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Corn and Barley seeds

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Abstract:

The current study investigated the response of barley and corn to foliar application the plants with proline, potassium nitrate fertilization and leaching fraction application, on both the growth and chemical composition of **corn and barley plants** and the salt accumulation in soil. The treatments included irrigation waters of different salinity (3.36, 5.88 or 7.95 dS/m), three rates of KNO_3 (zero, 4 and 8 g/pot) fertilizer and foliar application with three rates of proline (0, 100 and 200 mg/L). The first experiment was irrigated with leaching fraction and the second without leaching fraction. The effect of these parameters on salt accumulation in soil was discussed. The obtained results showed that the dry weight of shoots of corn and barley were decreased as salinity of irrigation water increased. High salinity of water increased the shoot contents of $Na^{+,}$ Cl^-, proline and decreased NO^-_3 contents with or without leaching fraction, but the values without leaching fraction were higher than those of without leaching fraction. In addition, increasing the salinity of irrigation water decreased K content in shoot, which was higher with leaching than without leaching. On the other hand, KNO_3 fertilization or proline spraying decreased Na^+, Cl^- contents and increased K^+ or NO^-_3 contents in plant shoot of both crops and their values without leaching were higher than with leaching. The EC values of soil were increased with both increasing salinity of irrigation water and KNO_3 fertilization. The decreased plant growth due to water salinity were partially offset by KNO_3 fertilization, proline spraying and leaching fraction application. In addition, KNO_3 fertilization was more effective than proline for reducing the adverse effect of water salinity.

Keywords: Seawater, saline water, irrigation, salinity, proline, potassium nitrate fertilization. Soil, fertilizers application.

Introduction:

Yemen is located in the South East of the Arabian Peninsula. It lies between 120° and 17°N Latitude and 43° and 56°E Longitude. The country has rugged surface features composed of mountains, hills, plateaus, plains, valleys and gorges. The varied topographic features and the variable climatic conditions of the country are among the major factors that resulted in diversified crop genetic resources in particular and vegetation and flora types in general. Nearly two decades ago, many internationally known scientists and plant collectors has recognized Yemen as one of the important regions of Asia in particular and world-wise in general. The utilization of various sources of water is necessary in Yemen due to increasing population and the consequent need of agricultural expansion. The main problem to be considered in using the different sources of water is the salinity hazards. Soil salinity is being progressively exacerbated by agronomic practices such as irrigation and fertilization, especially in arid regions. The effect of salinity on plant growth may be more related to the Na^+/K^+ ratio of the plant tissue than to absolute Na^+ concentrations. Thus the cultivars which have an ability to minimize this ratio may be more salt tolerant than those with lower K^+ concentration [1,2]. Soil salinity and solidity are global problems that are common in different part of the world. It affects more than 10 percent of arable land especially in West and South Asia and North Africa. **[**3**]** reported that salinization is fast growing on a global scale, decreasing average yield for most important crops by more than 50 %. Currently, saline soils occur in at least 100 countries [4], in total covering 932.2 Mha [5], with hotspots in Pakistan, China, United States, India, Argentina, Sudan, and many countries in Central and Western Asia [6,7], as well as in the Mediterranean coastline [8]. Salinity is a severe problem, which not only reduces the agricultural potential, but also creates serious effects on livelihood of farmers [9]. Several physical, chemical and biological soil management measures help to facilitate the safe use of saline water in crop production. The benefits anticipated from soil management practices to facilitate the safe use of saline water for irrigation will not be realized unless adequate supply of plant nutrients as fertilizers. Saline water irrigation containing phosphorus and potassium is essential for optimum crop productivity. Therefore, investigating the fertilizer management to maximize crop production under existing salinity is of greater importance. Application of K improved growth and yield under water stress possibly by regulating photosynthesis [10].

Proline accumulation has been shown to be fast, and is thought to function in salt stress adaptation [11], through protection of plant tissue against osmotic stress and/or acting as enzyme protector [12, 13].

The objective of the present study was to determine the possibility of compensating the negative effect of irrigation water salinity by foliar application the plants with proline, potassium nitrate fertilization and leaching fraction application, on both the growth and chemical composition of corn and barley plants and the salt accumulation in soil. This project will focus on information, education and demonstrations of proper management of saline areas during the project period. Result in the improvement, protection, and management of saline soil areas in Yemen

.Barley plant is considered one of the most important cereal crops in Yemen. It is actually quite an important and considered as a moderate salt tolerant plant crop in arid regions, poor and saline soils [14, 15]. The project area will include the saline soil areas in Yemen. The objective of this study is to investigating the possibility of plantation of barley and corn plants in salinity soil area without and with foliar applications irrigated with seawater in the Republic of Yemen.

Fig. 1. Corn and Barley seeds

Material and Methods:
Collection of Samples

Seeds of both barley and corn seeds were kindly provide by Yemen Ministry of Agriculture. Four kilograms of saline soil (without foliar application and with foliar application), Passed through a 2 mm, packed in plastic pots with a height 35 cm and diameter 15 cm with a hole in its bottom for drainage.

Experimental Layout and Measurements

The soil in each pot is irrigating with sea water before planting the seeds of corn and barley to achieve suitable seeding medium The plant shoots were collected after 60 days from planting, washed with tap water then by distilled water, dried in an oven at 65^{o} C for 48 hours and the dry weights were recorded. Sub-samples of plants were ground using stainless steel mill. The oven dried plant material was wet digested and the concentrations of Na, K were determined [16]. In addition, the concentrations of Cl and NO^3 were determined according to the methods outlined by [16] and by [17]. The proline content in plant leaves was determined according to the method of [18]. After plant harvest, soil samples were collected from each pot and their salinity were determined [19].

Results and Discussion

The main chemicals and physical characteristics of the soil was determined according to the methods outlined by [19] and the obtained data are presented in Table 1.

Table 1. The main chemical and physical characteristics of the used soil.

Soil properties	Value	Soil properties	Value
pH	8.31	**Particle size distribution**	
EC** (dS/m)	2.55	Sand (%)	64.1
Total CaCO3 (%)	31	Silt (%)	15.5
O.C. (%)	0.32	Clay (%)	21.2
Field capacity (%)	17.0	Soil texture	Sandy Clay Loam

The first one (S1) was with seawater of 3.36 dS/m and the other two (S2, and S3) were of 5.88 and 7.95 dS/m respectively. The main chemical compositions of seawater are given in Table 2.

Table 2. Chemical composition of the irrigation waters.

Water quality	**pH**	**EC_w dS/m**	**Cations, meq/ L**				**Anions, meq/L**		
			Ca+2	**Mg+2**	**Na+**	**K+**	**Cl-**	**SO^{-2}_4**	**HCO_3**
S1	7.94	3.36	2.09	4.52	22.89	0.39	26.12	6.09	12.58
S2	7.84	5.88	4.44	8.34	39.11	0.73	44.42	11.22	0.31
S3	7.72	7.95	6.87	11.8	51.99	0.84	56.99	16.75	0.43

In this study, two experiments were carried out. The first one included leaching fraction application. The desired leaching fraction was added to the amount of water required to keep the soil moisture content at field capacity. The second experiment was carried out without applying the leaching fraction.

Table 3 showed that the corn and barley shoots of plant dry weight was markedly decreased from 6.31 and 6.22 g/pot with water salinity of 3.36 and 5.88 dS/m to 4.82 and 4.77 g/pot, respectively.. However, with increasing water salinity to 7.95 dS/m, there were significant decreases of plants dry weights with or without leaching treatment. In this concern, It is also clear that the dry weight of corn and barley plants had decreased significantly from 5.02 g/pot to 2.36 g/pot with increasing water salinity from 3.36 to 7.95 dS/m without leaching fraction treatment. These results clearly showed that applying leaching fraction at any salinity level had decreased the harmful effect of salinity of irrigation water especially at water salinity of 3.36 dS/m. It is also clear that the harmful effect of salinity was greater in the treatment of without leaching. This is due to the accumulation of salts in the root zone, which did not occur with using the leaching fraction. [20-22], have also reported similar results.

Table 3. Effect of irrigation water salinity, Potassium nitrate and proline on the mean dry weight of corn and barley plants grown in soil with or without leaching.

Treatment	with leaching	without leaching	with leaching	without leaching
	Dry weight (g/pot) Corn		Dry weight (g/pot) Barley	
salinity of irrigation water (S), dS/m				
3.36	6.23	5.01	6.22	5.02
5.88	4.82	4.01	4.77	3.95
7.95	3.02	2.34	3.09	2.36
L.S.D $_{0.05}$	0.21	0.13	0.26	0.11
Potassium nitrate (K), g/pot				
0	5.0	4.12	4.99	4.10
4	5.13	4.39	5.12	4.36
8	5.29	4.59	5.29	4.58
L.S.D $_{0.05}$	0.04	0.09	.003	.09
Proline (P), mg/L				
0	5.10	4.27	5.10	4.26
100	5.19	4.39	5.16	4.35
200	5.21	4.50	5.21	4.42
L.S.D $_{0.05}$	0.05	.0.03	0.04	0.03

Table 3 indicated a significant increase in the dry weight of corn and barley plants, with or without leaching treatment, due to applying potassium nitrate fertilizer up to 8 g /pot. The relative increases in plant dry weights with potassium nitrate application indicate the beneficial effect of applying potassium nitrate fertilizer for decreasing the harmful effect of salinity on plant growth. This is evident for plants grown without leaching treatment than with leaching treatment.

Similar results were found by [23], who reported that increasing K^+ application could be useful to overcome the adverse effect of salinity (NaCl) on the growth of wheat plant. It can be stated that the ability of plants to retain K^+ at high Na^+ concentration, of the external solution, may be involved in reducing the damage associated with excessive Na+ concentration in plant tissue. In addition, the presence of N in the form of KNO_3 at this saline condition had improved the growth of corn and barley plants. Table (3) revealed that foliar application of proline increased significantly the dry weight of plant shoots, with or without leaching treatment. This points out that foliar application of proline at (200 mg/L) significantly decreased the harmful effects of salinity with or without leaching treatment.

Chemical Composition of Corn and Barely Plants

Table 4 showed that sodium concentration in the shoot of corn and barely plants increased significantly from 0.61 and 0.59 % with irrigation of 3.36 dS/m to 1.02 and 0.98% with irrigation of 7.95 dS/m respectively, with or without leaching treatment. On the other hand, K^+ concentration in plant shoot (corn and barely) decreased from 3.21 and 3.1 % to 1.62 and 2.22%, with same treatment respectively. These results are associated with increasing Na/K ratio in plant from 0.12 and 0.15 to 0.53 and 0.54, respectively. Santos et al. (1999) who reported that salinity decreased K^+ content in plants obtained similar results. On the other hand, applying KNO^3 fertilizer significantly decreased Na^+ and significantly increased K^+ concentrations in the shoot of corn and barely plant, with or without leaching treatment. This increase of K^+ content had improved the Na – K balance in plant tissue, which facilities plant growth as indicated in

Table 3. Foliar application of proline decreased the concentration of Na^+ in plant shoot. In the same time, K+ contents in shoot were increased. Close results were obtained by [24], with *Raphanus sativus* grown under salinity stress. Irrigation with 7.95 dS/m saline water produced the highest Na/K ratio with or without leaching (0.53, 0.54 and 0.73, 0.76 respectively). Similar results were found by [23], who confirmed that decreasing the value of Na/K ratio may be involved in reducing the damage associated with excessive Na^+ levels in plant. It is clear from Table 4 that the Na/K ratio, with or without leaching, was decreased significantly with increasing KNO_3 fertilization. This relation was associated with increasing the dry weight of plant shoot. This points out to the beneficial effect of K^+ to overcome the adverse effects of salinity. The occurrence of high K^+ in plant had involved in reducing the damage caused by high Na^+ concentration. Table 4 also, showed that foliar application of proline decreased the Na/K ratio in plant shoot with or without leaching and this ratio was higher in plant grown without leaching than with leaching treatment.

Table 4. Effect of irrigation water salinity and potassium nitrate and proline with or without leaching, on the mean value of Na, K concentrations (%) and Na/K ratio in shoot of corn and barley plants.

Treatment	with leaching			without leaching			with leaching			without leaching		
	Na+	K+	Na/K	Na+	K+	Na/K	Na+	K+	Na/K	Na+	K+	Na/K
	Corn						Barley					
salinity of irrigation water (S), dS/m												
3.36	0.61	3.21	0.12	0.80	3.04	0.25	0.59	3.1	0.15	0.80	3.12	0.25
5.88	0.83	2.19	0.35	1.04	2.09	0.49	0.76	2.63	0.34	1.02	2.08	0.49
7.95	1.02	1.62	0.53	1.29	1.69	0.75	0.98	2.22	0.54	1.27	1.67	0.76
L.S.D $_{0.05}$	0.03	0.21	0.01	0.049	0. 4	0.01	0.029	0.22	0.01	0.05	0.39	0.01
Potassium nitrate (K), g/pot												
0	0.79	2.13	0.34	1.01	2.21	0.50	0.80	2.31	0.35	1.0	2.23	0.50
4	0.70	3.02	0.30	0.89	2.71	0.39	0.71	2.97	0.27	0.9	2.88	0.39
8	0.61	3.57	0.211.0	0.81	3.17	0.30	0.62	3.51	0.20	0.8	3.31	0.30
L.S.D $_{0.05}$	0.03	0.14	0.01	0.04	0.39	0.01	0.03	0.13	0.01	0.03	0.44	0.01
Proline (P), mg/L												
0	0.74	2.93	0.32	0.94	2.74	0.72	2.89	0.31	0.94	2.72	0.42	0.41
100	0.72	3.01	0.30	0.91	2.77	0.69	2.99	0.29	0.91	2.84	0.39	0.38
200	0.70	3.09	0.31	0.89	2.87	0.66	3.03	0.28	0.88	2.90	0.37	0.36
L.S.D $_{0.05}$	0.02	0.11	0.01	0.02	.0.14	0.01	0.01	0.15	0.01	0.02	0.13	0.01

Increasing salinity of irrigation water significantly increased Cl^- content and decreased NO^-_3 contents in the shoot of corn and barley plants (Table 5). This decrease in NO^-_3 content can be attributed to Cl^- competition with NO^-_3 for binding sites on the plasma membrane, which suppressed the influx of NO^-_3 from the external solution [25]. The ratio of Cl^-/NO^-_3 in plant tissue increased with increasing salinity of irrigation water and was higher with leaching than without leaching treatment. This is due to low level of NO^-_3 in plant tissue, with leaching treatment as compared without leaching. In the same time, proline contents in shoots significantly increased with increasing irrigation water salinity and were higher in plants grown without leaching than with leaching treatment (Table 5). It is clear that there were positive relations between proline contents in plant tissue and both Cl^- contents and Cl^-/NO^-_3 ratio. It is also clear from Table (5) that chloride content decreased significantly with increasing KNO_3 application while NO^-_3 content increased significantly with or without leaching. Foliar application of corn and barley plants with proline significantly decreased Cl^- contents and increased NO^-_3 contents in shoot with or without leaching treatment (Table 5). This could be due to the role of proline in minimizing the adverse effect of salinity which is associated with the decrease of both Na^+ content (Table 4) and Cl^- content (Table 5) and increase of both K^+ content (Table 4) and NO^-_3 content (Table 5) in shoots.

Table 5. Effect of irrigation water salinity, potassium nitrate and proline on Cl^-, NO^-_3 contents, Cl/NO_3 ratio and proline contents of corn and barley plants with or without leaching.

Treatment	with leaching				without leaching			with leaching				without leaching		
	Cl^-	NO^-_3	Cl/NO_3	Proline **with**	Cl^-	NO_3	Cl/NO_3	Cl^-	NO_3	Cl/NO_3	Proline **W.out**	Cl	NO_3	Cl/NO_3
	Corn							Barley						
	($mg\ g^{-1}$)													
salinity of irrigation water (S), dS/m														
3.36	13.66	1.29	10.74	1.40	15.56	1.99	8.40	13.55	1.32	10.48	1.94	15.31	2.00	8.20
5.88	16.45	0.91	19.81	1.81	19.11	1.64	11.74	16.28	0.87	19.51	2.18	18.90	1.75	11.36
7.95	19.47	0.64	39.73	1.77	22.59	1.18	19.43	19.36	0.61	39.40	2.33	22.37	1.17	19.12
L.S.D $_{0.05}$	0.50	0.01	0.14	0.049	2.76	0.03	0.17	0.50	0.01	0.01	0.03	0.52	0.01	0.16
Potassium nitrate (K), g/pot														
0	14.32	0.71	28.8	1.57	16.79	1.11	15.00	14.10	0.70	29.34	2.34	16.44	1.20	15.00
4	13.22	1.01	15.32	1.31	15.49	2.01	9.34	13.32	1.00	15.51	1.96	15.32	1.99	9.39
8	12.12	1.49	9.43	1.49	14.09	2.79	7.09	12.00	1.48	9.54	2.01	14.00	2.00	7.15
L.S.D $_{0.05}$	0.14	0.01	0.07		1.49	0.04	0.09	0.12	0.01	0.07	0.03	1.44	0.44	0.09
Proline (P), mg/L														
0	13.56	1.00	20.76	0.92	16.00	1.89	11.31	15.99	1.86	10.99	1.41	15.77	1.79	11.00
100	13.32	1.10	18.10	1.54	15.51	2.02	10.49	15.44	1.87	10.23	2.20	15.53	1.99	10.44
200	13.02	1.09	16.22	1.87	15.16	2.10	9.68	15.14	2.09	9.55	2.48	15.21	2.03	9.55
L.S.D $_{0.05}$	0.03	0.01	0.03	0.01	0.70	0.03	0.08	0.69	0.03	0.077	0.03	0.70	0.03	0.088

This effect was more pronounced with leaching than without leaching treatment. On the other hand, proline foliar application increased significantly NO^-_3 contents in shoots and consequently decreased Cl^-/NO^-_3 ratio in both corn and barley. Table (5) showed that proline content in plant significantly increased with increasing salinity of irrigation water and significantly decreased with increasing potassium nitrate, with or without leaching (Table 5). It is obvious that proline plays an adaptive role in the tolerance of plant cells to salinity by increasing the concentration of osmotic active components in order to equalize the osmotic potential of the cytoplasm. [26] ,also found that proline accumulation in the leaves of plants grown on salt affected soil was 8 times higher than in the control.

Increasing levels of application foliar with proline significantly increased proline contents in the shoot of corn and barley plants. It can be pointed out that exogenous proline application might counteract the negative effects of high salinity on carbohydrate and nitrogen metabolism, which consequently could promote the whole plant growth.

Salinity Soil

Table 6 showed that the salinity of soil increased significantly with increasing salinity of irrigation water, with or without leaching. This is due to the accumulation of salts in the soil from water of irrigation. [27] obtained similar results, [28] , who found significant increases in soil EC when soil were irrigated with highly saline water. In addition, EC values in soil were increased significantly with increasing application of KNO_3 fertilizer, with or without leaching (Table 6). Table 6 showed significant interaction effects between irrigation water salinity and potassium nitrate on the EC of soil, with or without leaching. It is clear, that the leaching fraction was effective in reducing the accumulation of salts in soil.

Table (6). Effect of irrigation water salinity, potassium nitrate and proline with or without leaching, on the *EC (dS/m) of soil collected after harvesting of corn and barley plants.

Treatment	with leaching	without leaching	with leaching	without leaching
	Corn		Barley	
Salinity of irrigation water (S), dS/m				
3.36	1.26	1.78	1.24	1.79
5.88	4.39	5.21	4.41	5.29
7.95	6.19	8.52	6.24	8.63
L.S.D $_{0.05}$	0.42	0.42	0.45	0.45
Potassium nitrate (K), g/pot				
0	2.09	2.48	2.12	2.00
4	3.29	4.10	3.22	3.11
8	4.47	5.89	4.54	4.48
L.S.D $_{0.05}$	0.26	0.29	0.26	0.29
Proline (P), mg/L				
0	3.29	4.25	3.30	4.26
100	3.15	4.22	3.26	4.21
200	3.04	4.20	3.21	4.19
L.S.D $_{0.05}$	0.18	0.22	0.18	0.22

Conclusion

The present study confirms the potential of foliar application with proline, soil application with potassium nitrate and leaching fraction treatment for improving the growth of corn and barley under irrigation with saline water, especially at water salinity of 3.36 dS/m, which is less than the marginal value (3.6 dS/m) for corn and barley production. In addition, potassium nitrate fertilizer as a source for K and N had more adverse effects, due to salinity, on both plant and soil.

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