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Original article

Effect of seed priming by humic acid and zinc on some morpho-physiological traits of maize (*Zea mays* L.) seedlings under saline conditions

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Extended abstract

Introduction

Soil salinity is one of the most serious abiotic stress factors limiting crop productivity. Salinity disrupts plant morpho-physiological processes because it causes an increase in reactive oxygen species (ROS). One of the relatively new methods to increase the plant yield and reduce oxidative stress under salinity stress is seed- pretreatment or priming. Recently, compounds containing zinc as well as humic substances have been widely used to improve the quality and quantity of agricultural products. This study investigates the potential of seed priming by humic acid and zinc as the methods to overcome on limitations of seedling growth affected by soil salinity stress.

Materials and methods

An experiment was conducted as split plot using a randomized complete block design with three replications at 2019 in the research greenhouse of the Faculty of Agriculture, Shahid Chamran University of Ahvaz, Iran. Experimental treatments were included soil salinity (at two levels included non-saline and saline soils with an electrical conductivity of 2.2 and 8 dS m^{-1}, respectively) as the main factor and seed-pretreatment (at 4 levels included 250 mg l^{-1} solution of humic acid [HA], 4 mM zinc sulfate [Zn], 250 mg l^{-1} humic acid + 4 mM zinc sulfate [HA+Zn] and non-primed seed as control [Co]) as sub-factor. The maize seeds were disinfected and then pre-treatment was carried out in such a way that the seeds were exposed to the desired treatments (HA, Zn, HA + Zn and Co) for 24 hours in dark room at 15 ˚C. After the soaking of the seeds with the solutions, 10 maize seeds were sown in both saline and non-saline soils and cultivation was done in plastic pots and after reaching the 3-4 leaf stage, the density in each pot was reduced to 4 plants. In the sixth week at the start time of corn silk (stop the root growth), all the plants were harvested and some vegetative, physiological and biochemical traits were measured and analyzed.

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Results and discussion
The analysis variance of salinity and seed pre-treatment effects on the some morpho-physiological traits of corn seedlings showed that salinity stress has significantly reduced the length of shoot and dry weight of the shoot and root, amount of chlorophylls a and b and the values of leaf area and increased the activities content of catalase and superoxide dismutase enzymes, as well as the amount of proline compared to seedlings grown in non-saline soil so that the amount of length of shoot, dry weight shoot and root, leaf area, chlorophyll a and b were reduced 42.6, 38.9, 55.9, 33.9, 51.7 and 48.1%, respectively due to salinity, and the activities of catalase and superoxide dismutase enzymes were increased from 0.037 and 19.66 to 0.14, 30.54 $U.mg^{-1}$ protein, respectively and proline value was increased from 0.356 to 1.39 mg g^{-1} FW. However, the priming of corn seeds significantly improved the morpho-physiological traits of seedlings in both saline and non-saline soils, so that the amount of dry root weight, which was significantly reduced due to salinity (55.9%), increased 38.1, 33.1 and 71.1% affected by priming with HA, Zn and HA+Zn treatments (compared to un-primed seeds in saline soil), respectively. It was also observed an incensement of 49.7, 44.1 and 68.6% for shoot length, 23.4, 5 and 51% for dry weight of shoot, 33.37, 29.21, and 46.4% for leaf area, 87.16, 60.36, and 101% for chlorophyll a, 45.89, 20.54 and 64.83% for chlorophyll b due to HA, Zn and HA+Zn treatments, respectively, in saline soils. Also, priming increased the amounts of antioxidant enzymes as well as proline in both saline and non-saline soils, significantly.

Keywords: Catalase, Cholorophyll, Leaf area, Plant height, Proline, Superoxide dismutase

Table 1. Some physical and chemical properties of the used soil

Total Nitrogen	Available Phosphorus	Exchangeable K	CCE[1]	Organic Carbon	pH	EC	Soil Texture	Clay	Silt	Sand
%	------------- mg kg^{-1}	-------------	---------- %	----------		$dS.m^{-1}$		----------	%	----------
0.07	13.5	98	43.88	0.4	7.6	2.2	Loam	21.4	38	40.6

Table 2. Variance analysis of salinity Stress and priming on vegetative, physiological and biochemical traits of maize seedlings

S.O.V	df	Shoot Length	Shoot Dry-Weight	Root Dry Weight	Leaf Area
Replication (R)	2	12.43	0.001	0.006	250.87
Salinity (S)	1	1765.93^{**}	16.17^{**}	2.57^{**}	13737.73^{**}
R× S	2	0.072	0.013	0.008	56.12
Priming (P)	3	309.97^{**}	1.6^{**}	0.152^{**}	2003.47^{**}
S × P	3	13.72^{**}	0.2612^{**}	0.012^{ns}	11.03^{ns}
Error	12	0.33	0.025	0.0019	12.98
CV (%)		*1.27*	*5.81*	*4.87*	*2.61*

[1]Calcium Carbonate Equivalent

Table 2. Continued

S.O.V	df	Chlorophyll a	Chlorophyll b	CAT Activity	SOD Activity	Proline
Replication (R)	2	0.005	0.00006	0.0003	1.37	0.0009
Salinity (S)	1	1.062**	0.114**	0.2762**	662.34**	13.11**
R× S	2	0.006	0.0001	0.00009	0.489	0.0009
Priming (P)	3	0.1994**	0.016**	0.0247**	165.23**	0.4084**
S × P	3	0.0004ns	0.0009ns	0.0092**	0.1776ns	0.1368**
Error	12	0.0027	0.0007	0.0003	1.006	0.0048
CV (%)		*5.95*	*10.06*	*10.25*	*3.08*	*5.6*

ns and **: Non-significant and significant at 1% probability level, respectively

Table 3. Mean comparison of the seed priming on vegetative, physiological and biochemical traits of maize seedlings in non-saline and saline soils (slice by salinity)

		Shoot Length	Shoot Dry-Weight	Root Dry Weight	Leaf Area
		cm	---------------------- g pot^{-1}	------------------	cm^2
Non-Saline Soil	**C₀**	47.335 d	2.596 c	0.945 c	135.290 d
	HA	59.335 b	3.837 ab	1.326 a	170.133 b
	Zn	52.366 c	3.503 b	1.236 b	160.068 c
	HA + Zn	62.270 a	4.227 a	1.390 a	179.773 a
Saline Soil	**C₀**	27.144 d	1.582 c	0.416 c	89.31 c
	HA	40.651 b	1.950 b	0.580 b	119.033 b
	Zn	39.136 c	1.666 c	0.566 b	115.401 b
	HA + Zn	45.770 a	2.392 a	0.723 a	130.754 a

Table 3. Continued

		Chlorophyll a	Chlorophyll b	CAT Activity	SOD Activity	Proline
		---------------g g^{-1}FW	-----------	----------------U.mg^{-1} protein	------------	mg g^{-1}FW
Non-Saline Soil	**C₀**	0.854 c	0.27 b	0.037 c	19.665 c	0.356 d
	HA	1.966 a	0.376 a	0.084 b	27.653 b	0.543 b
	Zn	1.061 b	0.286 b	0.085 b	29.4799 b	0.483 c
	HA + Zn	1.256 a	0.396 a	0.093 a	32.076 a	0.623 a
Saline Soil	**C₀**	0.413 c	0.146 c	0.140 c	30.541 d	1.396 c
	HA	0.773 a	0.213 ab	0.326 b	37.774 c	2.156 b
	Zn	0.663 b	0.176 bc	0.306 b	40.195 b	2.101 b
	HA + Zn	0.831 a	0.240 a	0.386 a	42.407 a	2.346 a

Means with similar letter(s) in each column and each level of salinity are not significantly different ($P \leq 0.05$), according to the Duncan's multiple range test at 5% probability level

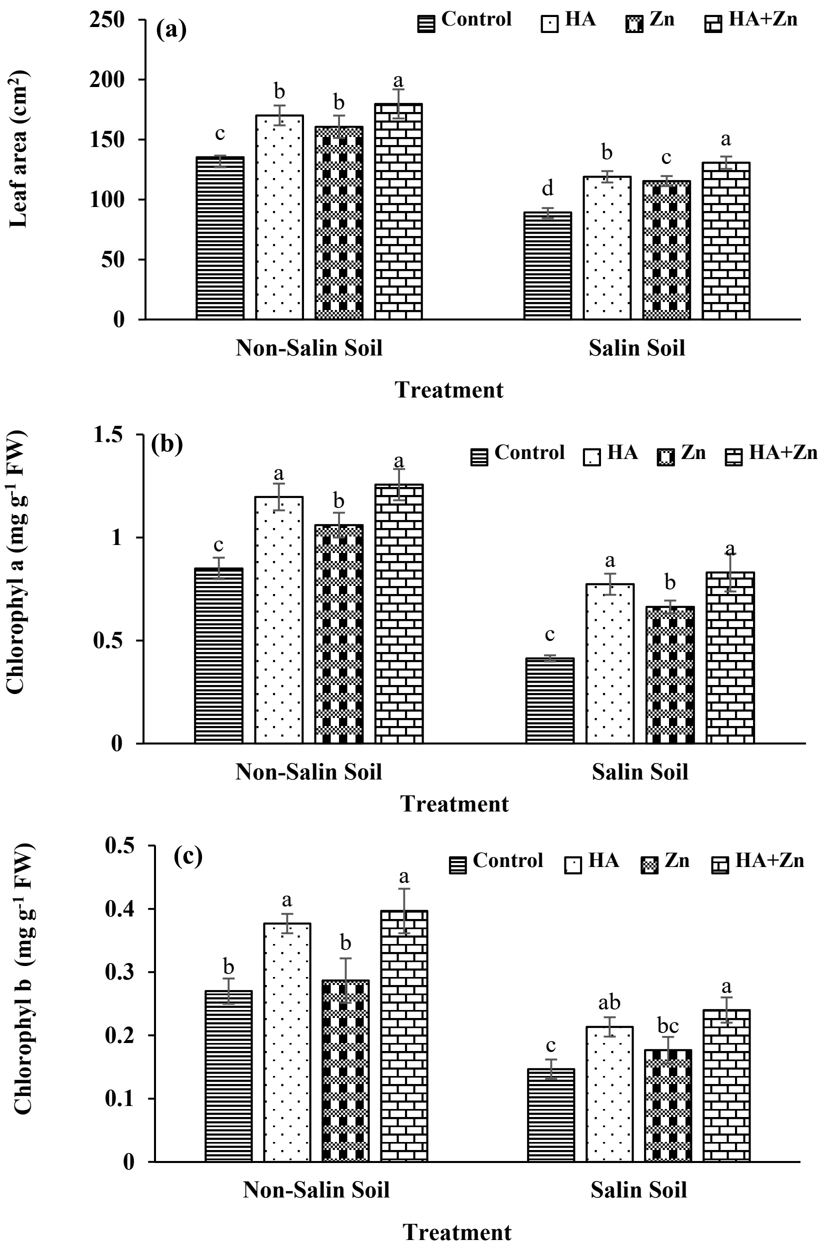

Fig. 2. Effect of soil salinity and seed priming of maize on (a) leaf area, (b) chlorophyll a and (c) chlorophyll b (slice by salinity). Means with similar letter(s) in each each level of salinity are not significantly different, according to the Duncan's -test at 5% probability level.

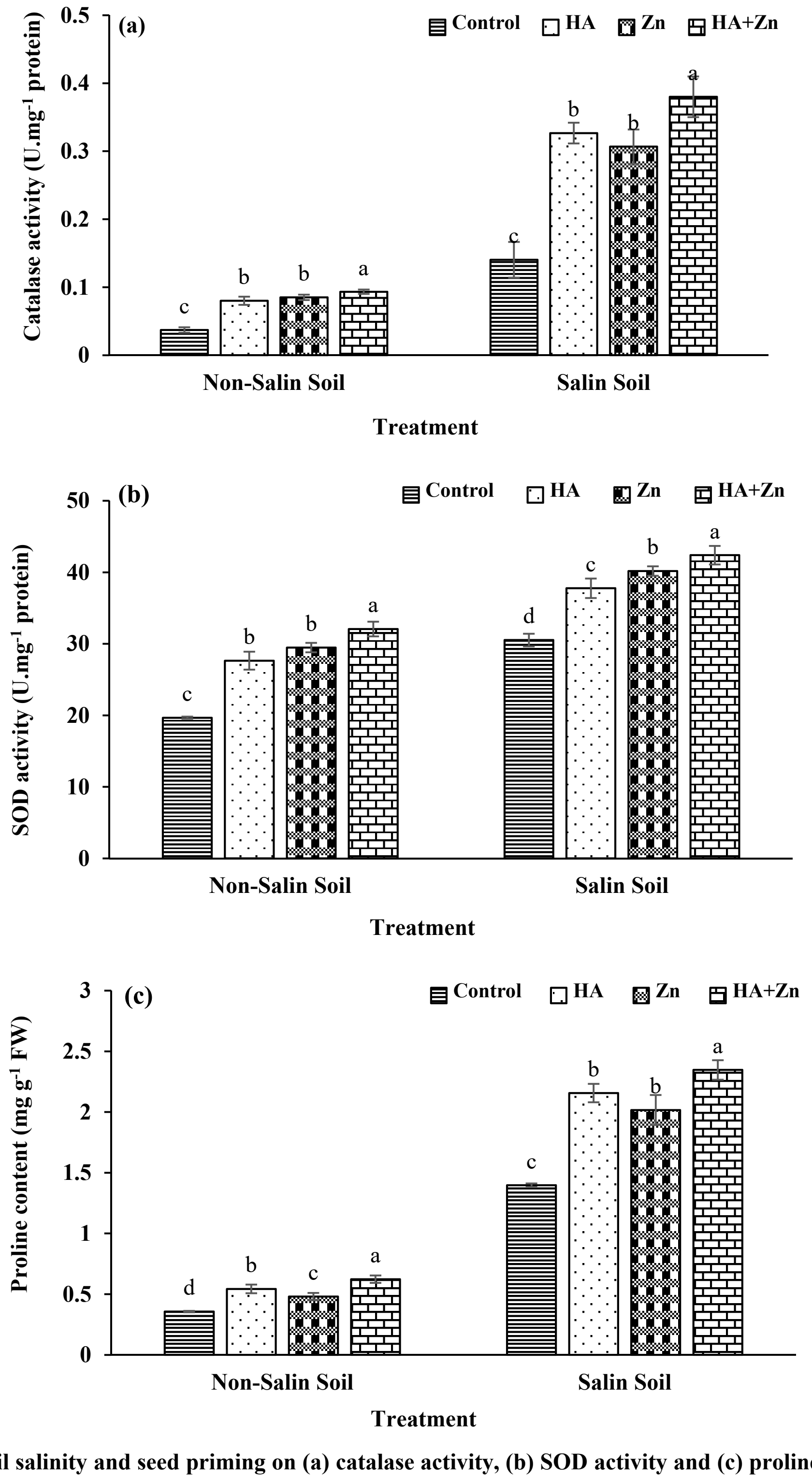

Fig. 3. Effect of soil salinity and seed priming on (a) catalase activity, (b) SOD activity and (c) proline content (slice by salinity). Means with similar letter(s) in each level of salinity are not significantly different, according to the Duncan's -test at 5% probability level.