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ORIGINAL ARTICLES

Evaluation of some cultivars of foxtail plants under salinity conditions

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ABSTRACT

A pot experiment was performed, during two successive seasons 2009 and 2010at the Experimental Station of National Research Centre, Dokki, Giza, Egypt to determine the effect of different levels of saline water irrigation and / or pix on growth, yield components and chemical constituents of two cultivars of foxtail plants cultivated under Egyptian condition. Generally, cultivars had no significant effect on most of yield components and the chemical constituents. On the other hand salinity and/ or pix and the combination treatments had a significant effect. Generally, cultivars had no significant effect on carbohydrate, protein and nutrients content. On the other, hand, salinity and pix alone or combined with cultivars had a significant effect on these characters. The limiting amino acids of both cultivars are Glutamic acid followed by Cystine and Leucine. The differences in amino acids composition in Foxtail millet varieties due to some various saline treatments were also detected.

Key words: Evaluation, cultivars, foxtail plants, salinity conditions.

Introduction

Foxtail millet (Setaria *italica L.)* has been cultivated for 7000 years or so. It is native to China and regarded as an elite drought – tolerant crop (Cheng and Liu, 2003). Foxtail is semi arid crop grown in India and Asia and form a staple food for the lower socio-economic class especially during drought or famine. They are consumed traditionally as health and vitality foods by the labour class.

Foxtail yellow seeded cultivars, medicinally used as astringent, digestive, emollient and stomachic (Yeung, 1985; Duke and Ayensu, 1985). It is also used in the treatment of dyspepsia, poor digestion and food stagnancy in abdomen (Yeung , 1985) . White seeds are refrigerant and used in the treatment of cholera and fever while the green seeds are diuretic and strengthening to virility (Duke and Ayensu, 1985). Moreover, the seed can cooked and eaten as sweet or savoury food (Harrison *et al* , 1979 and Uphof ,1959) or ground into a flour and made into porridge , cakes and puddings (Facciola, 1990).

On the other hand, salinity is one of the major environmental constraints to the crop productivity throughout the world. Cultivation of medicinal and aromatic plants in salt soils is limited by salt stress which arises from excessive uptake of salt by plants and is unavoidable consequence of high ion concentrations in the medium leading to water deficit stress as a result of the low external water potential and excessive accumulation of ion inside the plants (Bartels and Sunkar, 2005). Shailaja and Thirumeni (2007) evaluate the salt tolerance in 19 figer millet genotypes at seedling stage. Significant difference was observed among the genotypes at different stress levels. The germination, root length, shoot length, seedling and vigour index were declined with increasing salt stress in all genotypes.

Plants are able to response and adapt to change environments through the synthesis of specific proteins which can modify the cellular metabolism (Veeranagamallaiah *et al*, 2007). In many cases, the synthesis of stress tolerance mechanism (Przymusinski *et al*., 1995). However, some authors studied the influence of salt tolerance on Setaria *italica cv* .under different condition in India, i.e. Kubsad *et al* (1989, 1990, 1993) and Timmaiah *et al*., (1989). The increasing importance of producing some medicinal plants under local conditions of saline water sources, emphasis the need for information on its tolerance of salinity.

Thus in this study we determined the effect of different levels of saline water irrigation and pix on growth, yield components and chemical constituents of two varieties of foxtail plants cultivated under Egyptian condition.

Materials and Methods

A pot experiment was performed, under control condition, during two successive seasons 2009 and 2010 at the Experimental Station of National Research Centre, Dokki, Cairo, Egypt.

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2-1- Plant Materials and Salt Stress Conditions:

Seeds of the two cultivars of foxtail i.e. *Setaria italica* Empire, and *S. italica* Herbstfeuer,produced from Dreschflegel, Martina Bunger, Germany , were sown in 15th May for two successive seasons in pots of 30 cm diameter, filled with 5Kg of air dried soil. The mechanical and chemical analyses for soil under investigation were tabulated in Table (1)

Table 1: The mechanical and chemical analyses of soil.

Sandy	Silt	Clay	OM	EC mmhos / cm	Ca Cl	PH	
23.9%	30%	40%	0.6%	0.60	1.60	7.3	Loamy soil
Mg / 100g				Mg / Kg			
P	K	Na	Mg	Fe	Mn	Zn	Cu
8.6	27.6	110.1	245	21.0	3.8	2.1	2.5

After two weeks from planting, the growing plants of the two cultivars were subjected to saline irrigation. The salt levels were increased stepwise to prevent osmotic shock, until series of pots received the designated salt concentrations. Experimental salinized solutions were prepared by adding Na Cl and Ca Cl to modified Hogaland solution (zero salinity) to produce 0, 1000, 2000 and 4000 ppm. Pix (Chloride Muquite), produced by Passz , Germany was sprayed (2cm / L) after one week for half groups of saline irrigation treatments.

Pots of the two cultivars were divided into seven groups represented seven treatments (each group included 15 pots) as follows:

Treat .1. Control (irrigated with tap water)
Treat .2. Irrigated with saline water at 1000 ppm
Treat .3. Irrigated with saline water at 1000 ppm + Spraying with Pix.
Treat.4. Irrigated with saline water at 2000 ppm
Treat.5. Irrigated with saline water at 2000 ppm + Spraying with Pix.
Treat.6. Irrigated with saline water at 4000 ppm
Treat.7. Irrigated with saline water at 4000 ppm + Spraying with Pix.

Every three days, each group was irrigated with saline solution except control which was irrigated with tap water. All pots were leached weekly with excessive amount of tap water. The plants were harvested at 15th June for both seasons and the growth parameters, included shoot length (cm), number of spikes / plant , length of spike (cm), length of peduncle (cm) , fresh and dry weight of spikes and seeds (g/plant) were recorded.

On the other hand, the chemical analysis was carried out to determine:

1- Total carbohydrates percentage for leaves, which was determined spectrophotometrically according to Dubois *et al* (1956).

2- Minerals content in leaves, including total nitrogen percentage using the modified micro Kjeldahl methods as Jackson (1958), phosphorus and potassium percentage according to Chapman and Pratt (1978) and Cottonie *et al* (1982) respectively.

3- Amino acid analysis: Using the procedure of Spackman *et al* (1958) the weighted samples of undefatted whole seed were hydrolyzed using 6M HCl in sealed tubes at 110°C for 22 h. The HCI was later removed under reduced pressure and the residue dissolved in 0.2M **c**itrate buffer pH 2.2 and stored at -20°C. Amino acid analysis was carried out on a Eppendrof-Germany LC3000 Amino Acid Analyses.

Statistical analysis: The means of the obtained data were statistically analyzed for two successive seasons according to the procedure outlined by Snedecor and Cochran (1990).

Results and Discussion

1- Growth Characters:

A) Cultivars:

The growth characters of the two cultivars Empire and Herbstfeuer showed in most cases significant differences, (Table 2). Thus Empeir cultivar has more number of spikes / plant and longest length of spikes as well as highest spikes fresh and dry weight, in addition to heaviest seeds weight than Herbstfeuer cv. The variation values for these characters between two cv. reached to 48%, 15.5%, 2.4 %, 12.4% and 13.9, respectively. However, Herbstfeuer cv , gave the maximum mean values for length of shoot and peduncle comparing with those obtained by Empeir cv. The mean values of these characters for Herbstfeuer were 84.0 cm and 23.0 cm in corresponding to 83.5 cm and 20.3 cm for Empeire cv.

B) Salinity and Pix:

The data presented in Table (2) revealed that various salinity levels and / or Pix caused significant effect on growth characters in most cases except length of peduncle. In response to saline water irrigation, it can be observed that these treatments without Pix application decreased most of growth characters. Generally, foliar application of Pix solution to plants irrigated with saline water, significantly promoted growth characters comparing with control or those irrigated with saline water. Shoot length (cm) reached to 15.1% as a result of the 1st level of salinity with Pix treatment above the control treatment. The spikes number decreased gradually and significantly with increasing salinity levels, and this decrement continuance with adding Pix solution. Similarly, spikes length recorded significant inhibition with applied lower and highest salinity levels. On the other hand, the various salinity levels had insignificant effect on peduncle length, while the fresh and dry weight of spikes produced highest inhibition with employed the highest salinity level, and this decrement reached to 15.7% and 16.4%, respectively, less than control treatment. The spikes dry weight as well as seeds weight / plant were increased insignificantly only with lower salinity level (1000 ppm), while the gradual increment of salinity to 2000 and 4000 ppm cause significant inhibition for seeds weight of *Setaria italica* plants .

Furthermore, adding Pix solution to salinity treated plants caused in general decrement inhibition effects of salinity on all growth characters.

The reduction of growth characters under salinity conditions was reported by Arun *et al* (1997) on *Matricaria chamomile*,Loxaman *et al*. (1995) on *Plantago ovata* and Zhang *et al* (1996) on *Eleusine coracana*. The reduction in plant growth may be related to their osmotic inhibition of water adsorption or to the accumulation of toxic ion , or due to the combination of this physiological factors mentioned above , as reported by Everardo *et al*. (1975). On other side, the low level of salinization could stimulate the growth characters as reported with Kubsad *et al*. (1990 and 1995) on *Setaria italica*.

C-Cultivars X Salinity:

It is clear from data presented in Table (2) that the shoot length of two cultivars for *Setaria italica* were significantly tolerance to various salinity levels used. Moreover, the applied of Pix solution increased the tolerance of these plants under salinity in many cases. The maximum mean value of this character was recorded with Herbstfeir cultivar plants treated with 2000 ppm salinity + Pix. In contrast, spikes number decreased significantly under different salinity levels alone or combined with Pix for both cultivars. Moreover, Empeire cv. showed more resistance effect to various salt levels than Herbstfeir cultivar plants for most growth characters such as fresh and dry weight of spikes as well as seeds weight / plant. The highest mean values for these characters were recorded 2.28 g , 1.89g and 1.64 g / plant respectively as affected by 2000 ppm + Pix in corresponding to 1.28g , 1.01g and o.76 g respectively for Herbstfeir cv.

From the above mentioned results it could be concluded that, in general , Empeir cv was more tolerance to salinity than Herbstfeir cv., and adding Pix to treated salinity plants decrease the inhibition salinity effects for most growth characters. In this connection Kubsad *et al* (1995) stated that grain yield and DM production of *Setaria italica* were increased at all growth stage with irrigated saline water up to 6 ds/m but decreased at higher salinity level (6-21) ds/m except at 30 day after sowing. The same author reported that DW / hill of *S. italica* at flowering and harvest was not affected by salinity level (2 – 12 ds / m). Thimmaioh *et al*. (1989) added that *S. italica* grain yield and 1000 grain weight were decreased with increasing salinity from 1.0 to 16.0 ds/m. Furthermore, Trofimov and Ozhgibitseva (1979) revealed that *S. italica* showed high salt tolerance, and the application of 60 kg N + 60 kg P2 O5 / ha. Increased the biological yield under saline soil.

2- Total carbohydrate content (%):

A) Cultivars:

Data tabulated in Table (3) revealed that there is no significant difference between both cultivars of foxtail millet in total carbohydrate percentage. The mean values of total carbohydrate percentage were 51.1 % and 49.3 % for Empeire and Herbstfeir cultivars respectively.

B) Salinity and Pix:

With the respect to the effect of salinity and/ or pix on total carbohydrate percentage, it can be noticed that these treatments increased significantly total carbohydrate percentage comparing with control. On the other hand, plants treated with pix had decrement the accumulation of carbohydrate percentage comparing with those unsprayed with pix.

Table 2: Growth characters of two foxtail millet cultivars grown under salt stress conditions and pix treatments. (Mean values of two successive seasons).

Cultivars	Treat.	Shoot length (cm)	No. of Spikes/ plant	Length of spike (cm)	Length of peduncle (cm)	Spikes F.W (g/plant)	Spikes D.W (g/plant)	Seed Wt. (g/plant
Empeire	Cont	66.1	3.1	5.0	15.7	1.04	0.87	0.61
	S1	77.4	2.4	5.3	19.0	1.52	1.47	1.25
	S1+P	81.6	1.7	6.1	20.3	1.63	1.51	1.32
	S2	79.8	1.7	6.0	19.6	1.89	1.30	1.05
	S2+P	84.5	1.3	7.1	22.0	2.28	1.89	1.64
	S3	82.6	1.6	5.0	18.5	1.35	1.25	1.05
	S3+P	83.5	2.4	6.3	20.3	1.57	1.28	1.15
Mean Value of Empeir		79.4	2.0	5.8	19.3	1.61	1.37	1.15
Herbstfeir	Cont	88.7	1.4	5.2	29.0	2.13	1.69	1.41
	S1	79.1	1.4	4.7	25.2	1.51	1.19	1.06
	S1+P	96.6	1.2	5.5	27.3	1.93	1.53	1.32
	S2	75.6	1.3	4.4	23.3	1.28	1.01	0.76
	S2+P	81.1	1.0	5.1	24.6	1.40	1.09	0.84
	S3	73.5	1.0	4.3	21.0	1.32	0.89	0.73
	S3+P	84.0	1.0	5.0	23.0	1.45	1.01	0.82
Mean Value of Herbstfeir		82.7	1.2	4.9	24.8	1.57	1.20	0.99
Mean value of: salinity and pix treatments	Cont	77.4	2.3	5.1	22.4	1.59	1.28	1.01
	S1	78.3	1.90	5.0	22.10	1.52	1.33	1.16
	S1+P	89.1	1.5	5.8	23.8	1.78	1.52	1.32
	S2	77.7	1.5	5.2	21.5	1.59	1.02	0.91
	S2+P	82.8	1.2	6.1	23.3	1.84	1.49	1.24
	S3	78.1	1.3	4.7	19.8	1.34	1.07	0.89
	S3+P	83.8	1.7	5.7	21.7	1.51	2.29	0.99
L.S.D at 5% for :	Varietis	1.1	N.S	0.001	N.S	0.01	0.01	0.04
	Treat.	2.9	0.01	0.05	N.S.	0.06	0.04	0.02
	Interaction	5.3	0.4	0.30	N.S.	0.04	0.05	0.06

C) Cultivars X Salinity:

Concerning the combination effect between cultivars and salinity treatments, it can be revealed that the maximum mean value of total carbohydrate percentage was recorded as a result of the combination between Empeir cultivar and the 1st level of salinity (66.6%) followed by the combination between Herbstfeir cultivar plants and the 2nd level of salinity (63.7%).

3- Total protein content (%):

A) Cultivars:

Generally, cultivars had no significant effect on protein percentage. It is noticed from Table (3) that Herbstfeir cultivar gave the highest mean value of protein (13.5%) comparing with obtained from Empeir cultivar (13.2%).

B) Salinity and Pix:

From Table (3), it can be observed that salt stress and /or pix treatments had a pronounced and significant effect on protein content. These treatments Increased protein percentage comparing with control (10.8%). The maximum mean value of protein (17.6%) was observed as a result of the third level of salinity followed by the combination between the third level of salinity and pix which gave (15.7%).

C) Cultivars X Salinity:

Generally, the combination treatments increased significantly protein percentage comparing with untreated plants. From Table (3), it can be observed that the highest mean value of protein content (17.9%) was obtained as a result of the combination between Empeir cultivars with salinity at the third level followed by the combination treatment between Herbstfeir cultivar with the same level of salinity which gave 17.3%.

Table 3: Total carbohydrate, protein and fixed oil content (%) of two foxtail millet cultivars grown under salt stress conditions and pix treatments. (Mean values of two successive seasons).

Cultivars	Treat.	Total carbohydrate (%)	Total protein (%)
Empeire	Cont	46.2	10.6
	S1	66.6	11.6
	S1+P	49.1	10.9
	S2	52.6	14.6
	S2+P	46.8	13.4
	S3	51.1	17.9
	S3+P	44.2	15.6
Mean Value of Empeir		51.1	13.2
Herbstfeir	Cont	35.9	10.9
	S1	47.9	12.3
	S1+P	45.1	10.9
	S2	63.7	14.0
	S2+P	48.3	13.1
	S3	53.2	17.3
	S3+P	51.3	15.9
Mean Value of Herbstfeir		49.3	13.5
Mean value of: salinity and pix treatments	Cont	41.1	10.8
	S1	57.3	12.0
	S1+P	47.1	10.9
	S2	58.2	14.3
	S2+P	47.6	13.2
	S3	52.2	17.6
	S3+P	47.8	15.7
L.S.D at 5% for :	Varietis	N.S.	N.S.
	Treat.	2.3	1.9
	Interaction	4.6	2.1

4- Micro and macronutrients content (%):

A) Cultivars:

Generally, cultivars had no significant effect on micro and macronutrients content except with the three nutrients (Ca, Fe and Mn content) as shown in Table (4). The maximum mean value of Ca and Mn content, were obtained as a result of Herbstfeir cultivar while Empeire cultivar gave the highest value for Fe content.

B) Salinity and Pix:

Data tabulated in Table (4) revealed that salt stress and pix treatments had no significant effect on most of nutrients content except Ca and Mn content (mg/100g). Generally, these treatments increased nutrients content except K, Ca and Mn content (mg/100g) where the control gave the highest mean values (302.5, 40.5 and 5.60 mg/g, respectively).

The maximum mean values of N, P, Fe and Zn content were 2.815%. 384.5 mg/100g, 7.15 mg/100g and 4.90mg/100g respectively were obtained as a result of the third level of salinity.

C) Cultivars X Salinity:

Generally, data presented in Table (4) show that the combination treatments had no significant effect on all nutrients content. In this connection, the maximum mean values of N, P, Fe and Zn content were 2.863%, 390 mg/100g, 7.50 mg/100g and 5.10 mg/100g respectively as a result of the combination between Empier cultivar and the third level of salinity. On the other hand, Herbstfeir cultivar with control (no treated) gave the highest mean values of K (324mg/100g), Ca (44mg/100g) and Mn (6.40mg/ 100g).

Amino acids content :

The relative accumulation of 16 amino acids detected in the seeds of two varieties of the millet plants tested, as affected by saline irrigation and pix are summarized in Table (5). In comparison between the 2 varieties data indicate that there is considerable variation in the amino acids content of the different varieties. The non-essential amino acids such as aspartic (9.01-11.08), glutamic (17.11-30.40)and alanine (9.04-9.11) are present as major constituents. Among the essential amino acids, leucine (11.04-12.42) is majour and phenylalanine (1.1-1.23) is present in appreciable quantities. The contents of lysine (2.62- 3.0) and the sulphur amino acids-methionine (1.13-3.98) is low and cystine (18.73-19) is majour. The ratio of isoleucine to leucine is around 1: 3 in Empire varieties while, it is less than 1:2 in Herbstfeuer one.

Table 4: Nutrients content of two foxtail millet cultivars grown under salt stress conditions and pix treatments. (Mean values of two successive seasons).

Cultivars	Treat.	N (g/100g)	P (mg/100g)	K (mg/100g)	Ce (mg/100g)	Fe (mg/100g)	Mn (mg/100g)	Zn (mg/100g)
Empeire	Cont	1.969	275	281	37	6.20	4.80	3.50
	S1	1.852	296	265	32	6.60	4.30	3.80
	S1+P	1.744	275	270	33	6.40	4.40	3.60
	S2	2.333	335	247	27	6.90	3.90	4.20
	S2+P	2.140	313	255	24	6.40	4.30	3.90
	S3	2.863	390	195	20	7.50	3.60	5.10
	S3+P	2.488	374	200	24	7.10	3.80	4.60
Mean Value of Empeir		2.159	322.4	244.7	28.1	6.73	4.16	4.10
Herbstfeir	Cont	1.745	264	324	44	5.40	6.40	2.88
	S1	1.975	285	281	39	5.80	5.50	3.65
	S1+P	1.748	270	295	41	5.40	5.90	3.12
	S2	2.234	314	266	30	6.00	4.80	4.00
	S2+P	2.092	306	250	36	5.70	5.30	3.60
	S3	2.766	379	214	27	6.80	4.00	4.70
	S3+P	2.547	355	234	31	6.20	4.75	3.90
Mean Value of Herbstfeir		2.158	310.4	266.3	35.4	5.9	5.24	3.69
Mean value of: salinity and pix treatments	Cont	1.721	269.5	302.5	40.5	5.80	5.60	3.19
	S1	1.919	290.5	273.0	35.5	6.20	4.90	3.73
	S1+P	1.746	272.5	282.5	37.0	5.90	5.15	3.36
	S2	2.284	324.5	256.5	28.5	6.45	4.35	4.10
	S2+P	2.116	309.5	252.5	30.0	6.05	4.80	3.75
	S3	2.815	384.5	223.8	23.5	7.15	3.80	4.90
	S3+P	2.518	364.0	217.0	27.5	6.65	4.28	4.25
L.S.D at 5% for :	Varietis	N.S.	N.S.	N.S.	1.9	0.36	0.04	N.S.
	Treat.	N.S.	N.S.	N.S.	2.3	N.S.	0.09	N.S.
	Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

These data were partly agreement with Taira (1968) and Indira and Naik (1971). Also, Monteiro, *et al*., (1982) indicated that there is considerable variation in the amino acid content of the different 14 varieties. The non-essential amino acids such as aspartic and glutamic acids, proline and alanine are the major constituents. Among the essential amino acids, leucine and phenylalanine are present in appreciable quantities. The contents of tryptophan, lysine and the sulphur amino acids-methionine and cystine-are low. The ratio of isoleucine to leucine is 1: 3 or greater.

Data also in Table (5) pointed out that some differences occurred in amino acids composition in Italian milt varieties due to various saline treatments, i.e., glutamic acid showed high concentration that increased two time due to 1000 ppm salin + pix in Herbstfeuer variety while, at 2000 ppm + pix it is slight decrease in Empire one. Methionine and lysine percentage tended to be lower in two varieties due to all saline conditions while, Serine is disappear completely according to saline treatments. On the other hand, Proline, Histidine and Arginine were increased due to saline irrigation in both varieties. The other minor constituents showed slight responses.

Table 5: Amino acids content (g amino acid/100 g total amino acid) in *Sataria italica* cultivars under salt stress and pix treatments.

Varieties	Empire		Herbstfeuer	
Amino acid detection	control	2000 ppm Pix	control	1000 ppm pix
Aspartic	9.01	8.65	11.08	5.73
Threonine	3.58	2.43	2.29	3.7
Serine	4.92	Tr	6.47	Tr
Glutamic acid	30.4	29.71	17.11	35.73
Glycine	0.14	0.15	0.26	1.14
Alanine	9.11	9.8	9.04	5.65
Cystine	18.73	17.68	19	17.87
methionine	1.13	0.62	3.98	1.18
Isoleucine	4.18	5.49	8.85	5.09
Leucine	11.04	14.1	12.42	9.12
Tyrosine	1.1	1.13	2.67	1.93
Phenylalanine	1.1	2.31	1.23	3.44
Proline	0.7	2.05	1	1.5
Histidine	0.6	1.64	0.4	0.5
Lysine	2.62	1.49	3.0	2.11
Arginine	1.64	2.75	1.2	5.31
Isoleucine/ leucine	0.38	0.39	0.71	0.56

These results were in fairly good agreement with those of Thimmaiah *et al*., (1989) recognized that higher concentrations of cations and associated anions in irrigation waters may adversely affected the growth, yield, nutrient composition and seed quality characteristics of cereals, while, total phenols and free amino acids were found to be significantly lower at 8 dS/m.

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