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Effect of Salinity and Temperature on Seed Germination and Seed Vigor Index of Chicory (*chichoriumintynus L.*), Cumin (*CuminiumCyminium L.*) and Fennel (*Foeniculum Vulgare*)

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Abstract

To evaluate the effect of different levels of salinity and temperature on germination and seed vigor of three medicinal plants of Chicory (*Cichoriumintybus* L.), Cumin (*Cuminumcyminum* L.) and Fennel (*Foeniculumvulgare*) three separated experiments were carried out by factorial experiment based on complete randomized block design with three replications in 1393 at the laboratory of Agricultural University of Payam Noor, Meshkinshahr center for each plant. Factors were salinity with six levels (0. 2, 4, 6, 8 and 10 ds/m for all plants) and temperature with three levels (22, 25 and 28 °C for Chicory; 27, 29 and 31 °C for Cumin; 17, 19 and 21 °C for Fennel). Seedling tissue water content was affected by salinity levels in Cumin and Fennel. Salinity reduced seedling length, shoot length, root length, germination percentage, germination rate, seedling dry and fresh weight and seed vigorindex. In all traits that affected by salinity, the highest rate was observed in the control. Seed vigor index, germination percentage, dry weight of seedling, fresh weight of seedling in Chicory, seedling length and root length in Cumin and seed vigor in Fennel were significantly affected by temperature regime. In general it can be stated that Fennel, Cumin and Chicory, are the most sensitive to salinity respectively by 74, 72 and 47% reduction in seed vigor index at the highest levels of salinity in compared to the control level.

Keywords: Germination Percentage, Medicinal Plants, Seed Vigor Index, Seedling Germination Rate

1. Introduction

Soil salinity is one of the major factors of soil degradation that limit crop production. Many social and economic problems are caused by salinity that affects the growth, productivity and distribution of plants (Bojovic et al. 2010). Salinity inhibition of plant growth is the result of osmotic and ionic effects and the different plant species have developed different mechanisms to cope with these effects (Munns, 2002). High rate of seedling mortality, delayed germination, stunted growth and reduced yield are some of the most common effects of salted soils. Research in relation to the effect of salinity has mostly been carried out on agricultural, forage and fuel wood species. However, little work has been done for exploring the possibility of using salted soil for the cultivation of medicinal plants (Zahir and Hussainn, 2010, Asimi and Sahu, 2013, Jahanshir, 2015).

Reduction in osmotic potential in salt stressed plant can be a result of inorganic ion (Na^+, Cl^- and K^+) and complete organic solute (soluble carbohydrates, amino acids, proline, betaines, etc.) accumulations (Hasegawa et al. 2000). Some plants will tolerate high levels of salinity while others can tolerate little or no salinity. Salinity acts like drought on plants, preventing roots from performing their osmotic activity where water and nutrients

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move from an area of high concentration. Therefore, because of the salt levels in the soil, water and nutrients cannot move into the plant roots. Germination is a critical part of plant life histories. The ability of their seeds to germinate at high salt concentration in the soil is therefore of crucial importance for the survival and perpetuation of these species. Recently, medicinal plants have received much attention in several fields such as agro alimentary, perfumes, pharmaceutical industries and natural cosmetic products. Although, secondary metabolites in the medicinal and aromatic plants were fundamentally produced by genetic processing but, their biosynthesis is strongly influenced by environmental factors. A biotic environmental stresses, especially salinity has the most effect on medicinal plants. The different results were dedicated from the effect of salinity stress on the quantitative and qualitative parameters. For instance, it was found that, increasing of salinity stress decreased almost all of growth parameters. Liopa-Tsakalidi (2010) reported that enhancing salinity treatments lead to growth reduction. It also reduces germination amounts and seedling weight. Overall, salinity through enhancement of osmotic pressure leads reduction of water absorbance and metabolically and physiological processes will be under its effect. So it causes more delay in germination beginning following by enhancing seed germination duration. Therefore seedling growth can be limited by decreased mobilization of seed reserve and/or the conversion efficiency of mobilized seed reserves. Salinity is one of the environmental factors having a critical influence on seed germination, seed physiology and plant establishment (Hashemi and Akhavan Armaki, 2015). Salinity affects imbibitions, germination and radical elongation. It reduces substrate water potential, thereby restricting water and nutrient uptake by plants (Safarnezhad and Hamidi, 2008). Salinity may also cause ionic imbalance and toxicity. Because substrate salinity fluctuates through the growing season, a plant may be exposed to different salinity levels, at various stages of development, with potentially significant consequences on population dynamics (Hosseini and Rezvani Moghadam, 2006).

Present study was conducted to see the possible effects of NaCl salinity and different temperature on the germination and seedling growth of three species of medicinal plants. The findings might help enhancing the medicinal wealth of Iran by utilizing the otherwise non-productive saline habitats.

2. Material and Methods

In order to evaluate of the effect of different levels of salinity and temperature on germination and seed vigor of three medicinal plants of Chicory (*Cichoriumintybus* L.), Cumin (*Cuminumcyminum* L.) and Fennel (*Foeniculumvulgare*) three separated experiments were carried out by factorial experiment based on complete randomized block design with three replications in 1393 at the laboratory of Agricultural University of Payam Noor, Meshkinshahr center for each plant. Factors were salinity with six levels (0. 2, 4, 6, 8 and 10 ds/m for all plants) and temperature with three levels (22, 25 and 28 ^{o}C for Chicory; 27, 29 and 31 ^{o}C for Cumin; 17, 19 and 21 ^{o}C for Fennel). Distilled water was used for the control (zero) and sodium chloride salt solutions for specific electrical conductivity. Salinity levels were created by solving the amount of salt (NaCl) (Manufactured by Merck Company with a purity of 95%) in distilled water. Each experimental unit consists of one sterile Petridish containing 100 seeds. Seed sterilization was performed by using 70% alcohol (10 seconds), 10% sodium hypochlorite (60 seconds) and fungicides (60 seconds). After treatment, the Petri dishes were placed in Germinator with relative humidity of 80%, temperature 25°C (16 hours) and 15°C (8 hours). The duration of the test was 12 days. On the last day of test 10 seedlings randomly selected from each Petridish and the average length of root and shoot were determined. Then the 10 seedlings were placed to measure root dry weight and shot dry weight for 24 hours at 70°C in electric oven. The total number of germinated seeds in a Petridish was recorded until the twelfth day of germination. Germination Rate (GR), Germination vigor index and water content of seedling tissue were determined by Equation 1, 2 and 3 respectively (Segatoleslami, 2010). Data were subjected to analysis by the SAS software and graphs were drawn using Excel program.

$$GR = \frac{X1}{Y1} + \frac{X2 - X1}{Y2} + \ldots \frac{Xn - 1}{Yn} \qquad (1)$$

X$_n$: The number of germinated seeds to the n-th day

Y$_n$: The number of day from cultivation time until final time

$$SVI = \frac{GP \times SL}{100} \qquad (2)$$

GP: Germination percentage

SL: The mean of seedling length

Water content of seedling tissue = (FW-DW)/FW×100 **(3)**

FW: Fresh weight of seedling
DW: Dry weight of seedling

3. Results and Discussion

3.1 Seedling Length, Shoot Length and Root Length

In case of Chicory analysis of variance showed a significant effect of salinity on seedling length, shoot length and root length. Temperature levels were not significantly effected on these treats (Table 1). Salinity and temperature were significantly effect on seedling length, shoot length and root length in Cumin (Table 1). Also seedling length and root length were significantly affected by salinity and temperature levels in Fennel (Table 1).

Mean comparison of traits showed that in the case of Chicory with increasing salinity, seedling length, shoot length and root length were significantly decrease (Table 2). Results showed that in Chicory, maximum of seedling length, shoot length and root length (33.09, 20.54 and 13.13 mm, respectively) was observed at control level of salinity and minimum of them (21.86, 13.50 and 8.7 mm) were obtained at highest level of salinity (Table 2). In case of Cumin, mean comparison of traits showed that with increasing salinity, seedling length, shoot length and root length, were significantly decrease (Table 2). Also results showed that maximum of seedling length (229.2 mm), shoot length (149.2) and root length (77.1 mm) were obtained at control level of salinity (Table 2). In case of Fennel, maximum of seedling length (97.98 mm), shoot length (57.05 mm) and root length (40.92 mm) and minimum of them (53.68, 57.05 and 22.32 mm respectively), were obtained at control

Table 1. Main comparison of effect of salinity and temperature on seed germination characteristics Cumin, Chicory and Fennel

	SOV	DF	Seedling length	Shoot length	Root length	Fresh weight of seedling	dry weight of seedling	Water content of seedling tissue	Root shoot ratio	Germination Percentage	Germination Rate	Seed vigor index
Chicory	Salinity (S)	5	136.1**	51.49**	21.37**	0.21**	0.06**	1.30	0.0007	116.5**	5.02*	65.9**
	Temperature (T)	2	8.03	3.72	1.41	0.052**	0.010**	1.005	0.00003	22.77**	2.31	5.51**
	S×T	10	0.078	0.015	0.005	0.0007	0.00006	0.958	0.00002	0.004	0.03	0.04
	Error	36	6.61	3.04	1.68	0.004	0.001	2.10	0.0005	3.91	1.71	0.90
	CV (%)	-	9.09	10.06	11.51	4.42	4.03	3.00	3.68	4.33	10.22	7.34
Cumin	Salinity (S)	5	634.9**	286.15**	74.08**	0.004**	0.0010*	73.23**	0.00005	1178**	198.2**	6641**
	Temperature (T)	2	267.5**	126.3*	39.5**	0.0004	0.0001	9.23	0.000001	2.65	0.48	60.72
	S×T	10	0.37	0.18	0.03	0.0001	0.00002	7.88	0.000001	0.104	0.032	2.57
	Error	36	35.80	30.44	6.07	0.0012	0.0002	27.31	0.0007	45.13	3.28	241.9
	CV (%)	-	2.69	3.82	3.17	29.52	28.33	10.84	5.06	26.48	19.99	27.19
Fennel	Salinity (S)	5	3327**	1132.6	585.8**	0.87**	0.36**	62.41**	0.00067	1535**	742.7**	3094**
	Temperature (T)	2	63.32	19.48	9.33	0.229	0.032	3.98	0.000005	30.18	4.02	71.72*
	S×T	10	1.25	0.72	0.62	0.005	0.0009	1.07	0.0003	0.32	0.15	2.80
	Error	36	52.28	18.82	8.63	0.26	0.049	19.73	0.0006	13.37	16.42	15.35
	CV (%)	-	9.79	10.4	9.61	15.54	13.11	9.12	3.59	7.09	21.53	9.85

*** Significant in 5 and 1 percentage probability respectively.

level of salinity and highest level of salinity, respectively (Table 4). In the case of effect of temperature on seedling length, shoot length and root length, result indicated that maximum of seedling length (225.8 mm) and root length (79.0 mm) were obtained at 29 ^{O}C condition. Minimum of seedling length (218 mm) and root length (76.1 mm) was observed at 27 ^{o}C condition. Maximum of shoot length (146.7) and minimum of this trait were obtained at 27 ^{o}C and 31 ^{o}C respectively (Table 2). Decrease at root and shoot length and finally decrease in seedling length with increasing of salinity also reported by Hosseini and Rezvani Moghaddam (2006). Rahimian Mashadi *et al*. (1991) stated that reduce the length of root and shoot, probably due to the influence of sodium chloride ion toxicity and negative effects on the cell membrane. Root length decrease following increase salinity level has been reported by Qu et al. (2008). However, the Segatoleslami (2010) in study on effect of salinity on seed germination of Chicory reported that seedling length of this plant increase with increasing of salinity. They reported that increasing seedling length with increasing of salinity depends on production of hormone like auxin at salinity condition. Significantly reduced seedling characteristics with increasing salt levels in the present study agrees with the findings of Khan et al. (1994), Ibrar et al. (2003) and Jabeen et al.(2003) who also reported significant decline in growth at 10 ds/m and higher salinity levels. Our results are in agreement with Fallahi et al. (2008) in which they showed that with increasing in salinity levels, the seedling length had decreased and minimum and maximum length of seedling were observed for control and 300 Mm NaCl treatments, respectively.

3.2 Fresh and Dry Weight of Seedling

Results showed that salinity and temperature were significantly effect on fresh and dry weight of seedling in Chicory (Table 1). In case of Cumin and Fennel, fresh and dry weight of seedling was significantly affected by salinity. However temperature levels were no significantly effect on those traits in Cumin and Fennel (Table 1).

With increasing salinity in the Chicory, fresh and dry weights were decreased. Maximum of fresh and dry weight (1.69 and 0.87 mg, respectively) and minimum of them (1.26 and 21.86 mg, respectively) was obtained at control levels and highest level of salinity (10 ds/m), respectively (Table 3). In other hand at the highest levels of salinity fresh and dry weights were reduced by 25 percent compared to control (Table 3). In the case of effect of temperature on fresh and dry weight of seedling in Chicory, result indicated that maximum of fresh and dry weight of seedling was obtained jointly at 25 and 29 ^{O}C condition. Minimum of those traits were observed at 22 ^{O}C condition (Table 3).

In case of Cumin and Fennel maximum of fresh weight (0.14 and 3.7 mg, respectively) and minimum of them (0.083 and 3.78 mg, respectively) were obtained at control levels and highest level of salinity (10 ds/m), respectively. Similar results were observed for dry weight of seedling (Table 2). Ali et al. (1992) and Lyra et al. (1992) also reported a similar trend in the fresh weight of Trigonella and Sesamum seedlings. Reduction in fresh biomass at higher concentration might be due to poor absorption of water from the growth medium due to physiological drought (HussainandIlahi, 1992). Increased fresh weight under low salt concentration in *Lepidium*, *Plantago*and *Trigonella*is attributable to the development of succulence to cope with salt stress (Zahir and Hussainn, 2010). Ilahi and Hussain (1990) also reported a similar increase in fresh weight for *Brassica campestris*. The increase in the dry weight of seedlings with increasing salt concentration is in contrast to the findings of Younis et al. (1987) and Lyra et al. (1992) who reported decreased dry weight of Linumand Sesamum seedlings as a result of salt stress. Decrease in seedling weight has been reported by Almodares et al. (2007).

3.3 Water Content of SeedlingTissue

Water content of seedling tissue, play important role in various physiological processes. In the present study analysis of variance showed a significant effect of salinity on water content of seedling tissue of Cumin and Fennel (Table 1). Water content of seedling tissue of Chicory was not significantly affected by salinity. Also temperature levels were not effect this trait in all three studied plants (Table 1).

Maximum water content of seedling tissue in Cumin (52.71%) and Fennel (52.54%) was obtained in the control and the lowest level of this trait (44.84 and 46.01%, respectively) was obtained at highest level of salinity (Tables 2 and 4). Shadded and Zaidan (1989) recorded reduced water contents with increased salt stress in *Trigonella* while Ibrarand Hussain (2003) reported enhanced root water contents with increasing salinity level in *Medicagopolymorpha*.

Table 2. Effect of salinity and temperature on seed germination characteristics Cumin

Treatments		Seedling length (mm)	Shoot length (mm)	Root length (mm)	Fresh weight of seedling (mg)	dry weight of seedling (mg)	Water content of seedling tissue (%)	Germination Percentage	Germination Rate (seed/day)	Seed vigor index
Salinity (ds/m)	0	229.16 ^{a}	149.2 ^{a}	77.99 ^{a}	0.144 ^{a}	0.068 ^{a}	52.71 ^{a}	40.40 ^{a}	15.60 ^{a}	92.65 ^{a}
	2	229.11 ^{a}	148.7 ^{a}	80.18 ^{a}	0.141 ^{ab}	0.068 ^{a}	48.99 ^{ab}	35.53 ^{a}	13.28 ^{b}	81.59 ^{a}
	4	226.56 ^{ab}	147.2 ^{a}	79.25 ^{ab}	0.120 ^{ab}	0.062 ^{a}	48.47 ^{ab}	27.08 ^{b}	9.86 ^{c}	61.42 ^{b}
	6	222.28 ^{bc}	144.4 ^{ab}	77.60 ^{bc}	0.111 ^{abc}	0.060 ^{a}	48.15 ^{b}	23.69 ^{b}	6.79 ^{d}	53.02 ^{b}
	8	217.35 ^{c}	141.1 ^{b}	76.00 ^{c}	0.110 ^{bc}	0.058 ^{a}	45.29 ^{b}	13.24 ^{c}	4.47 ^{e}	29.04 ^{c}
	10	207.57 ^{d}	134.5 ^{c}	72.75 ^{d}	0.083 ^{c}	0.040 ^{b}	44.84 ^{b}	12.22 ^{c}	4.05 ^{e}	25.41 ^{c}
Temperature (°C)	27	218.1 ^{b}	146.7 ^{a}	76.1 ^{b}	-	-	-	-		-
	29	225.8 ^{a}	144.3 ^{ab}	79.0 ^{a}	-	-	-	-		-
	31	221.9 ^{ab}	141.5 ^{b}	77.6 ^{ab}	-	-	-	-	-	-

Table 3. Effect of salinity and temperature on seed germination characteristics Chicory

Treatments		Seedling length (mm)	Shoot length (mm)	Root length (mm)	Fresh weight of seedling (mg)	dry weight of seedling (mg)	Germination Percentage	Germination Rate (seed/day)	Seed vigor index
Salinity (ds/m)	Control	33.09 ^{a}	20.54 ^{a}	13.13 ^{a}	1.69 ^{a}	0.87 ^{a}	49.22 ^{a}	13.98 ^{a}	16.20 ^{a}
	2	30.48 ^{b}	18.46 ^{b}	12.18 ^{ab}	1.62 ^{b}	0.84 ^{b}	48.41 ^{a}	12.28 ^{ab}	14.70 ^{b}
	4	29.51 ^{b}	16.06 ^{b}	11.74 ^{b}	1.56 ^{bc}	0.81 ^{c}	47.52 ^{a}	12.95 ^{abc}	13.90 ^{b}
	6	28.63 ^{b}	17.37 ^{bc}	11.46 ^{bc}	1.56 ^{c}	0.81 ^{c}	45.24 ^{b}	12.41 ^{bc}	12.88 ^{c}
	8	26.09 ^{c}	15.99 ^{c}	10.43 ^{c}	1.43 ^{d}	0.73 ^{d}	43.71 ^{b}	12.29 ^{bc}	11.35 ^{d}
	10	21.86 ^{d}	13.50 ^{d}	8.70 ^{d}	1.26 ^{e}	0.65 ^{e}	39.57 ^{c}	11.94 ^{c}	8.55 e
Temperature (°C)	22	-	-	-	1.46 ^{b}	0.76 ^{b}	44.38 ^{b}	-	12.30 ^{b}
	25	-	-	-	1.57 ^{a}	0.81 ^{a}	46.59 ^{a}	-	13.24 ^{a}
	28	-	-	-	1.53 ^{a}	0.79 ^{a}	45.86 ^{a}	-	13.27 $_{a}$

Numbers with the same letter, have no significant difference.

Table 4. Effect of salinity and temperature on seed germination characteristics Fennel

Treatments		Seedling length (mm)	Shoot length (mm)	Root length (mm)	Fresh weight of seedling (mg)	dry weight of seedling (mg)	Water content of seedling tissue (%)	Germination Percentage	Germination Rate (seed/day)	Seed vigor index
Salinity (ds/m)	0	97.98 a	57.05 a	40.92 a	3.69 a	1.91 a	52.54 a	62.60 a	27.71 a	61.39 a
	2	96.54 a	56.46 a	40.05 a	3.50 a	1.89 a	51.35 ab	62.26 ab	27.37 a	60.13 a
	4	72.76 b	42.95 b	29.82 b	3.40 a	1.81 ab	48.11 bc	58.84 b	23.26 b	42.60 b
	6	63.01 c	37.16 c	25.86 c	3.27 a	1.61 ab	47.44 bc	53.03 c	18.13 c	33.45 c
	8	58.81 cd	34.40 cd	24.44 cd	3.22 ab	1.50 c	46.76 c	43.17 d	10.94 d	25.22 d
	10	53.68 d	31.05 d	22.32 d	3.78 b	1.45 c	46.01 c	29.42 e	5.47 e	15.74 e
Temperature (°C)	17	-	-	-	-	-	-	50.22 b	-	37.72 b
	19	-	-	-	-	-	-	52.80 a	-	41.71 a
	21	-	-	-	-	-	-	51.61 ab	-	39.83 ab

3.4 Germination Percentage and Germination Rate

Results showed that salinity were significantly effect on germination percentage and germination rate in Chicory, Cumin and Fennel (Table 1). Germination percentage was affected by temperature regimes in Chicory and Fennel. However temperature levels were no significantly effect on germination rate in all three studied plants (Table 1). Germination percentage and germination rate in all three plants was significantly decreased with increasing salinity levels (Figures 1 and 2). The highest decrease in germination percentage was observed in Cumin with about 70 percent. The lowest decrease in germination percentage (38%) was found in Chicory. 53% reduction in germination percentage was found in Fennel. Chicory, Cumin and Fennel germination rate significantly decreased with increasing salinity levels (Figure 2). Increasing salinity

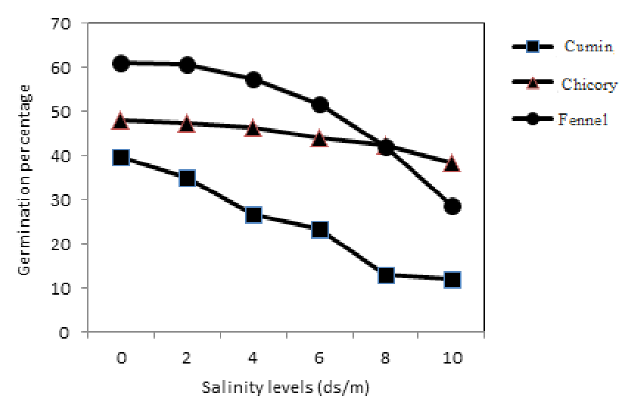

Figure 1. Effect of salinity ongermination percentage of Cumin, Chicory and Fennel

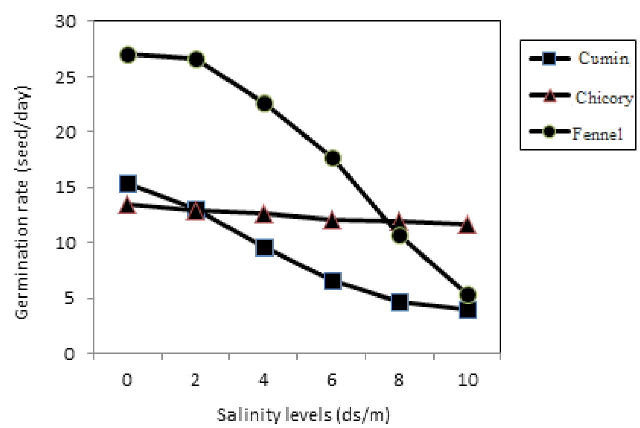

Figure 2. Effect of salinity ongermination rate of Cumin, Chicory and Fennel

10 ds/m led to decrease 20, 74 and 80 percent in germination rate of Chicory, Cumin and Fennel respectively. Germination and seedling establishment are generally most sensitive stages in plant life (Ashraf et al. 1986). Salinity causes osmotic stress (Nandawal et al. 2000; Daniela et al. 2004) or specific ion effects, which delay, reduces or completely inhibit seed germination (Munns, 2002; Hanselin and Eggen, 2005). Our findings agree with them in this regard.Furthermore Anwar et al. (2001); Zia and Khan (2002) also reported reduced germination under saline conditions in some other medicinal plants that also strengthen our findings. Reduced germination by increasing salinity has been reported in several studies (Ajmal Khan and Ghulzar, 2003; Akbari et al. 2007; Almansori et al. 2001; Guan et al. 2009*;* Jamil et al. 2007 and Qu et al. 2008). Various studies showed that in the average concentrations of salt, reducing the osmotic potential causes reduced germination. But toxic in high concentrations, followed by ion absorption and nutrient imbalance between important factors led to disrupt and reduce germination. Segatoleslami (2010) reported that salinity has not significantly effect on germination rate. Decrease in germination rate have been reported in cotton (Kernezhady et al. 2004), Hibiscus tea, Indian Senate, hyssop, basil and artichoke (Khumri and Dehmorde, 2007) and Plantago Psyllium (Hosseini and Rezvani Moghaddam, 2006) and savory (Segatoleslami, 2010). In case of effect of temperature levels on germination percentage in Chicory and Fennel results showed that maximum of this trait (46.59 and 52.80, respectively) was obtained at 25 C in Chicory and 19 C in Fennel (Tables 3 and 4).

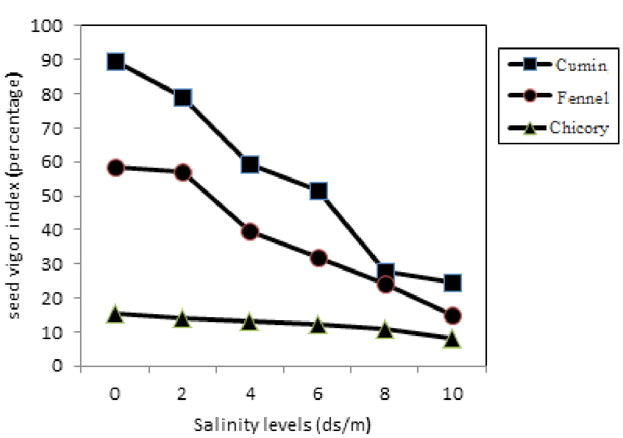

Figure 3. Effect of salinity on seed vigor index of Cumin, Chicory and Fennel.

3.5 Seed Vigor Index

In all three studied plant analysis of variance showed a significant effect of salinity on seed vigor index. Temperature levels were not significantly effect on this treat (Table 1). Results indicated that with increasing salinity seed vigor was significantly decreased (Figure 3). With increasing salinity to 10 ds/m, seed vigor was decrease to 47.4, 72.26 and 74.4 percent in Chicory, Cumin and Fennel, respectively. Since the seed vigor index is obtained by multiplying of seedling length and germination percent, reduction in seed vigor was expected. Seed vigor decrease with increasing salinity also been reported by Segatoleslami (2010). The results of the present study were in agreement with those of Salami et al. (2006) in study of the effect of salinity stress on *Cuminumcyminum* and *Valerianaofficinalis* and Safarnejad and Hamidi (2008) in study of the morphological characters of *Foeniculumvulgare* under salt stress in which they showed that with increasing in salinity levels, seed vigor, the ability of plant for survival and normal living were decreased. In case of effect of temperature levels on seed vigor in Chicory and Fennel results showed that maximum of this trait (13.24 and 41.71, respectively) was obtained at 25 C in Chicory and 19 C in Fennel (Tables 3 and 4).

4. Conclusions

According to the results, all germination characteristics except the shoot length in Fennel, root shoot ratio in all three studied plant and water content of seedling tissue in Chicory significantly declined with increasing salinity. Seed vigor index, germination percentage, dry weight of seedling, fresh weight of seedling in Chicory, seedling length and root length in Cumin and seed vigor in Fennel were significantly affected by temperature regime. Finally it can be stated that Fennel, Cumin and Chicory, respectively by 74, 72 and 47% reduction in seed vigor index at the highest levels of salinity in compared to the control level are the most sensitive to salinity. Consequently, based on the results, the published studies and regarding high medicinal values of this genus and their sensitivity to salinity stress, we recommend that the genus is cultivated in environments that plants are not in expose to salinity.

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