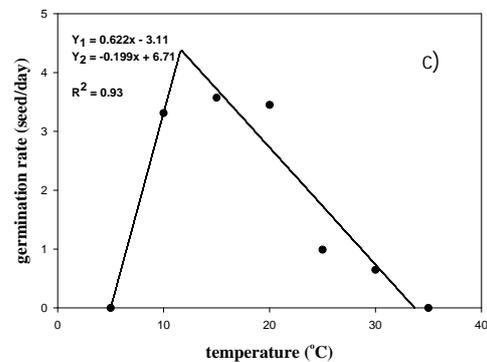
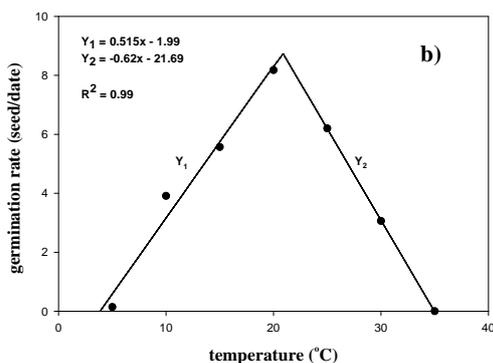
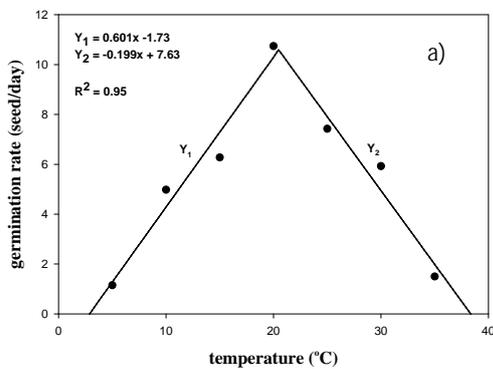


Figure 1: Regression lines for germination rate of a) Ajowan b) Fennel c) Dill

With increasing temperature up to 10°C, the percentage of germination for three species was increased (Table 1). However, by increasing temperature from 10 to 25 °C for Ajowan and from 10 to 25°C for Fennel, no difference was observed while for Dill, the percentage of germination was reduced by increasing temperature beyond 10°C and the maximum percentage for these species was observed at 10°C. Based on the nature of this plant, it was not an unexpected event. At 35 °C, germination of



Fennel and Dill was halted while 7.33 percentage of Ajowan seeds germinated. Tabrizi et al. found that with increasing temperature from 5 to 15°C, seed germination of *Plantago ovata* was increased and there was a declining trend afterwards (Tabrizi et al, 2004). This was also the case for *Plantago Psyllium* but the highest percentage of germination occurred at 25°C. Koocheki and Zarif Ketabi also found that the maximum percentage of germination for some forage species was at 15°C and by increasing or decreasing temperature beyond this level percentage of germination was decreased significantly and the lowest value was obtained at 5°C which was 72 percent lower than the value obtained for 15°C (Koocheki and Zarif, 1996).

Table 2: Cardinal temperatures for three species Ajowan, Fennel and Dill

Species (°C) Temperature	Dill	Fennel	Ajowan
basic	5	3.86	2.88
optimum	13	22	20
maximum	33.7	34.98	38.35

Conclusion

In conclusion, the optimal range of temperature for Ajowan and Dill was 10-20°C at which the maximum percentage of germination were 67.11 and 80.22 percent for Ajowan and Fennel, respectively.

However, maximum percentage of germination for Dill was obtained at 10°C. In general, seed germination for Dill was more affected by temperature compared to other two species and under different temperature level, there was higher variability for seed germination of this species.

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