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Mineral Status and Lupine Yield Responses to Ascorbic Acid Spraying and Irrigation by Diluted Sea Water

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A pot experiment was conducted in the greenhouse of the National Research Centre at Dokki, Cairo Egypt during 2010 -2011 winter seasons to evaluate the effect of different salt stress degrees on the growth and yield characters. The salinity treatments were: Irrigation by three concentrations of diluted seawater (2000, 4000 and 6000 ppm) more than the control treatment (irrigated by tap water 250 ppm) and spraying ascorbic acid (AsA) with two concentrations (100, and 200 ppm). Salinity depressed the pods, straw, straw+ pods and seeds weight relative to the control plants but the depression of these traits showed its maximum values when plants subjected to the higher level of salinity (6000 ppm) markedly more than that with the other two levels of salinity. Slight differences in the mentioned characters of plants irrigated by solution contained 2000 or 4000 ppm. Gradual depressions in pods/straw, seeds/pods and seeds/straw ratios were detected with the

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increase in salt concentration in water of irrigation. Ascorbic acid application led to increase the pod, straw, total and seeds yields. The high increment in pods weight and seeds to straw ratio wereshown by using 100 ppm ascorbic acid but the increment in straw, totalseeds weight and seeds/pods and pods/straw ratios.Furthermore, the absorption rate of N, K, P, Ca, and Mg ions from the growth medium significantly inhibited as a result of treatment with diluted sea water. Meanwhile, significant increases in the uptake of these ions were obtained in response to ascorbic acid application.

Keywords: Lupine (Lupinus termis L); salinity-ascorbic acid; yield-mineral status.

1. INTERODUCTION

The genus Lupinus (Papilionaceae) is known to be a rich source for lupine alkaloids [1]. *Lupinus termis*is cultivate in the Mediterranean region for its edible seeds [2]. Also, lupine is considered as one of the important plant from medical and nutritional points of view [3].

Adverse environmental condition plays an important role in lowering the food production and raised the poverty worldwide [4]. High salinity and drought are common stress conditions that adversely affect plant growth and crop production Hussein and Alva 2014; [5,6,7]. Under these both condition, the ability of plants to uptake water was reduced and this intern quickly causes reductions in growth rate along with cascade of metabolic changes [8,9,10]. Salinity stress significantly declined the photosynthetic rate [11,12,13]. This effect may be a result of stomata closure due to osmotic stress, or salt-induced damage to photosynthetic apparatus [14]. Products of altered chloroplast and mitochondrial metabolism during stress cause oxidative damage to different cellular compounds including membrane lipids, proteins and nucleic acids, Apse and Blumwald [15] reported thatone approach for inducing oxidative stress tolerance would be through increase the cellular of enzyme substrates such as ascorbic acid.

Ascorbic acid (AsA) is a small water soluble anti-oxidant molecule which acts as a primary substrate in the cyclic pathway of enzymatic detoxification of hydrogen peroxide (Dolatadion and Joueghan, 2009). Improved understanding of ascorbate in plant will lead to the possibility of increasing ascorbate concentration in plants by genetic manipulation. This will have benefits to tolerance of plants to oxidative stresses Smimolf, 1995 and Beltagi [16] and Orabi et al. [17,18]. Salinity sensitivity varies between plant organs and between cell at different developmental stages in a single organ.The physiological and molecular bases for the differential responses are not known. It is well known that exposure of plants to salinity is induce formation of reactive oxygen species (ROS), which are involved in damage mechanisms but in addition in cell growth processes [19]. Nevertheless, [20] on halophyte *Hordeum maritimum* and [21] on *L. vulgare* concluded that the antioxidative response was enhanced by the low and moderate salinity levels.

Plant spraying or seed soaking with ascorbic acid affected the oxidative defense and mitigated the inhibitory effect of NaCl on the growth parameters [22,23 24].

Therefore, the current research work was performed to investigate the effect of ascorbic acid application in ameliorate salt stress in lupine straw and seeds.

2. MATERIALS AND METHODS

A pot experiment was conducted in the greenhouse of the National Research Centre at Dokki, Cairo Egypt during 2010-2011 winter seasons to evaluate the effect of different salt stress degrees on the growth and yield characters.

The treatments were as follows: 1 – Salinity: Irrigation by three concentrations of diluted seawater (2000, 4000 and 6000 ppm) more than the control treatment (irrigated by tap water 300 ppm). 2 – Spraying ascorbic acid with two concentrations (100, and 200 ppm).The control plants sprayed by the samequantity of distilled water.The experiment included four levels of salinity in combination with three concentrations of ascorbic acid i.e. 12 treatments in 6 replicates. Metallic pots 35 cm. in diameter and 50 cm. in depth (The inner surface of the pots was coated with three layers of bitumen to prevent direct contact between the soil and metal) were used. Every pot contained 30 kg of air dried clay loam soil with 2 kg of gravel

Table 1. Some physical and chemical properties of studied soil (a, b) and sea water ©

a. Soil mechanical analysis

Sand		Silt	Clay	Soil
Course >200 µ %	Fine 200-20µ %	20-2 µ %	< 2 µ %	texture
7.20	14.25	48.33	30.22	Clay Loam

b . Soil chemical analysis

pH 1:2.5	EC dSm^{-1} 1:5	$CaCO_3$ %	CEC C mole Kg^{-1}	OM %	Soluble cations and Anions meq/100 g soil							
					Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	CO^{-3}	HCO^{-3}	Cl^{-1}	SO^{-2}
7.15	1.3	2.53	33.5	1.3	1.82	0.23	2.38	1.27	0.0	0.91	1.9	1.89

Available macro-nutrients %			Available micro-nutrients ppm			
N	P	K	Zn	Fe	Mn	Cu
0.47	0.25	0.95	3.1	4.8	7.3	5.2

c- Chemical analysis of sea water

pH	EC	Cations (meq/L)				Anions (meq/L)			
	(dSm^{-1})	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	CO^{-3}	HCO^{-3}	Cl^{-1}	SO^{-2}
8.62	50.0	393.5	20.4	26.2	118.3	0.53	9.6	253.2	295.1

Table 2. Effect of salinity on yield of lupine plant

Salinity	Pods	Straw	Total	Seeds	Pods/straw	Seeds/pods	Seeds/straw
T.W.	3.32	2.46	5.78	2.19	1.35	o.66	0.88
2000 ppm	2.44	2.04	4.48	1.48	1.20	0.61	0.73
4000 ppm	2.46	2.14	4.59	1.20	1.15	0.49	0.65
6000 ppm	1.44	1.14	2.59	0.57	0.79	0.40	0.54
LSD at 5 %	0.354	0.664	1.67	1.040	------	-------	------

T.W. = Tap water (300 ppm)

(Particles about 2-3 cm in diameter) at the bottom of the pot. Some chemical and physical properties and nutrients concentration of the experimental soil are presented in Tables 1a and 1b.The irrigation water with different salt concentration was prepared by using the sea water as a source. The analysis of sea water is shown in Table 1c.

Seeds of lupine (*Lupinus termes L.*) c.v. Balady were sown in the first of December, 2010-2011 plants were thinned twice, the 1st after days of sowing and the 2nd two weeks later to leave three plants/pot. Calcium super phosphate (15.5% P_20_5) and potassium sulfate (48.5% K2O) in the rate of 6.0 and 3.0 g/pot were added before sowing. Ammonium sulfate (20.5% N) in the rate of 3.43 g/pot was added. Irrigation with diluted seawater in different concentrations was started 30 days after sowing.

Samples were taken from every sub-treatment, cleaned, dried in electrical oven at 70 C, ground in a stainless steel mill. Minerals determination was done as the methods was described by Cottenie, et al. [25].

Data collected were subjected to the proper statistical analysiswith the methods described by Snedecor and Cochran [26].

3. RESULTS AND DISCUSSION

3.1 Salt Stress

a)- Yield

Data presented in Table (2) showed that salinity depressed the pods, straw, straw+ pods and seeds weight relative to the control plants but the depression of these traits showed its maximum values when plants subjected to the higher level of salinity (6000 ppm) markedly more than the other two levels of salinity. Slight differences were detected in the previous mentioned characters of plants irrigated by solution contained 2000 or 4000 ppm. Gradual depressions in pods/straw, seeds/pods and seeds/straw ratios were detected by increasing in salt concentration in water of irrigation. Several

investigations reported the adverse effect of salinity on legumes growth and yield [16,27,28].

Salinity is generally detrimental of plant growth through its adverse effects on plant metabolism that induces important modifications in gene expression. Such modifications may intern lead to accumulation of depletion of certain metabolites resulting in an imbalance in the levels of a relatively mall set of cellular proteins, which could increase, decrease, appear or disappear after salt treatment [29,16 and 7].The inhibitory effects of salt stress on yield of lupine may be attributed to the effect on growth traits such as number and area of green leaves, number of pods/plant and weight of seeds/pod which caused from the effect of one or more from these reasons: protein formation [28, 30, 31] photosynthetic activity and carbohydrate accumulation [32, 33], hormonal balance [34,35] enzymes activity and oxidative defense 36, 37, and 17, 18] water adjustment [38] and /or mineral absorption and distribution [39, 40, 41, 42].

b)-Minerals

Data in Tables 3 and 4 revealed the fluctuated response in the P, K, and Ca concentration as well as Na:Ca and Ca:(Na+ K) ratio as results of salt stress. Meanwhile, Na concentration and Na:K ratio increased parallel to the increase of salts concentration in diluted sea water used in irrigation.

Several studies have shown a close relationship between salt concentration and its effect on mineral concentration. Li, et al. [43] noticed thatthe content of Naion increased, while K ion decreased with increasing salinity and pH, and this suggesting competitive inhibition between absorptions of Na and Kions. Ashraf and Ahmad [44] revealed thatthesalt-tolerant andsalt-sensitive lines of cotton did not differ in leaf or root Na^+ concentrations. The salt-sensitive lines accumulated more chloride ions in the leaves than all the three salt-tolerant lines at the highest salt level. These all-tolerant lines had higher concentrations of K, Ca^2ions, K+/Na- ratio and nitrogen in the leaves than those of the salt-sensitive lines at the highest NaCl concentration, whereas no relationship could be drawn between salt tolerance and tissue phosphorus concentration. The seed oil content of salt-tolerant lines was slightly higher than that of the salt-sensitive lines.

Low levels of potassium ions relieved sodium ions toxicity, but low levels of Na^+ enhanced K^+ toxicity. Tissue concentrations of Na^+ were reduced by Ca^{2+} and K^+ in the rooting medium, and tissue concentrations of K^+ were enhanced by Ca^{2+} [45]. The most significant response of lupine plants to excess of NaCl is the increase of leaves sucrose content, which is partially due to SS activity which increase under salinity; Fernandes, et al. [46].

Adverse effects of salt stress may be due to the depression on photosynthetic rate and carbohydrate metabolism as found by Fernandes, et al. [46] who showed the decrease in glucose content as salt increased up to 150 mM NaCL.While, Keutgen and Pawelzik [47] emphasized that salt stress affected mainly the protein building. Salinity affected the absorption, translocation, distribution and adjustments of

Table 3. Effect of salinity on nutritional status of lupine straw

Salinity	Macro-nutrients %						Ratios			
ppm	N	P	K	Mg	Ca	Na	Na:K	Na:Mg	Na:Ca	Ca;(Na+K)
T.W.	2.47	0.1093	1.35	0.62	2.20	0.91	0.67	1.47	0.41	0.97
2000	1.85	0.0837	1.13	0.41	1.73	0.99	0.88	2.42	0.57	0.82
4000	2.31	0.1066	1.18	0.56	2.13	1.09	0.92	1.95	0.51	0.94
6000	1.91	0.0082	1.76	0.43	2.16	2.08	1.18	4.83	0.96	0.56

T.W. = Tap water (300 ppm)

Table 4. Effect of salinity on nutritional status of lupine seeds

Salinity	Macro-nutrients %						Ratios			
ppm	N	P	K	Mg	Ca	Na	Na:K	Na:Mg	Na:Ca	Ca;(Na+K)
T.W.	6.87	0.27	2.86	0.39	1.47	0.97	0.34	2.49	0.66	0.38
2000	6.63	0.29	2.50	0.35	1.44	0.51	0.20	1.46	0.35	0.48
4000	5.30	0.26	2.50	0.27	1.37	0.46	0.18	1.70	0.34	0.46
6000	5.13	0.20	2.40	0.26	1.15	0.43	0.18	1.65	0.37	0.41

T.W. = Tap water (300 ppm)

water as detected by Maggio, et al. [23] on eggplants.Antioxidants content and activity which affected the oxidative defense by the increase of salts in the zone plant [48], Kinrade, et al. (1999) suggested that the depression on growth and yield may be due to the disturbance in mineral status, However, Hussein and El-Greatly (2007) related this phenomenon to the disturbance in growth hormones. These effects might be altered the dry matter accumulation rates and this intern affected the translocation of metabolites from source to think which reflected in the weight of seeds [49].

3.2 Ascorbic Acid

a)- Yield

Ascorbic acid application led to increase in the pod, straw, total and seeds yields. The high increment inpods weight and seeds to straw ratio were by using 100 ppm ascorbic acid but the increment in straw,total, seeds weight and seeds/pods and seeds/straw ratios, were obtained by application of 200 ppm as shown in Table (5). Shetewie [50] indicated that plants sprayed with ascobin and irrigated with water gave 174% fresh weight and 129% dry weight soybean of the control. Soybean plants sprayed with ascobin yielded 159% as compared with non-sprayed plants. Foyer [51] and Beltagy [16] stated that Ascorbate in plants occurs in the cytosol, chloroplasts,vacuoles, mitochondria and cell wall. The concentration in chloroplast can be high (up to 50mM in spinach) and is probably related to its central role in photosynthesis. Abd El-Bakey, et al. [24] on wheat concluded that spraying AsA improved growth and yield and enhancing the oxidative defense.Talaat, et al. [22] on sweet pepper, mentioned that AS counteracted the suppressive effect of the high salinity levels on seedlings growth.Talaat, et al. [22] mentioned that the interaction showed a marked decrease in concentration of Na, while, N,P and K percentages were increased.

b)-Minerals

Data in Tables (6 and 7) for both straw and seeds showed that foliar ascorbic application alleviated deleterious effects of salinity stress on growth and nutrient accumulation.The highest values were achieved when plants sprayed by 100 ppm AsA. The detrimental effects of salinity on nutrient accumulation in the stressed plants have been previously reported by several workers [52, 53 and 54]. Exogenous supply of AsA enhanced the concentration of N, P and K in stressed plants in comparison with the control plants. These increases in N, P and K may be attributed to the positive effect of AsA on root growth which consequently increased the absorption of different nutrients and alleviating the harmful effects of salinity. Similar results were previously recorded by Hanafy Ahmed, *et al.[55]* on wheat and faba bean plants, Talaat (1995) on spinach and lettuce plants, Tarraf, *et al.[56]* on lemongrass plants; Singh and Chatrath [57] on wheat plants; and Neveen Shawky [58] on sweet pepper plants. AsA is an important primary metabolite in plants that functions as an antioxidant, an enzyme cofactor and a cell signalling modulator in a wide array of crucial physio-logical processes, including biosynthesis of the cell wall, secondary metabolites and phytohormones, stress tolerance, photoprotection, cell division and growth [59].

Table 5. Effect of ascorbic acid on yield of lupine plant

Ascorbic acid	Pods	Straw	Total	Seeds	Pods/straw	Seeds/pods	Seeds/straw
D. W.	1.67	1.38	3.06	0.99	0.92	0.44	0.54
100 ppm	2.33	2.14	5.00	1.70	0.92	0.72	0.79
200 ppm	2.17	2.31	5.03	1.75	1.07	0.81	0.75
LSD at 5 %	0.49	0.199	N.S	0.135	------	-------	------

D.W: Distilled water

Table 6. Effect of ascorbic acid on nutritional status of lupine straw

Ascorbic	Macro-nutrients %							Ratios		
acid	N	P	K	Mg	Ca	Na	Na:K	Na:Mg	Na:Ca	Ca;(Na+K)
D.W.	2.14	0.1103	1.23	0.40	2.04	1.27	1.03	3.18	0.62	0.82
100	2.13	0.0932	1.24	0.44	1.96	1.13	0.91	2.57	0.58	0.78
200	2.19	0.0800	1.15	0.55	2.08	1.40	1.22	2.55	0.67	0.82

D.W: Distilled water

Table 7. Effect of ascorbic acid on nutritional status of lupine seeds

Ascorbic acid	Macro-nutrients %								Ratios	
	N	P	K	Mg	Ca	Na	Na:K	Na:Mg	Na:Ca	Ca;(Na+K)
D.W.	5.93	0.25	2.62	0.35	1.39	0.65	0.25	1.86	0.47	0.43
100	5.95	0.27	2.62	0.32	1.37	0.60	0.23	1.88	0.44	0.43
200	6.08	0.25	2.45	0.28	1.32	0.53	0.22	1.89	0.40	0.44

D.W: Distilled water

Table 8. Effect of salinity and ascorbic acid on yield of lupine plants

Salinity ppm	Ascorbic acid ppm	Pods	Straw	Total	Seeds	Pods/ straw	Seeds/pods	Seeds / straw
Tap Water	D.W.	2.53	2.05	4.58	1.53	1.23	0.61	0.75
300 ppm	100	3.97	2.76	6.73	2.68	1.44	0.65	0.94
	200	3.47	2.57	6.04	2.45	1.39	0.71	0.95
2000 ppm	D.W.	2.09	1.53	3.62	1.20	1.37	0.57	0.78
	100	2.64	2.07	4.71	1.56	1.28	0.59	0.75
	200	2.60	2.51	5.11	1.67	1.04	0.64	0.67
4000 ppm	D.W.	2.07	1.95	4.02	1.23	1.06	0.59	0.63
	100	2.71	2.18	4.89	1.24	0.80	0.46	0.57
	200	2.59	2.28	4.87	1.70	1.14	0.66	0.75
6000 ppm	D.W.	1.23	1.21	2.44	1.01	1.02	0.82	0.84
	100	2.12	1.54	3.66	1.40	1.38.	0.66	0.91
	200	2.21	1.89	4.10	1.17	1.17	0.52	0.61
LSD at 5 %		0.98	0.40	N.S	0.171	----------	---------	--------

T.W.= Tap water; D.W.= Distilled water

Table 9. Effect of salinity and ascorbic acid on nutritional status of lupine straw

Salinity ppm	Ascorbic acid ppm	Macro-nutrients %					
		N	P	K	Mg	Ca	Na
Tap .W	D.W.	2.38	0.098	1.504	0.611	2.734	1.398
300	100	2.48	0.132	1.363	0.683	1.650	0.599
ppm	200	2.56	0.098	1.175	0.558	2.213	0.751
2000 ppm	D.W.	2.02	0.123	1.128	0.532	1.313	1.075
	100	1.69	0.119	1.178	0.155	1.875	0.699
	200	1.84	0.119	1.081	0.537	1.988	1.183
4000 ppm	D.W.	1.98	0.111	1.222	0.419	1.988	0.753
	100	2.66	0.115	1.175	0.671	2.213	0.806
	200	2.52	0.094	1.128	0.574	1.980	1.720
6000 ppm	D.W.	2.20	0.082	1.081	0.463	2.138	1.881
	100	1.69	0.082	1.222	0.252	2.175	2.419
	200	1.84	0.082	1.222	0.546	2.175	1.935

T.W.= Tap water; D.W.= Distilled water

3.3 Salt Stress X Ascorbic Acid

a)- Yield

Data presented in Table (8) indicated that significant response of pods, straw and seeds yield to the interactive effect of AsA and salt stress. Control only revealed that total yield was not significant responded to this interaction.The highest values of straw, pods, seeds and total yield were observed when plants sprayed by 100 ppm AsA and irrigated regularly with fresh water but the lowest values, on the opposite, when lupine plants irrigated by 6000 ppm. Shelling percentage increased as increase in concentration of AsA under different concentration rate of salts but the reverse was true under irrigation with water contains 6000 ppm salts.M'rah, et al. [60] stated that the induced biosynthesis of the antioxidants ascorbic acid and α-tocopherol (ATOF) appeared to be integrated into a network of reactions controlling

the levels of reactive oxygen species which affected by salt stress. Xu, et al. [61] noticed that, however, root applied AsA counteracted the adverse effects of salt stress on thegrowth of cv. S-24 only, particularly at 100 mg L^{-1} AsA level. AsA-induced enhancement ingrowth of salt-stressed plants of S-24 was associated with enhanced endogenous AsA level and CAT activity, and higher photosynthetic capacity, and accumulation of K+ and Ca2+ in the leaves of wheat.

Maggio, et al. [23] reported that salinity decreased stomatal conductance, plant water use, leaf total and osmotic water potentials.In addition, reduced leaf area, plant dry mass yield, fruit yield and fruit size. AsA treatments reduced stomatal conductance, but had a negative effect on plant growth and yield regardless the irrigation treatment. Consistent with other reports, AsA reduced the stomatal conductance but did not seem to improve commercial yield and total dry matter in saline environment. Meanwhile, significant synergistic effect between NaCl (40 mM) and ascorbic acid treatment increased the contents of chlorophyll a andchlorophyll stability index in leaves of chick pea plants. The total number of protein bands/lane did not change under the low (20 mM) NaCl concentration but was dramatically reduced by the high (40 mM) NaCl treatment. Also, the sum of optical densities of protein bands was inhibited by the two levels of NaCl, but was induced by 10.68% by the added ascorbic acid at 20 mM NaCl and by 21.39% at 40 mMNaCl. Six different polypeptides of molecular weights 146.28, 117.98, 51.55, 49.6, 44.49 and 38.34were completely disappeared under NaCl stress (40 mM). These bands reappeared in response to the application of ascorbic acid treatment. Moreover, the optical density of every individual protein band was induced by ascorbic acid under the low NaCl concentration. The results indicate synergistic interaction between salinity stress and ascorbic acid for the sake of salt resistance in chick pea plants (Beltagi, 2008).Nevertheless, a supply of exogenous AsA increased the nodule AsA+dehydroascorbate (DHA) pool in comparable with water-stressed nodules without ASC, and significantly modulated the response to water stress of the unspecific guaiacolperoxidase in leaves and nodules.

However, AsA supply did not produce recovery from water stress in other nodule antioxidant enzymes, nodule carbon and nitrogen enzymes, or nitrogen fixation. The supply of the immediate ASC precursor, galactono-1,4-lactone (GL), increased the nodule AsA+DHA pool, but also failed to prevent the decline of nitrogen fixation and the reduction of carbon flux in nodules. These results suggest that ASC has a limited role in preventing the negative effects of water stress on nodule metabolism and nitrogen fixate [62].

Fig. 1. Effect of salinity and ascorbic acid on ratio of some nutrients concentration in lupine straw

S0 = Tap water (300 ppm); S1= 2000 ppm; S2 = 4000 ppm; S3= 6000 ppm; Ao = Distilled water; A1= 100 ppm AsA; A2= 200 ppm AsA

Table 10. Effect of salinity and ascorbic acid on nutritional status of lupine seeds

Salinity	Ascorbic acid	Macro-nutrients %					
ppm	ppm	N	P	K	Mg	Ca	Na
Tap Water	D.W.	6.6	0.24	3.2	0.38	1.83	0.65
300 ppm	100	6.9	0.32	2.9	0.43	1.11	0.28
	200	7.1	0.24	2.5	0.35	1.48	0.35
2000 ppm	D.W.	5.6	0.30	2.4	0.33	0.88	0.50
	100	4.7	0.29	2.5	0.11	1.25	0.33
	200	5.1	0.29	2.3	0.34	1.33	0.55
4000 ppm	D.W.	5.5	0.27	2.6	0.26	1.33	0.35
	100	7.4	0.28	2.5	0.42	1.48	0.38
	200	7.0	0.23	2.4	0.36	1.30	0.80
6000 ppm	D.W.	6.1	0.20	2.3	0.31	1.43	0.88
	100	4.7	0.20	2.6	0.16	1.45	1.13
	200	5.1	0.20	2.6	0.34	1.45	0.90

T.W.= Tap water; D.W.= Distilled water

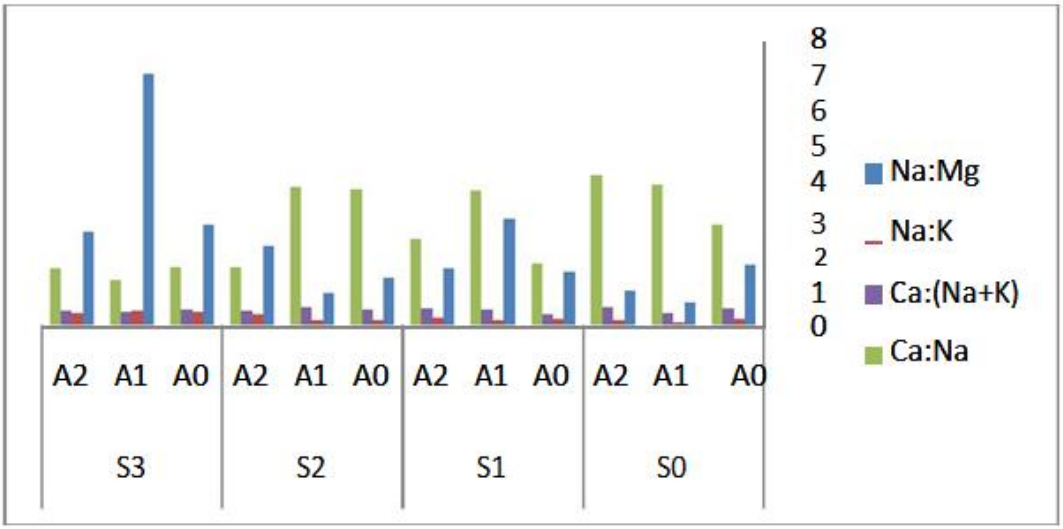

Fig. 2. Effect of salinity and ascorbic acid on ratio of some nutrients concentration in lupine seeds

S0= Tap water (300 ppm); S1= 2000 ppm; S2= 4000 ppm; S3= 6000 ppm; Ao=Distilled water; A1= 100 ppm AsA; A2= 200 ppm AsA

b)-Mineral

Both nutrient supply and nutrient balance are important factors for plant growth and development. Nutrient interactions consisting of vital influence on absorption, distribution and functioning exist.The interaction between nutrients can occur at the root surface or within the plant and might be due to: i) formation of precipitates and complexes between ions with different chemical properties, and ii) competition between ions with similar properties. Generally, increases N reduces cation uptake for both saline and non-saline treatments, Na/K, Na/Ca, Na/Mg and Ca/Na+K ratios were lowest in studied treatments as shown in Tables 9 and 10 as well as Fig. 1, 2, for concentration and Fig 3 and4 for nutrients uptake in both straw and seeds.Slightly increase in Na, salinity was associated with an increase in straw N, and K with a decrease in P, Mg, and Ca, the same trend was noticed in the lupine seeds. Most interactions are complex i.e. a nutrient interacts simultaneously with more than one nutrient. These low ratios indicate that Ca, K and Mg transport was not impaired by Na under 2000 pmm 4000 ppm but impaired by Na under 6000 ppm and could disturb plant metabolism and reduce plant growth.

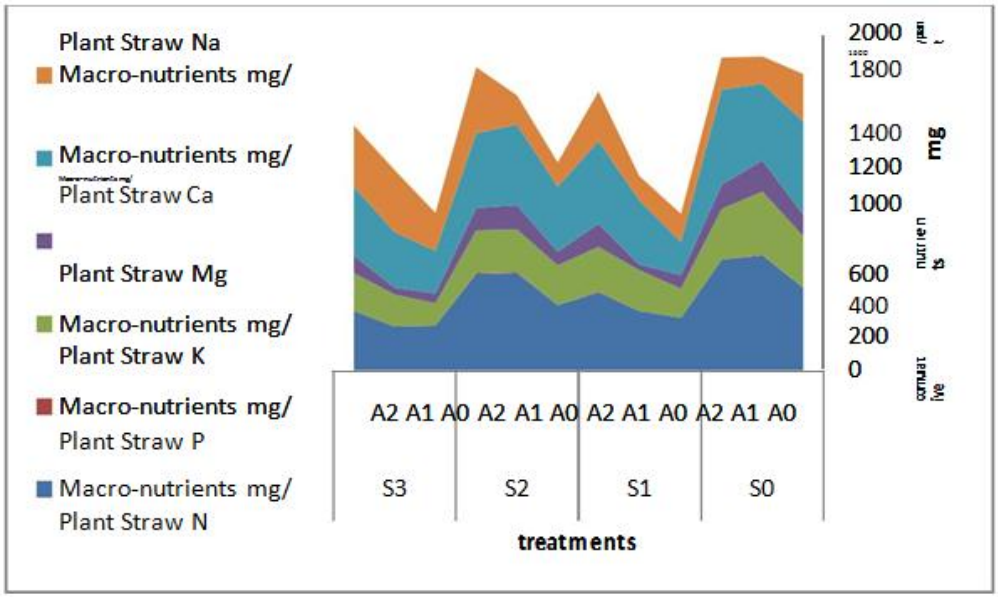

Fig. 3. Macronutrients uptake in lupine straw as affected by salinity and ascorbic acid
S0= Tap water (300 ppm); S1= 2000 ppm; S2= 4000 ppm; S3= 6000 ppm; Ao=Distilled water
A1= 100 ppm AsA; A2= 200 ppm AsA

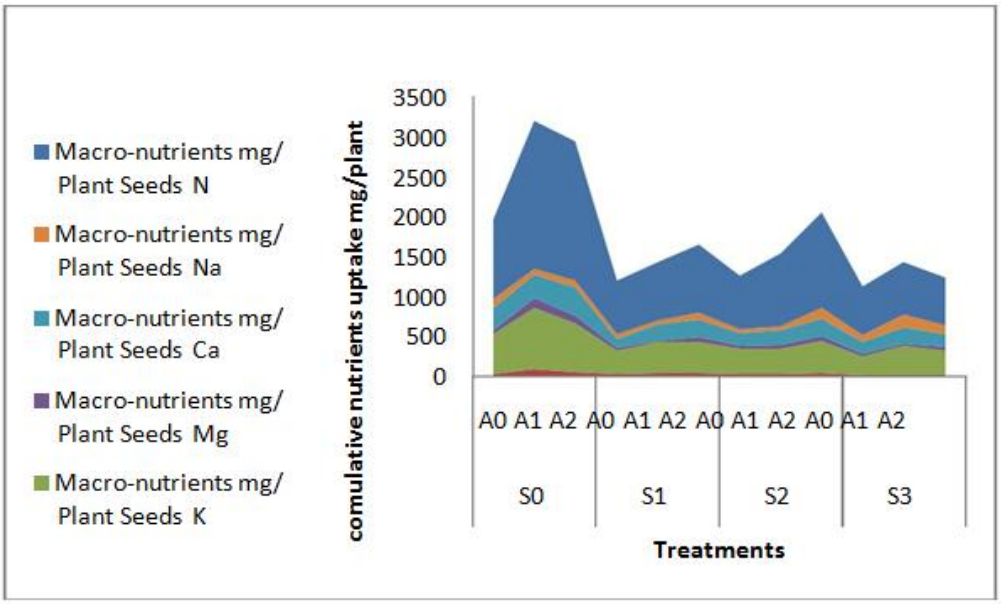

Fig. 4. Macro nutrients uptake in lupine seeds as affected by salinity and ascorbic acid
S0= Tap water (300 ppm); S1= 2000 ppm; S2= 4000 ppm; S3= 6000 ppm; Ao=Distilled water
A1= 100 ppm AsA; A2= 200 ppm AsA

Xu, *et al*. (2008) found that imposition of salt stress reduced the growth of both wheat cultivars by causing reduction in photosynthesis, and endogenous AsA level, and enhancing accumulation of Na^+ and Cl^- coupled with a decrease in K^+ and Ca^{2+} in the leaves and roots of both cultivars thereby decreasing tissue K^+/Na^+ ratio. AsA-induced enhancement ingrowth of salt-stressed plants was associated with enhanced endogenous AsA level; higher photosynthetic capacity, and accumulation of K and Ca ions in the leaves. These findings led us

to conclude that root applied AsA counteracts the adverse effects of salt stress ongrowth of wheat by improving photosynthetic capacity of wheat plants against salt-induced oxidative stress and maintaining ion homeostasis, however, these effects were cultivar specific. They added that sstress in both cultivars increased the antioxidant capacity, antioxidants pools (ascorbic acid, anthocyanins andsuperoxide dismutase) and selected minerals such as Na, Cl, K, N, P and Zn ions, as well as lipid peroxidation.

Furthermore, salt stress increased the content of free and essential amino acids, especially in cv. Elsanta. The more tolerant cv. Korona was characterized by an increase of reduced glutathione and a better fruit taste.

In salt-stressed fruits of cv. Elsanta, taste was significantly impaired. Athar, *et al.* [48] Plant pre-conditioning with mild concentrations of ascorbic acid (AA) has been proved to be effective in protecting horticultural crops in hyperosmotic environment. The protective effect of AA seems to be associated to the control of stomatal aperture and, consequently, to a reduced water loss in response to hyperosmotic stress. They also added that salinity decreased stomatal conductance, plant water use, leaf total and osmotic water potentials. Salt stress increased dry matter content in all plant organs (leaf, root and fruit) and reduced leaf area, plant dry mass yield, fruit yield and fruit size. AA treatments reduced stomatal conductance, but had a negative effect on plant growth and yield regardless the irrigation treatment. Consistent with other reports, AA reduced the stomatal conductance but did not seem to improve total dry matter and yield matter in saline environment. Lu, et al. [63].

4. CONCLUSION

The obtained results in this study proved the beneficial effects of AsA on growth characters, N, K, and Ca counteracted the deleterious effects of salinity stress on the investigated parameters, help lupine plants to avoid Na toxicity and improved cell membrane stability and nutrient uptake under salinity stress and consequently the productivity of lupine plants under salinity stress conditions. These effects may be attributed to the protective role of AsA in plant cells from the oxidative stress induced by salinity. Therefore, we concluded that foliar application of AsA on lupine plants with 200 ppm at 30 and 60 days after sowingis the most effective treatment to enhance growth and yield of lupine plants under salinity stress conditions in comparison with the control plants.The addition of AsA could offer an economical and simple solution to problems in production of lupine plants in arid region soils caused by high salinity. In addition,AsA improved mineral status of seeds under fresh water or under saline irrigation conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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