Shahid Chamran
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Effect of Saline Water on Seed Germination Indices of Salvia Hispanica L., Cyamopsis Tetragonoloba L., Luffa Cylindrical L., and Momordica Charantia L. (Chia, Guar, Luffa, and Karela)

H. Kaab Omair[1], M. Golabi[2*], A. A. Naseri[3] and S. Boroomand Nasab[4]

1- Master Student of Irrigation and Drainage, Faculty of Water and Environmental Engineering, Shahid Chamran University of Ahvaz, Iran.
2- Corresponding Author, Assistance Professor, Department of Irrigation and Drainage, Faculty of Water and Environmental Engineering, Shahid Chamran University of Ahvaz, Iran.(m.golabi@scu.ac.ir).*
3- Professor, Department of Irrigation and Drainage, Faculty of Water and Environmental Engineering, Shahid Chamran University of Ahvaz, Iran.
4- Professor, Department of Irrigation and Drainage, Faculty of Water and Environmental Engineering, Shahid Chamran University of Ahvaz, Iran.

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Abstract

The salinity of water and soil resources and lack of appropriate quality water resources are major threats to agricultural development in arid and semiarid regions such as Iran, Khouzestan province. The implementation of haloculture projects causes the availability of saline water resources in these areas. Therefore, the study on the effects of salinity on seed generation was the essential aim of current research. In this study, because of the importance of nutrition, medical and industrial of Chia (Salvia hispanica L.), Guar (Cyamopsis tetragonoloba L.), Luffa (Luffa cylindrical L.), and Karela (Momordica charantia L.), the effect of saline water on seed germination indices were evaluated. The seed germination indices consisted of germination percentage (Gp%), the coefficient of the velocity of germination (Gi), seed vigor index (Vi), germination uniformity (GU), salinity tolerance index (STI), dry weight, fresh weight, and the percentage of moisture of the radical and plumule were determined under salinity stress. To achieve the aims of the current study, four salinity levels were used, including Karoon River water (as a control treatment) with an average electrical conductivity of 1.21 dS /m and diluted drain water with an electrical conductivity of 5, 10, 15, 20 dS/m (S1, S2, S3, S4, S5, respectively) in three replications (R1, R2, and R3). The experimental design was completely random. The analysis of variance of measured indices in the experiment showed that the effects of salinity on germination percentage of Guar and Luffa at 1% and Karela and Chia at 5% level of probability were significantly affected by salinity stress. The effect of salinity on the velocity of germination of the studied species was significant. Also, the salinity effect on the seed vigor index of Guar and Chia was significant at the 1% level. Increasing salinity significantly decreased the seed vigor index in the mentioned species. According to the results of this study, among four seeds, Chia and Guar were identified as the most tolerant plant to salinity stress in the seedling stage.

Introduction

Various biotic/abiotic factors often control agricultural productivity. However, wild plants and elite varieties have developed different mechanisms and approaches to overcome these factors throughout the years. The most critical problems cultivated crops face are drought, water, and salt stress. Salt stress itself is divided into different parts. But, one of the essential parts is soil salinity. According to Plaut et al. (2013), the weathering of parent rocks and minerals in the soil, seawater intrusion into coastal areas, rainwater, and windborne materials from lakes and other land surfaces play a significant role. Whether directly or indirectly, these factors increase soil salinity and affect physiology, growth, yield, nutritional superiority, and the crops' magnitude. Yadav et al. (2011) suggested that the salt concentration might even stimulate water and ions imbalance and reduce nutritional management collectively due to altered stomatal conductance, photosynthesis, and stunted growth. Soil salinity and sodicity cause severe problems in the agricultural world. Therefore, the amount of salt tolerance in crops is a critical trait, and has many researchers worked on it. Hasegawa et al. (2000), Munns (2002), Muscolo et al. (2007& 2013), Zhu (2007), and Sidari et al. (2008), all proved that detrimental effects of high salinity on crops are multifaceted and they affect plants in several ways; like drought stress, ion toxicity, nutritional disorders, oxidative stress, alteration of metabolic processes, membrane disorganization and reduction of cell division and expansion. As a result, plant growth, development, and survival are reduced severely. It is proven by Muscolo et al. (2011) and Schleiff and Muscolo (2011).

The two significant stresses that affect plants under salinity are osmotic and ionic. Osmotic stress, proved by Munns and Tester (2008), occurs immediately in the root medium when exposed to salts and can inhibit water uptake, cell expansion, and lateral bud development. Yeo and Flowers (1986) and Glenn et al. (1999) pointed out that ionic stress develops when toxic ions like Na+ accumulate in cells, which causes an increase in leaf mortality, chlorosis, necrosis, and a decrease in the activity of cellular metabolism, including photosynthesis. To address the detrimental effects of salinity on agricultural production, extensive research on plant screening for salt tolerance has been conducted to provide more tolerant cultivars (e.g., Shannon & Noble, 1990; Chen et al., 2005; Sevengor et al., 2011). Flowers et al. (2010) pointed to a significant detail; there are very few investigations on screening available halophytes and their responses to saline conditions. Stepien and Johnson (2009) stressed this point further, suggesting salinity as one of the most critical environmental stresses and is considered a complicated and crucial widespread problem. Li et al. (2011) and Wu et al. (2012) both believed that salinity causes severe limitation in the growth and yield of crop plants due to their sensitivity to high concentrations.

Salinity causes many physiological, Salinity causes many physiological, morphological, and metabolic responses. It can also induce osmotic and oxidative stresses by increasing reactive oxygen species (ROS), including free radicals, hydrogen peroxide, and singlet oxygen. Regarding the importance of Chia, Guar, Luffa, and Karela plants nutritionally and considering the importance of haloculture, the purpose of the present study is to investigate the effect of salinity on these four plants.

One of the plants mainly grows in Mexico and Guatemala's mountain areas (Cahill, 2004). In the pre-Columbian epoch, Chia was one of the four essential diet elements of Central America. Referring to Busilacchi et al. (2013), Chia is grown in Australia, Bolivia, Colombia, Guatemala, Mexico, Peru, and Argentina. Alenbrant et al. (2014) proved that Chia is mainly grown in Mexico; this country currently exports Chia seeds to Japan, U.S.A., and Europe. This plant naturally grows in tropical and subtropical environments (Orozco et al., 2014). Jamboonsri et al. (2012) and Busilacchi et al. (2013) showed that Chia must be considered as a short-day plant, as it only has a threshold of 12 to 13 hours, and, referring to this point, its period of growth and fruiting will depend on the latitude of the place it grows. Looking from an agronomic point, studies of S. hispanica- especially in seed technology- are scarce.

Therefore, it is crucial to be cautious and know the factors that limit germination and seedling development to formulate management for S. hispanica cultivation.

Salinity stands out among these must-know factors, for S. hispanica seeds are particularly vulnerable to its effects. Falk and Munne-Bosch (2010) and Taiz and Zeiger (2013) had one similar point in their reports; that S. hispanica, under high salinity conditions, there is a high decrease in water absorption in return, a reduction in germination. Flowers and Colmer (2008), Munns and Tester (2008), and Zhang et al. (2015) proved that reduction in germination power in salt-stressed plants compared with control plants serves as an indication of the tolerance index of the species to salinity, elucidating the possible responses and tolerance of the plant to salt stress in different development levels.

According to Ashraf et al. (2002), Guar has grown as a vegetable for the human diet, the animals' forage crop, and a green manure crop. Francois et al. (1990) and Vinizky and Ray (1998) prove that the endosperm of Guar seed, when powdered, is a food stabilizer and is also used in textile, paper, petroleum, and mining, pharmaceutical, and cosmetics industries. Rosas et al. (1996) said that Guar grows well in semiarid and arid followed by salinity locations. The level of salinity soil in America is a problem and can pose a serious threat at times. For the same reason, Francois et al. (1990) offered Guar as it reduces salinity soil. Jeschke (1989), in American soil, saline subtracts are mostly salt-more accurately, sodium chloride (NaCl), though calcium salts and sulfates are also present. The reason for the posing threat of salinity soils, a research done by Ashraf et al. (2002), was that salt lowers the soil's osmotic potential, leading to dehydration and the plant's death.

One of the many plants belonging to the Curcurbitaceae family is the Momordica Charania L., also identified as Karela, balsam pear, and bitter gourd. In Pakistan, it is essential as it is one of the most critical summer crops. Having universal growth, you can find this plant in Asia and other parts of the world. It can be grown as an annual crop, a perennial crop in temperate areas, and a crop for frost-free winters. This plant needs an optimum temperature of 25 to 28 0C. Bitter gourd's importance can be found in eating diets and economics. In both, it plays a vital role. When immature and still young, the fruit contains a decent amount of Vitamins A and C (Yibchok-Anun et al., 2006). Yibchok-Anun et al. (2006) claimed that bitter gourd is a blood purifier, an activator of the spleen and liver, and very beneficial in curing diabetes. Grover and Yadav (2004) discovered that bitter melon is a cancer fighter due to having anti-carcinogenic properties. Liu et al. (2002) and Wang et al. (2010) found out that this plant is traditionally grown in India, China, Africa, and South America for having anti-diabetics, antioxidants, contraceptives, and antibacterials.

Also, widely being grown worldwide, Luffa, belonging to the Cucurbitaceae family, is one of the many vegetables Indians use in their diets. Chandra (1995) proved that Luffa acutangula (L.) Roxb – more commonly known as ridged ground-are wildly cultivated in the plains and low hills of the country and, therefore, may be influenced by salt stress. Prakash et al. (2014) proved that due to the long history of cultivation of Luffa in India under varied climatic, geographical, and environmental conditions, large numbers of variants had been developed from the cultivars through introgression and selection.

Due to the water crisis in Iran, using proper agricultural methods such as low-irrigation techniques, low-quality irrigation water (saline and brackish water), and dry and saline plants in the production of agricultural products are used of particular importance. On the other hand, crop production in arid and semiarid lands inevitably requires leaching to control the salinity of the root zone, and increasing saline water consumption, in turn, leads to increased salt intake. However, the cultivation of salt-tolerant crops and halophytes usually reduces both plant water requirement and the need for leaching (Khoorsandi et al., 2010). It is crucial in Khouzestan province, where drain water is a problem, and much of the province's south is affected by salinity. The essential salinity factors in the region are saline irrigation and high groundwater level. The combined use of saline water resources to produce forage, wood, livestock, and aquaculture is known as haloculture. Recently the economic efficiency of haloculture in arid and semiarid lands has increased. Haloculture is the sustainable and economical production of crops using saline water and soil resources, where conventional farming is either not economical or sustainable. The domestication of salt-tolerant plants growing in saline and arid areas has introduced them as new varieties that produce more satisfactory crops under environmental stress caused by salinity and drought (Khoorsandi et al., 2010). Due to the importance of the subject, in this study, the effect of water salinity on germination indices of Chia, Guar, Luffa, and Karela was investigated. The main aim of the current study was to determine the most resistant seed to salinity at the germination stage.

Materials and Methods

This study was carried out in the water and soil laboratory of the water and environmental engineering faculty, the Shahid Chamran University of Ahvaz, in January 2020. Seeds were surface-sterilized for 20 min in 20 % (v/v) sodium hypochlorite, rinsed and soaked for one h in distilled water (Ruiz-Carrasco et al. 2011; Burrieza et al. 2012). Also, Petri dishes are placed in an oven at 160 ° C for two hours to disinfect. Figure 1 shows the seeds of this research.

To achieve the aims of the current study, five salinity levels were used, including Karoon River water (as a control treatment) with an average electrical conductivity of 1.21 dS /m and diluted drain water with an electrical conductivity of 5, 10, 15, 20 dS/m (S1, S2, S3, S4, S5, respectively) in three replications (R1, R2, and R3). The experimental design was completely random. Drain water was provided from Zoheh-Jarahi irrigation and drainage networks located in the southwest of Iran in Khuzestan province. The salinity of this water was 67 (dS/m). Diluted drain water was used to provide the required salinity water. The required volumes of water were initially calculated for each treatment. Then according to the available drain water salinity and control water salinity (Karoon water), the desired salinity values were calculated by the mixing formula (Eq. 1).

$$EC_{adj} = \frac{V_1.EC_1 + V_2 EC_2}{V_1 + V_2} \tag{1}$$

In the above equation, V1 and V2 are the control water and drain water volumes, EC_1 and EC_2 are the control water and the drain water salinity, and EC_{adj} is the equilibrium salinity. After mixing, the drain water salinity was re-measured and used if the difference was less than 0.1 dS/m. Finally, ECs of 5, 10, 15, and 20 dS/m were obtained using the mixing formula. From each sample, sets of 20 seeds were counted, and each set was placed in a 90-mm diameter petri dish lined with two layers of filter paper. Dishes were covered with lids and stored in the germinator at 250C temperature. The germinated seeds, radical length, and plumule length per petri dish were counted daily until day 10. After ten days, dry weight, fresh weight, and the radical and plumule moisture percentage were measured. From these germination counts, several germination indicators were calculated to characterize the salt tolerance, including germination percentage (Gp %), the velocity of germination (Gi number of germinated seed /day), and seed vigor index (Vi) as follows (Bajji et al., 2002):

$$G_p = \frac{N_G}{N_T} \times 100 \tag{2}$$

$$G_i = \frac{\sum_{i=1}^{10} n_i}{t_i} \tag{3}$$

$$V_i = \frac{L_S \times G_P}{100} \tag{4}$$

Where NG is the number of seeds germinated on the day, NT is the total number of germinated seeds, ni is the number of seeds grown on the day I, ti is the number day after germinated, and LS is the sum of the average of the radical and plumule length.

Also, the amount of germination uniformity (Soltani et al., 2001) and the salinity tolerance index (Sapra et al., 1991) were calculated from the below equations.

$$GU = D10 - D90 \tag{5}$$

$$STI = \frac{TWSs}{TWSc} \qquad (6)$$

where D10 is the time until 10% of maximum germination, D90 is the time until 90% of maximum germination, TWSs is the dry weight of plumule under salinity stress, and TWSc is the dry weight of control plumule.

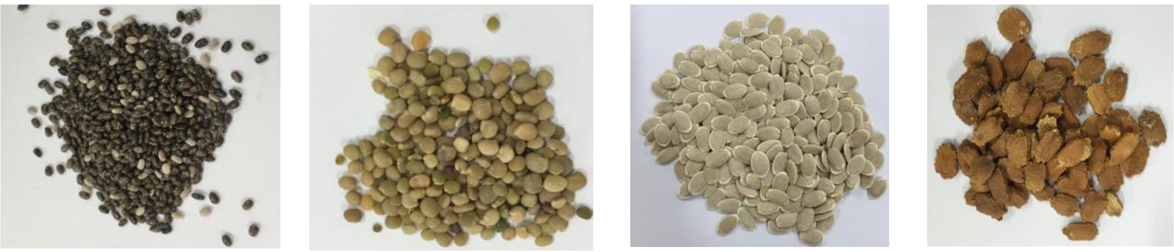
For statistical analysis, SPSS software was used, and the effect of salinity was evaluated on germination indicators. Also, all correlation coefficients between properties were assessed to study and compare the correlation relationships between measured and calculated parameters in different salinity treatments.

Results and Discussion

After making different salinity levels, water was analyzed qualitatively. The results are presented in Table (1).

In the present study, the electrical conductivity of the control (S1) was 1.21 (dS/m). As the results of Table (1) show, the electrical conductivity of irrigation water used is in the very high salinity range (C4). In other words, the water used is in the brackish to the very saline range. Also, irrigation water ranges from low to high and very high in terms of sodium.

As mention before in the current study, the germination indices of four seeds were investigated. During and at the end of the experiment, the germination indicators were measured and determined. Table (2) shows the results of the analysis of variance of germination indicators.



Chia Guar Luffa Karela

Fig. 1.- The seeds used in this study

Table 1- Qualitative analysis of irrigation water

Sample	EC (dS/m)	pH	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SAR	Classification
					(meq/l)				
S1	1.21	7.58	22.56	0.28	3.40	33.34	28.00	5.26	C_3-S_1
S2	5.0	7.90	38.26	0.47	3.89	41.32	68.00	8.05	C_4-S_1
S3	10.00	8.50	96.74	0.97	14.00	59.21	87.00	15.99	C_4-S_2
S4	15.00	7.28	138.41	1.23	15.00	110.91	125.0	17.44	C_4-S_3
S5	20.00	7.63	163.77	1.40	22.66	127.30	190.00	18.91	C_4-S_4

Table 2– Analysis of variance of the germination indicators

Plant			Mean Square												
								Radical			Plumule			Radical length/ Plumule length	Radical fresh weight/ Plumule fresh weight
	Source	df	GP%	Gi(n/day)	Vi	GU	STI	fresh weight (gr)	dry weight (gr)	Moisture (%)	fresh weight (gr)	dry weight (gr)	Moisture (%)		
Chia	Treatment	4	482.52*	0.19*	1361.38**	-	0.36**	0.004**	0.0006**	119.54	0.01**	0.003**	230.62**	1332.48**	0.014*
	Error	0	148.80	0.06	8.84	-	0.005	0.0001	0.00003	48.72	0.0002	0.00004	13.21	1.35	0.004
	CV%		14.28	14.24	8.01	-	15.73	16.63	19.87	12.09	9.87	16.1	4.76	2.81	16.32
Guar	Treatment	4	189.89**	0.08**	1251.80**	0.57*	0.25**	0.03	0.0004	120.18	0.66**	0.003**	2.83	1533.68**	0.096**
	Error	0	21.28	0.008	8.05	0.13	0.01	0.03	0.0001	70.84	0.01	0.0001	1.41	4.21	0.01
	CV%		5.71	5.72	8.27	22.82	17.09	54.90	33.98	9.71	9.84	14.93	1.27	5	39.45
Luffa	Treatment	4	49.06**	0.02**	2.03	28.23**	2.35*	0.05*	0.0002**	0.05*	0.75	0.0008**	5052.11**	121.13	0.30
	Error	0	6.7	0.002	1.18	4.2	0.48	0.02	0.00004	0.01	0.26	0.0001	482.43	60.18	0.19
	CV%		53.19	53.19	180.08	62.74	50.87	77.44	43.12	82.43	90.68	49.97	33.66	125.93	112.51
Karela	Treatment	4	109.72*	0.06**	0.89	25.6**	1.54	0.35*	0.002**	6764.47**	1.13	0.002	5715.63**	40.67*	0.53*
	Error	0	29.08	0.008	0.38	1.53	0.79	0.07	0.0002	113.89	0.45	0.0007	646.24	10.43	0.16
	CV%		78.54	59.54	106.38	39.52	112.46	77.35	61.15	18.28	99.87	91.49	41.19	76.52	86.46

Germination percentage (G_p%), the coefficient of velocity of germination (G_i), seed vigor index (V_i), germination uniformity (GU), salinity tolerance index (STI)

The analysis of variance of measured indices in the experiment showed that the effects of salinity on germination percentage of Guar and Luffa at 1% and Karela and Chia at 5% level of probability were significantly affected by salinity stress. The effect of salinity on the velocity of germination of the studied species was significant. Also, the salinity effect on the seed vigor index of Guar and Chia was significant at a 1% level. Increasing salinity significantly decreased the seed vigor index in the mentioned species. While increasing salinity had no significant effect on the seed vigor index of Karela and Luffa. Among the species studied, uniformity of germination of Luffa and Karela at 1% level and Guar at 5% level was significantly affected by salinity stress. The effect of salinity on the salinity tolerance index of Guar and Chia was significant at 1% and in Luffa at 5%. Increasing salinity level decreased the salinity tolerance index in the mentioned species, while increasing salinity had no significant effect on the Karela salinity index. Analysis of variance showed that salinity significantly affected the fresh and dry weight of Chia, Luffa, and Karela radicals. Still, its impact on the fresh and dry weight of radicals of Guar was not significant. The effect of salinity on the moisture of Karela and Luffa was significant. But other species were not affected by salinity in this trait. Analysis of variance showed that salinity had a significant effect on the fresh and dry weight of plumules of Chia and Guar and dry weight of plumules on Luffa, but its effect on the fresh and dry weight of plumules of Karela and shoot fresh weight of plumules of Luffa were not significant. Also, analysis of variance showed that salinity had a significant effect at the 1% level on the moisture of the plumule of Chia, Luffa, and Karela. Still, its effect on the fresh and dry weight of radical of Guar was not significant.

Salinity significantly affected radical fresh weight to plumule of Chia, Karela (5%), and Guar (1% level). Still, its impact on the radical to plumule fresh weight of Luffa was not significant.

To further investigate the effect of salinity on germination, indicators of Chia, Guar, Luffa, and Karela were studied. The results are presented in Tables (3) to (6).

Comparing the mean germination percentage of Chia showed that increasing salinity up to 15 dS/m had no significant effect on germination percentage, but with increasing salinity up to 20 dS/m, it decreased significantly. Increasing salinity at any amount decreased the resistance index of Chia species. Increasing salinity to more than 5 dS / m significantly decreased Chia's radical fresh and dry weight.

A comparison of the mean germination percentage of Guar showed that increasing salinity up to 15 dS / m had no significant effect on germination percentage, but with increasing salinity up to 20 dS / m, and germination percentage decreased significantly. Increasing salinity up to 10 dS /m had no significant effect on germination uniformity of the studied species but decreased with increasing salinity. Increasing salinity levels reduced the fresh and dry weight of the plumule. Increasing salinity up to 5 and10 dS/m, respectively, had no significant effect on the plumule's fresh and dry weight but decreased with increasing salinity.

Luffa germination percentage decreased significantly with increasing salinity, which stopped at 20 dS / m salinity. Increasing salinity levels reduced the velocity of germination. A comparison of the germination rate of Luffa at different salinity levels indicates that salinity significantly reduced the velocity of germination. Salinity up to 10 dS / m had no significant effect on the salinity index, but the salinity index decreased significantly with increasing salinity. Increasing up to 10 dS/m had no significant effect on the weight of the fresh radical. Comparison of the moisture of radical Luffa showed that increasing salinity up to 10 dS had no significant effect on radical water content. Still, radical water content decreased significantly with increasing salinity, and 20 dS / m reached zero.

Table 3- The effect of salinity on germination indicators of Chia

Water Salinity (dS/m)	GP%	Gi(n/day)	Vi	STI	Radical			Plumule			Radical length/ Plumule length	Radical fresh weight/ Plumule fresh weight
					fresh weight (gr)	dry weight (gr)	Moisture (%)	fresh weight (gr)	dry weight (gr)	Moisture (%)		
1.21	92.3a	1.87a	62.73a	0.97a	0.120a	0.043a	63.833a	0.26a	0.093a	85.97a	66.90a	0.46a
5	92.3a	1.85a	52.33b	0.58b	0.077b	0.037b	61.667ab	0.18b	0.053b	80.50a	56.67b	0.42a
10	90.0a	1.80a	36.93c	0.356c	0.06bc	0.023b	61.267ab	0.17b	0.033c	80.43a	41.03c	0.36ab
15	89.5a	1.79a	24.00d	0.25c	0.043c	0.017bc	51.867ab	0.12c	0.023c	70.63b	26.90d	0.35ab
20	62.8b	1.26b	9.63e	0.11d	0.020d	0.010c	50.000b	0.07d	0.010d	64.17b	15.27e	0.282b

Table 4- The effect of salinity on germination indicators of Guar

Water Salinity (dS/m)	GP%	Gi(n/day)	Vi	GU	STI	Radical			Plumule			Radical length/ Plumule length	Radical fresh weight/ Plumule fresh weight
						fresh weight (gr)	dry weight (gr)	Moisture (%)	fresh weight (gr)	dry weight (gr)	Moisture (%)		
1.21	86.5a	1.73a	61.00a	2.00a	1.00a	0.453a	0.046a	94.467a	1.58a	0.116a	94.86a	70.63a	0.58a
5	85.0a	1.70a	44.73b	2.00a	0.89a	0.320a	0.033ab	90.033ab	1.42a	0.103a	93.33ab	53.10b	0.35b
10	84.3a	1.69a	36.70c	1.67ab	0.64b	0.300a	0.033ab	86.00ab	1.42a	0.073b	92.73ab	43.13c	0.31bc
15	81.2a	1.62a	19.77d	1.33bc	0.58b	0.267a	0.026b	85.600ab	0.89b	0.066b	92.63b	24.33d	0.19bc
20	67.0b	1.34b	9.30e	1.00c	0.25c	0.170a	0.016b	77.367b	0.45c	0.030c	92.53b	13.83e	0.11c

Table 5-The effect of salinity on germination indicators of Luffa

Water Salinity (dS/m)	GP%	Gi(n/day)	Vi	GU	STI	Radical			Plumule			Radical length/ Plumule length	Radical fresh weight/ Plumule fresh weight
						fresh weight (gr)	dry weight (gr)	Moisture (%)	fresh weight (gr)	dry weight (gr)	Moisture (%)		
1.21	9.8a	0.20a	1.99a	6.33a	2.16a	0.316a	0.023a	0.296a	1.01a	0.036a	97.03a	15.96a	0.83a
5	7.8ab	0.16ab	0.67ab	5.67a	2.00a	0.263ab	0.020a	0.250ab	0.93ab	0.033a	94.60a	7.80ab	0.49ab
10	4.6ab	0.09bc	0.32ab	4.33a	1.66a	0.186abc	0.016a	0.176abc	0.82abc	0.026a	84.60ab	5.83ab	0.40ab
15	2.0c	0.04c	0.03ab	0.00b	1.00ab	0.050bc	0.013a	0.033bc	0.03bc	0.006b	50.00b	1.20b	0.18ab
20	0.0c	0.0c	0.00b	0.00b	0.00b	0.00c	0.00b	0.00c	0.00c	0.00b	0.00c	0.00b	0.00b

Table 6- The effect of salinity on germination indicators of Karela

						Radical			Plumule				
Water Salinity (dS/m)	GP%	Gi(n/day)	Vi	GU	STI	fresh weight (gr)	dry weight (gr)	Moisture (%)	fresh weight (gr)	dry weight (gr)	Moisture (%)	Radical length/ Plumule length	Radical fresh weight/ Plumule fresh weight
1.21	11.7a	0.30a	1.15a	6.00a	1.67a	0.690a	0.053a	95.767a	1.32a	0.056a	95.37a	8.43a	1.03a
5	11.2a	0.23a	0.99ab	5.33a	1.18ab	0.690a	0.046a	93.067a	1.15ab	0.050a	95.30a	6.57ab	0.63ab
10	11.0a	0.22a	0.77ab	4.33a	1.00ab	0.420ab	0.016b	89.700a	0.81ab	0.040b	86.67a	5.33abc	0.51ab
15	0.5b	0.00b	0.01b	0.00b	0.11b	0.016b	0.010b	13.333b	0.05b	0.003c	31.23b	0.77bc	0.10b
20	0.00b	0.00b	0.00b	0.00b	0.00b	0.00b	0.00b	0.000c	0.00b	0.000c	0.00c	0.00c	0.00b

A comparison of the germination rate of Karela at different salinity levels indicates that salinity significantly reduced the germination rate. Increasing salinity levels reduced the fresh and dry weight of the radical of Karela. Increasing salinity to 5 dS /m had no significant effect on the fresh and dry radical weight of Karela, but with increasing salinity, the fresh and dry radical weight was decreased. Comparison of the mean of radical moisture of Karela showed that increasing salinity up to 10 dS/m had no significant effect on radical water content. Still, the radical tissue water content decreased significantly with increasing salinity, and in salinity, 20 dS / m reached zero. Also, correlation coefficients between different traits of Chia, Guar, Luffa, and Karela were determined. The results are presented in table (7) to (10).

A comparison of mean germination percentage of Guar showed that increasing salinity up to 15 dS / m had no significant effect on germination percentage, but with increasing salinity up to 20 dS / m, germination percentage decreased significantly. Increasing salinity up to 10 dS /m had no significant effect on germination uniformity of the studied species but decreased with increasing salinity. Increasing salinity levels reduced the fresh and dry weight of the plumule. Increasing salinity up to 5 and10 dS/m, respectively, had no significant effect on the fresh and dry weight of plumule but decreased with increasing salinity.

Luffa germination percentage decreased significantly with increasing salinity, which stopped at 20 dS / m salinity. Increasing salinity levels decreased the velocity of germination. A comparison of the germination rate of Luffa at different salinity levels indicates that salinity significantly reduced the velocity of germination. Salinity up to 10 dS / m had no significant effect on the salinity index, but with increasing salinity, the salinity index decreased significantly. Increasing up to 10 dS/m had no significant effect on the weight of the fresh radical. Comparison of the moisture of radical of Luffa showed that increasing salinity up to 10 dS had no significant effect on radical water content but with increasing salinity, radical water content decreased significantly and in salinity 20 dS / m reached zero.

A comparison of the germination rate of Karela at different salinity levels indicates that salinity significantly reduced the germination rate. Increasing salinity levels reduced the fresh and dry weight of the radical of Karela. Increasing salinity to 5 dS /m had no significant effect on the fresh and dry radical weight of Karela but with increasing salinity, the fresh and dry radical weight were decreased. Comparison of the mean of radical moisture of Karela showed that increasing salinity up to 10 dS/m had no significant effect on radical water content but with increasing salinity the radical tissue water content decreased significantly and in salinity 20 dS / m reached zero. Also, correlation coefficients between different traits of Chia, Guar, Luffa, and Karela were determined. The results are presented in table (7) to (10).

According to Table (7), the seed vigor index, the salinity tolerance index, and plumule fresh and dry weight with all traits except germination percentage and rate, root tissue water content had positive and significant correlations of radical length. These traits also had a negative and significant correlation with the water content of plumule at the 1% level. The radical length was positively and significantly correlated with plumule length only at the 5% level. Plumule tissue water content had a significant negative correlation at the 1% level with all traits except germination percentage and radical water content and length.

The plumule length was positively and positively correlated with seed vigor index, salinity index, radical length, and plumule fresh and dry weights. Also, this trait had a significant negative correlation with plumule water content (at 5% level) and plumule fresh weight (at 1% level). According to Table (7), the radical to plumule fresh weight ratio had a significant positive correlation with all traits except radical percent and germination rate, radical water content, and radical and plumule length. Also, this trait had a significant negative correlation with the water content of plumule tissue at the 1% level.

Also, according to Table (7), radical water content did not correlate with any of the traits tested.

The correlation coefficients of studied traits in Guar are shown in Table (8).

Correlation coefficients of studied traits in Guar showed a positive and significant correlation between germination percentages with germination rate, salinity index, plumule fresh weight, and plumule dry weight, and radical to plumule fresh weight ratio. Germination rate showed a positive and significant correlation with salinity index, plumule fresh and dry weight, and negative and significant correlation with the radical to plumule fresh weight ratio at 5%. Seed vigor index had a positive and significant correlation (at 1% level) with salinity index, plumule dry weight, and the radical to plumule ratio. . Salinity index had a positive and significant correlation with germination percentage, germination rate, seed vigor index, plumule fresh weight, plumule dry weight, and radical to plumule ratio, as well as a negative and significant correlation (P <0.05) 1% level was observed with the radical to plumule fresh weight ratio. According to Table (8), plumule fresh weight had a positive and significant correlation with germination percentage, germination rate, seed vigor index, salt-resistance index, plumule dry weight, and the radical to plumule length ratio. There was also a significant negative correlation (at 5%) with the radical to plumule fresh weight ratio.

According to Table (8), the ratio of radical length to plumule, seed vigor index, salinity index, plumule fresh, and dry weight had a positive and significant correlation. The fresh weight ratio of radical to plumule had a significant negative correlation with germination percentage, germination rate, seed vigor index, salinity index, radical to plumule fresh weight, radical to plumule dry weight, and radical to plumule length ratio. Generally, according to Table (8), no significant correlation was observed between germination uniformity, radical fresh weight, radical dry weight, and radical tissue water content with the studied traits.

As mention before, the correlation coefficients between different traits of Luffa are presented in Table (9).

Table 7- Correlation coefficients between different traits of Chia

		1	2	3	4	5	6	7	8	9	10	11	12
GP%		1											
Gi(n/day)		0.99^{**}	1										
Vi		0.78	0.81	1									
STI		0.64	0.66	0.94^{*}	1								
Radical	fresh weight (gr)	0.71	0.74	0.96^{**}	0.99^{**}	1							
	dry weight (gr)	0.72	0.74	0.99^{**}	0.96^{**}	0.96^{**}	1						
	Moisture (%)	0.65	0.67	0.42	0.46	0.54	0.35	1					
Plumule	fresh weight (gr)	0.76	0.78	0.97^{**}	0.97^{**}	0.99^{**}	0.95^{**}	0.58	1				
	dry weight (gr)	0.63	0.66	0.94^{*}	0.99^{**}	0.99^{**}	0.96^{**}	0.47	0.97^{**}	1			
	Moisture (%)	-0.69	-0.72	-0.96^{**}	-0.98^{**}	-0.97^{**}	-0.98^{**}	-0.38	-0.94^{*}	-0.98^{**}	1		
Radical length/ Plumule length		0.76	0.78	0.99^{**}	0.94^{*}	0.96^{**}	0.99^{**}	0.39	0.97^{**}	0.95^{**}	-0.96^{**}	1	
Radical fresh weight/ Plumule fresh weight		0.83	0.85	0.96^{**}	0.93^{*}	0.95^{**}	0.96^{**}	0.50	0.93^{*}	0.93^{*}	-0.97^{**}	0.95^{**}	1

* and ** were significant at the five and one percent level respectively.

Table 8- Correlation coefficients between different traits of Guar

		1	2	3	4	5	6	7	8	9	10	11	12	13
GP%		1												
Gi(n/day)		1^{**}	1											
Vi		0.83	0.83	1										
GU		-0.31	-0.31	0.27	1									
STI		0.89^{*}	0.89^{*}	0.95^{**}	0.09	1								
Radical	fresh weight (gr)	0.20	0.20	-0.05	-0.42	-0.19	1							
	dry weight (gr)	0.15	0.15	-0.28	-0.68	-0.25	0.51	1						
	Moisture (%)	-0.20	-0.20	0.07	0.41	-0.11	0.36	-0.60	1					
Plumule	fresh weight (gr)	0.94^{*}	0.94^{*}	0.95^{*}	-0.01	0.92^{*}	0.13	0.05	-0.13	1				
	dry weight (gr)	0.88^{*}	0.88^{*}	0.96^{**}	0.10	0.99^{**}	-0.19	-0.26	-0.10	0.92^{*}	1			
	Moisture (%)	0.01	0.01	-0.12	-0.15	-0.30	0.75	0.73	-0.04	0.09	-0.31	1		
Radical length/ Plumule length		0.82	0.82	0.99^{**}	0.29	0.96^{**}	-0.07	-0.29	0.06	0.94^{*}	0.96^{**}	-0.13	1	
Radical fresh weight/ Plumule fresh weight		-0.90^{*}	-0.90^{*}	-0.86^{*}	-0.07	-0.96^{**}	0.23	0.03	-0.38	-0.90^{*}	-0.96^{**}	0.25	-0.88^{*}	1

* and ** were significant at the five and one percent level respectively

Table 9- Correlation coefficients between different traits of Luffa

		1	2	3	4	5	6	7	8	9	10	11	12	13
GP%		1												
Gi(n/day)		1**	1											
Vi		0.88*	0.88*	1										
GU		0.93*	0.93*	0.71	1									
STI		0.54	0.54	0.42	0.44	1								
Radical	fresh weight (gr)	0.99**	0.99**	0.85	0.96**	0.56	1							
	dry weight (gr)	0.60	0.60	0.43	0.53	0.98**	0.63	1						
	Moisture (%)	0.98**	0.98**	0.84	0.97**	0.53	0.99**	0.61	1					
Plumule	fresh weight (gr)	0.91*	0.91*	0.68	0.99**	0.49	0.95**	0.60	0.96*	1				
	dry weight (gr)	0.81	0.81	0.49	0.94*	0.55	0.87	0.67	0.88*	0.96**	1			
	Moisture (%)	0.86	0.86	0.63	0.85	0.83	0.90*	0.89*	0.88*	0.88*	0.90*	1		
Radical length/ Plumule length		0.94*	0.94*	0.97**	0.82	0.55	0.93*	0.56	0.93*	0.81	0.66	0.78	1	
Radical fresh weight/ Plumule fresh weight		0.21	0.21	0.07	0.00	0.42	0.13	0.42	0.09	-0.02	0.05	0.30	0.08	1

Correlation coefficients of studied traits on Luffa showed that germination percentage with all tested traits except salinity index, radical dry weight, plumule dry weight, plumule water content, and the radical to plumule fresh weight ratio had a positive and significant correlation. Germination rate showed a significant positive correlation with seed vigor index, germination uniformity, radical and plumule fresh weight, plumule water content, and radical to plumule length ratio. Seed vigor index was positively and significantly correlated with the radical and plumule ratio at 1% and 5% germination percentage. Germination uniformity was positively and significantly correlated with germination percentage, germination rate, radical fresh weight, radical tissue water content, plumule fresh and dry weight. According to Table (9), the salinity index only had a significant positive correlation with radical dry weight at a 1% level. Radical fresh weight had a positive and significant correlation with all traits except seed vigor index, salt-resistance index, radical and plumule dry weight, and radical to plumule ratio. Radical dry weight had a significant positive correlation with the salinity index, plumule water content.

T The plumule fresh weight had a positive and significant correlation with all traits except seed vigor index, salt-resistance index, radical dry weight, fresh weight ratio, and radical length to plumule. Plumule dry weight was positively correlated with germination uniformity, plumule fresh weight, and radical and plumule tissue water content. Plumule tissue water content had a positive and significant correlation with fresh and dry radical and plumule weight and radical tissue water content.

According to Table (9), radical tissue water content showed a positive and significant correlation with all tested traits except seed vigor index, salt-resistance index, radical dry weight, and radical fresh to plumule fresh weight ratio.

Radical to plumule ratio had a positive and significant correlation with germination percentage and rate, seed vigor index, radical fresh weight, and radical tissue water content. According to Table (8), the radical to plumule fresh weight ratio had no significant positive correlation with any of the studied traits of Luffa. Investigating correlation coefficients of studied traits in Luffa showed that germination percentage had only a positive and significant correlation with germination rate. Germination rate also showed a significant positive correlation with germination percentage only.

Also, correlation coefficients between different traits of Karela are presented in Table (10).

Correlation coefficients of studied traits in Karela showed that between germination percentage and germination rate, seed vigor index, germination uniformity, salinity index, radical fresh weight, radical tissue water content, plumule fresh weight. There was a significant positive correlation between plumule dry weight, the radical water content of radical, and plumule length to plumule ratio (Table 10).

Germination rate showed a positive and significant correlation with seed vigor index, germination uniformity, salinity index, radical tissue water content, plumule dry weight, plumule tissue water content, and radical to plumule ratio.

Seed vigor index had a significant positive correlation at 5% level with germination uniformity, radical fresh weight, fresh and dry plumule weight, the plumule water content of plumule and radical to plumule ratio, and a significant positive correlation with 1% level.

Germination uniformity was positively and significantly correlated with germination percentage, germination rate, seed vigor index, salinity index, radical fresh and dry weight, radical tissue water content, plumule fresh weight, plumule dry weight, the tissue water content of plumule, radical water content of radical, the ratio of radical length to plumule and the ratio of fresh, radical weight to plumule.

Table 10- Correlation coefficients between different traits of Karela

		1	2	3	4	5	6	7	8	9	10	11	12	13
GP%		1												
Gi(n/day)		0.97**	1											
Vi		0.96**	0.94*	1										
GU		0.98**	0.92*	0.93*	1									
STI		0.95*	0.91*	0.83	0.96**	1								
Radical	fresh weight (gr)	0.95*	0.86	0.91*	0.99**	0.92*	1							
	dry weight (gr)	0.80	0.65	0.78	0.88*	0.77	0.94*	1						
	Moisture (%)	0.97**	0.98**	0.96**	0.97**	0.94*	0.93*	0.78	1					
Plumule	fresh weight (gr)	0.96**	0.88	0.90*	0.99**	0.95*	0.99**	0.92*	0.94*	1				
	dry weight (gr)	0.98**	0.91*	0.91*	0.99**	0.96**	0.99**	0.89*	0.97**	0.99**	1			
	Moisture (%)	0.97**	0.95*	0.92*	0.94**	0.94*	0.90*	0.77	0.99**	0.92*	0.94*	1		
Radical length/ Plumule length		0.94*	0.91*	0.99**	0.91*	0.84	0.91*	0.82	0.94*	0.89*	0.91*	0.91*	1	
Radical fresh weight/ Plumule fresh weight		0.87	0.78	0.93*	0.90*	0.75	0.94*	0.93*	0.87	0.90*	0.89*	0.84	0.96**	1

According to Table (10), the salinity index According to Table (10), the salinity index positively correlated with all traits except the seed vigor index. Radical fresh weight had a positive and significant correlation with all traits except the germination rate. Radical dry weight had a positive and significant correlation with germination uniformity, radical fresh weight, plumule fresh weight, plumule dry weight, and radical to plumule fresh weight ratio. Radical length to plumule ratio and all traits except for salt resistance index and radical dry weight had a positive and significant correlation. According to Table (10), the radical tissue water content showed a positive and significant correlation with all traits except radical dry weight and radical to plumule fresh weight ratio. The plumule fresh weight had a significant positive correlation with all traits except the germination rate. Plumule tissue water content had a positive and significant correlation with all traits except radical dry weight and radical to plumule fresh weight ratio. The radical fresh weight to plumule ratio, seed vigor index, germination uniformity, fresh and dry weight of radical and plumule, and radical length to plumule ratio was observed. However, plumule dry weight was positively correlated with all tested traits at 5 and 1%, respectively. The present study showed that radical length was more sensitive to salinity stress than plumule length. Therefore, it can be said that radical length is an appropriate criterion for measuring salinity stress in different plants. Results show that Chia had more percentage of generation (more than 80% till 15 dS/m salinity of water), and the seed vigor index was more than 40% till 10 dS/m salinity of the water. The most sensitive seed was Luffa. Generally, Salinity affects all major processes such as growth, photosynthesis, protein synthesis, and lipid metabolism, and energy at all stages of plant growth, from germination to seed production.

The results of this study agree with the findings of Kaya et al. (2003) in safflower, Shahid et al. (2011) in peas on germination percentage. Their results showed that germination percentage decreased with increasing salinity stress. The deterrence effects of sodium chloride on seed germination can be due to its direct effect on embryo growth. The researchers found that the high sodium chloride level strongly inhibits embryonic axis elongation in the irrigation solution. On the other hand, sodium chloride affects the number of germinated seeds due to its inhibitory effect on water absorption. Turhan and Ayaz (2004) found that increasing salinity levels reduced the germination effect on cell division and metabolism. Also, Bybordi and Tabatabaei (2009) reported that the decrease in germination percentage was correlated with decreased seed water uptake during dewatering. Germination can be divided into three stages, water uptake, increasing metabolic activities, and radical exited. During these three stages, dry seeds absorb sufficient moisture for germination (Finch-Savage and Leubner-Metzger, 2006).

As the potential osmotic decreases under osmotic stress, seed access to water for germination is reduced. It takes longer for the seed to obtain sufficient water; thus, germination time gets longer. Delay in germination inhibits radical and plumule elongation and growth (Baalbaki et al., 1990). Studies have shown that salinity decreases water absorption capacity and nutrients by reducing radical growth (Jamil et al., 2006). Although the molecular and biological mechanisms of salt resistance in plants have not been well understood, it has been reported that the amount of resistance is related to the amount of sodium present in the tissues. In this regard, plants resistant to salinity have mechanisms such as less uptake of sodium in the root, less transfer to the aerial parts, and accumulation in some cellular organelles (Omielan et al., 1991).

Conclusion

Knowledge of the response of species and plant varieties to salinity stress during the germination stage is critical from ecological and physiological aspects because germination is a crucial stage for plant establishment. Investigation of the effect of salinity on germination rate and percentage as well as radical and plumule growth in many crops has shown that salinity stress at the germination stage is a reliable test in assessing tolerance of many species because salinity decreases germination percentage, radical and plumule growth. According to the results of this study, among four seeds, Chia and Guar were identified as the most tolerant plant to salinity stress in the seedling stage. Since salinity stress at the seedling stage has a significant effect on the final yield of the plant, so the selection of tolerant cultivar at this stage can significantly contribute to the improvement of crop production and agricultural extension in saline stress areas. Based on these results, the Chia can be used for further research to investigate the mechanism of this plant's tolerance to salinity and modify and isolate genes that are effective in salinity tolerance. It seems that by implementing proper management on the farm, the establishment of these plants in water and saline soil conditions can be guaranteed. The Luffa seed germination process was more sensitive to salinity than other species. The increase in salinity levels caused a sharp decrease in the percentage and rate of Luffa seed germination so that germination stopped at the highest salinity level.

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