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Full Length Research Paper

Effect of mycorrhiza symbiosis on the Nacl salinity in *Sorghum bicolor*

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In order to determine mycorrhizal symbiosis on the Nacl salinity tolerance in *Sorghum bicolor* (aspydfyd cultivar), an experiment with two factors was done in Damghan Islamic Azad University laboratory (Iran) in 2007. The first factor with two levels (mycorihizal and non-mycorihizal) and second factor with six levels Nacl concentration of (0, 50, 100, 150, 200 and 250 Mmol) were examined in a random design with three replication in sand environment for 15 weeks. The measurements were the absorption of K, Na, P, N, plant growth, tolerance for different salinity concentrations and traits such as stem and root dry weight and the length of stem. The results showed that the dry weight and stem height in M plants were higher than NM plants. The increase in Nacl concentration decreased the stem height in both groups. However, there was no significant different in root dry weight. The measurement of elements in different organs showed that with increase in Nacl concentration, there would be a significant decrease in N, P, K absorption. But Na absorption increase is more in lower Nacl concentration. Generally, the amount of N, P, K in M plant organs is more than NM plant organs. The result of the experiment showed that mycorrhizal symbiosis is not only effective on element absorption, but also in plant growth and to some extent on salinity tolerance of the plant. So it will be suggested that mycorrhizal be used in salty soils with high Nacl for *Sorghum bicolor*.

Key words: Sorghum, mycorrhizal, salinity, symbiosis, tolerance.

INTRODUCTION

Today, the existence of salt in the plant habitat is the most important factor which causes tension in the environment (Hajiboland, 1992; Khajehzadeh, 1996). Salt prevents the growth of plants in salty soils. It was a time when the role of mycorrhiza in the economy of the plants growing in these salty soils has not been completely understood (Fahmi and Khajehzadeh, 1998; Khajehzadeh, 1996). Mycorrhiza is a mutual symbiosis between thallus of some fungi and the root of organic plants. In nature, mycorrhiza is important in satisfying the needs of the plants for water and nutrition. Among the microorganisms living in the soil, arbuscular mycorrhiza fungi are especially important. According to the available estimations, about 70% of the volume of alive bacterial mass is the mycelium (Mukerjii and Chamola, 2003). The word mycorrhiza is the combination of two words, the Greek word of mikes means fungi and the Latin word mycorrhizal means root, which shows the symbiosis between the host plant root and the mycorrhiza fungi (Mukerjii, 1996). Since the discovery of the symbiosis relationship, the scientists defined and discussed this relationship from different points. Mycorrhiza symbiosis appears between most of the vascular plants (more than 80%) and a group of soil fungi belong to three branches of Basidiomycota, Ascomycota and Zygomycotina (Harley and Smith, 1983). The result of this symbiosis is the fungi help in the absorption and transfer of nutrition to the host plant and on the other hand, the absorption of carbon combinations produced by photosynthesis by symbiotic fungi (Harley and Smith, 1983). Symbiosis relationship affects all of the biological aspects of host plant root system. Since plants are the first producers in every ecosystem, we can conclude that all living things, all ecosystems from bacteria to humans and from wet lands to arid deserts are somehow dependent on mycorrhiza symbiosis (Allen, 1992). The symbiosis relationship

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between plants and mycorrhiza fungi is beneficial to both. The most important benefit for host plant is the increase in the absorption of unavailable and insoluble nutrition by plants especially phosphor (Jakobsen, 1999). Furthermore, mycorrhiza fungi increase the aggregation of nitrogen in plant textures (Ibijbijen et al., 1996). Mycorrhiza fungi also have mutual relationship with other living things in the soil whose existence is critical to nutrition cycle (on the contrary, the host plant provide the symbiotic fungi with some carbon and carbon combinations) (Johnson et al., 2002). The growth reaction of host plant to mycorrhiza fungi colonization has different degrees including mutualism, indifference and sometimes antagonism. The reaction depends upon different factors such as the composition of fungi type and the host (Talukdar and Germida, 1994), the availability of nutrition (Xavier and Germida, 1997), interaction with other living things in the soil (Wilson, 1984; Walley and Germida, 1997) and other environmental factors (Leyval et al., 1997; Johnson et al., 2002; Karasawa et al, 2002).

Mycorrhiza interactions exist in all wet and arid lands (Khajehzadeh, 1996; Amerian, 1992; Read and Stribley, 1973). The use of symbiotic mycorrhiza fungi is important since they are a replace for chemical factors (Hajiboland, 1992; Khajehzadeh, 1996; Brunney and Scheidegger, 1994).

The agriculture Sorghum plant has the fifth place of importance among grains in the world. It is really compatible with Iran climatic condition since it can tolerate arid lands, so it is cultivated in most parts of Iran (Yazdi samadi and Abdemishani, 2001). This plant can tolerate environmental tensions including salinity (Ghahraman, 1993; Sabzinel monthly magazine, 2001).

The importance of mycorrhiza in producing economic plants and plant toleration of salinity has already been confirmed, but a few fundamental researchers have already done on it in Iran.

MATERIALS AND METHODS

The experiment was a factorial with two factors, factor A with two levels (mycorrhiza and control) and factor B with six levels (with different concentration of Nacl 0, 50, 100, 0, 150, 150, 200 and 250 mmol, respectively). The research was done in a random form with three repetitions in Damghan Islamic Azad University laboratory during 15 weeks in a sand medium in 2007 (Iran).

At first the Sorghum seeds were disinfected superficially. Sterilized seeds were placed on water-agar medium for germination and selection of good seeds (Abousalim and Mantel, 1992; Khajehzadeh, 1996). The plastic vases were used for inoculation of the newly germinated seeds. The vases with germinated seeds were kept in a natural condition and watered about 200 ml two times a week. During this time, some of the inoculated seeds were randomly selected and removed from the medium to investigate the existence of mycorrhiza in their roots (Kormanik et al, 1989).

Plants removed from the medium and the stem length, dry weight of aerial organs and root were determined separately after 15 weeks of transferring the germinated seeds to the medium. After solving the plant samples in Cl_2O_7 (70%), the amount of sodium and potassium were measured by Film photometry unit and the amount of nitrogen and phosphor was measured by chronometry method through spectrophotometer unit (Khajehzadeh, 1996).

In this experiment, effect of mycorrhiza symbiosis on the Nacl salinity in *Sorghum bicolor* and also characters like the stem dry weight, and the length of the stem were measured. The data were analyzed by SAS software and means comparison by Duncan multiple range test at the level of 5% and correlation coefficient, relationship between different densities of salinity, absorption of elements and characters were determined through response curve.

RESULTS AND DISCUSSION

Analysis of variance in Table 1 shows that among the levels of factor A (with and without mycorrhiza) for stem length, plant dry weight, amount of sodium, potassium, nitrogen and phosphor in aerial organs and the amount of potassium, nitrogen and phosphor in the root had significant effect at the level of 1%.

Table 2 shows the mean comparison by Duncan multiple range test at the level of 5% which for the levels of factor A (with and without mycorrhiza) for stem length, the dry weight of aerial organs, amount of sodium, potassium, nitrogen and phosphor in aerial organs and also amount of potassium, nitrogen and phosphor in the root of Sorghum were more in the case of the existence of mycorrhiza fungi around the root than the non-existence of mycorrhiza fungi. In this study, the effect of mycorrhiza symbiosis on the absorption of phosphor, potassium and nitrogen in aerial organs and root was more in comparison with the control plants. In the experiments reported by Jakobsen (1999), the symbiosis relationship between plants and mycorrhiza fungi were in the way that both benefit from this symbiosis. The important influence of this symbiosis on the host plant is the increase in the absorption of nutrition not available or insoluble by the plant especially phosphor. Ibijbijen et al. (1996) concluded in another experiment that the existence of mycorrhiza fungi increases the collection of nitrogen in plant textures. So the results of this experiment confirm the effect of mycorrhiza fungi on the absorption of nutrition. But in the root, the increase in salt density of the medium does not significantly decrease the dry weight of mycorrhiza plants or control plants.

On the other hand, the amount of sodium absorption in root and aerial organs has increased. This can be a sign of increase in osmotic power of the plant to absorb water. With the increase in sodium elements, the amount of salts in plant sap will be increased in comparison with the medium. Consequently, the water absorption will increase too. Analysis of variance in Table 1 shows that among the levels of factor, different densities of Nacl for stem length, dry weight of aerial organs, amount of sodium, potassium, nitrogen and phosphor in aerial organs and also the amount of potassium, nitrogen and phosphor in Sorghum root was significantly different at the level of 1% but not significantly different for the dry weight of the root.

Table 3 shows different densities of Nacl, it became

Table 1. Mean variance analysis of factor a (with and without mycorrhiza), factor B (NaCl densities) and the interaction between factors (A×B) for the studied characters on Sorghum.

S.O.V	d f	Stem height	Dry weight	Property related to aerial organ plant				Dry weight	Property related to root plant			
				Sodium	Potassium	Nitrogen	Phosphor		Sodium	Potassium	Nitrogen	Phosphor
Factor A	1	259**	0.02**	623310**	1720906**	8172928**	9900**	0.01^{ns}	31093**	26722**	2901344**	11095**
Factor B	5	121**	0.06**	94795**	45280**	1028325**	10720**	0.02^{ns}	43003**	17126**	814704**	10044**
Interaction A*B	5	2.21**	0.00^{ns}	4180**	3384^{ns}	16962**	252**	0.02^{ns}	1042^{ns}	26444**	9616**	156*
Error	24	0.35	0.001	87	1464	95	97	0.02	490	69	69	69
CV%		2.99	6.83	2.26	3.7	0.92	5.3	9.21	1.88	7.41	0.68	5.2

ns,* and**: non significant, significant at 5 and 1% levels, respectively.

Table 2. Mean Comparisons of the studied characters in Sorghum for levels of factor a (with and without mycorrhiza) by Duncan multiple range test at the level of 5%.

Trait	Stem height	Dry weight	Property related to aerial organ plant				Dry weight	Property related to root plant			
			Sodium	Potassium	Nitrogen	Phosphor		Sodium	Potassium	Nitrogen	Phosphor
Factor A	(cm)	(mg)	(mg/100 gD.W)				(mg)	(mg/100 gD.W)			
Mycorrhiza	23^{a}	0.50^{a}	1527^{a}	1250^{a}	3266^{a}	151^{a}	0.16^{a}	1207^{a}	377^{a}	2257^{a}	149^{a}
Non- Mycorrhiza	17^{b}	0.44^{b}	1264^{b}	813^{b}	2313^{b}	118^{b}	0.12^{a}	1149^{b}	323^{b}	1689^{b}	114^{b}

Mean followed by similar letters in each column are not significantly different.

Table 3. Mean comparison of the studied characters of Sorghum in different salinities of NaCl By Duncan multiple range test at the level of 5%.

Trait	Stem height	Dry weight	Property related to aerial organ plant				Dry weight	Property related to root plant			
			Sodium	Potassium	Nitrogen	Phosphor		Sodium	Potassium	Nitrogen	Phosphor
Density	(cm)	(mg)	(mg/100 gD.W)				(mg)	(mg/100 gD.W)			
0	26^{a}	0.58^{a}	1180^{d}	1110^{a}	3307^{a}	190^{a}	0.13^{a}	1045^{a}	424^{a}	2467^{a}	183^{a}
50	24^{b}	0.57^{a}	1311^{c}	1107^{a}	3093^{b}	173^{b}	0.13^{a}	1132^{d}	396^{a}	2311^{b}	163^{b}
100	22^{c}	0.49^{b}	1432^{b}	1071^{ab}	2971^{c}	139^{c}	0.12^{a}	1165^{c}	351^{b}	2031^{c}	148^{c}
150	19^{d}	0.43^{c}	1470^{a}	1048^{b}	2716^{d}	126^{d}	0.11^{a}	1198^{b}	335^{bc}	1814^{d}	126^{d}
200	16^{e}	0.38^{d}	1482^{a}	962^{c}	2445^{e}	104^{e}	0.10^{a}	1253^{a}	319^{c}	1712^{e}	93^{e}
250	14^{f}	0.33^{e}	1500^{a}	893^{d}	2205^{f}	77^{f}	0.12^{a}	1276^{a}	276^{d}	1500^{f}	76^{f}

Mean followed by similar letters in each column are not significantly different.

clear that the stem had the highest length and the dry weight of aerial organs was highest at the density of zero. But with the increase in salt density, the length and the weight of the plant decreased. Considering Graph 3 and 4 of regression relationship of weight and length of the

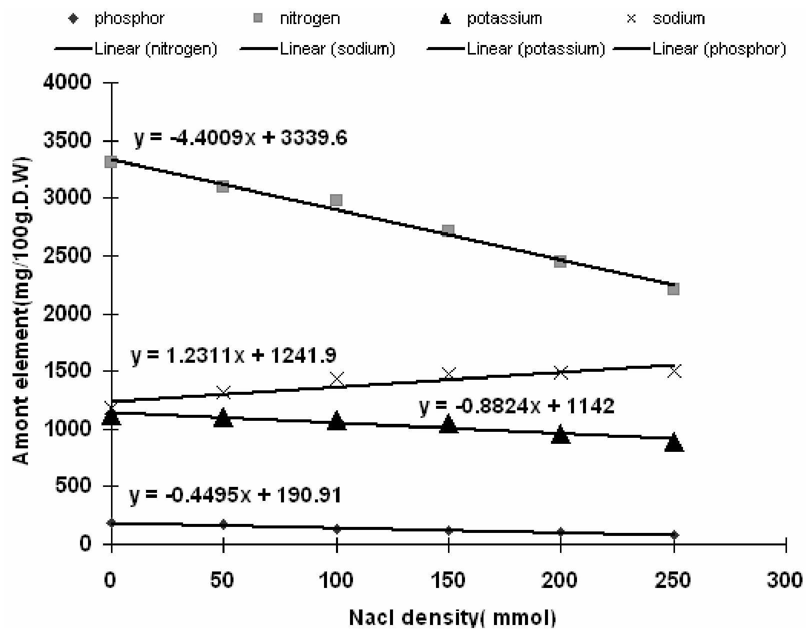

Figure 1. Relationship between Nacl density and the amount of sodium potassium, nitrogen and phosphor in aerial organs of Sorghum.

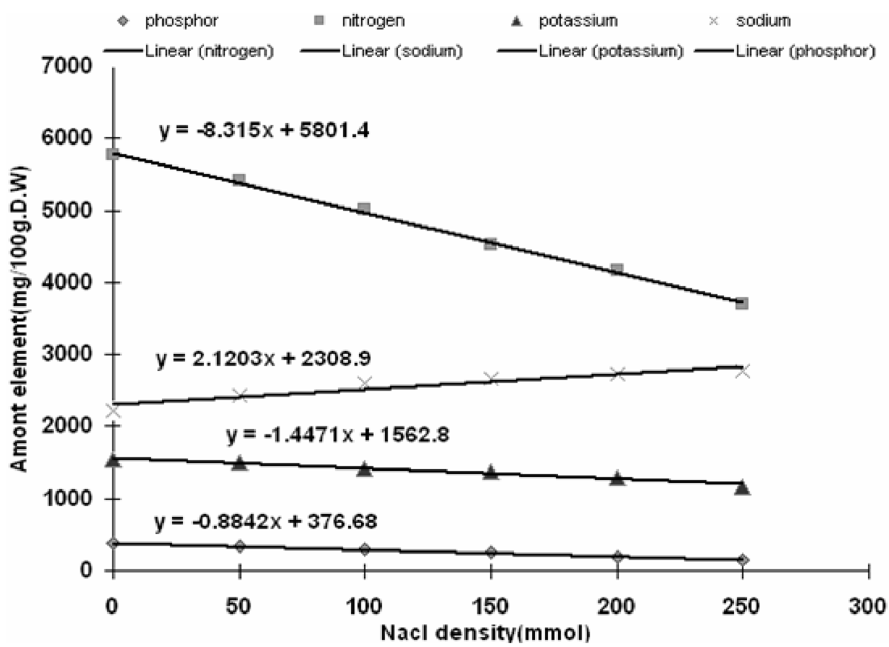

Figure 2. The root of plant infected by endomycorrhiza fungi.

stem with salinity, there is a clear decrease in the two characters linearly and negatively. In other words, with the increase in salinity, the stem length and the dry weight of aerial organs has decreased more and quicker. For the dry weight of aerial organs, the slope of regression line was -2.462, the slope of plant organs' total weight was -0.0582 and the slope of root dry weight line was -0.0051. With theses three negative slopes for dry weight of aerial organs, root and all the plant, it can be concluded that with the increase of salinity, the decrease in the weight of aerial organs was more than the decrease in the total weight and the root weight.

With the increase in Nacl density, the amount of sodium in aerial organs and root of the plant increased (Table 3, Figures 1 -4). The highest amount of density was 250. Generally, with the increase in Nacl density in

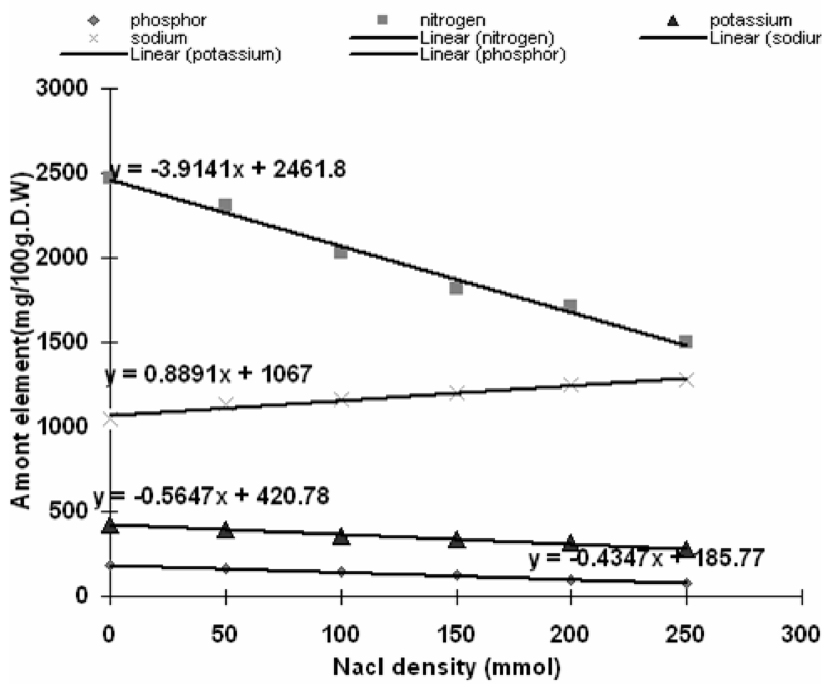

Figure 3. Relationship between Nacl density and the amount of sodium potassium, nitrogen and phosphor in Sorghum root.

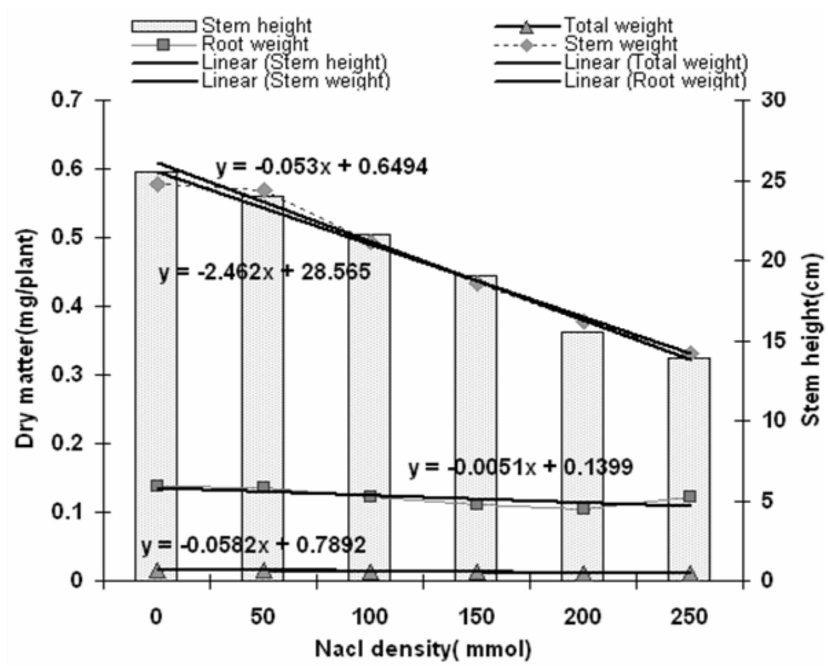

Figure 4. Relationship between Nacl density and weight of root and stem, all the aerial organs of the plant and the stem length in Sorghum.

medium, the amount of sodium in root and aerial organs also increases. So, with the increase of salt density in the medium, the plant has to absorb more sodium to increase salts and overcome the osmotic situation. So the amount of this element will increase in the plant. By Figures 1 and 2, it can be concluded that the amount of sodium in aerial organs, in comparison with the root, will be increased with the increase in Nacl density, so the slope of positive

Table 4. Mean comparison of the studied characters of Sorghum for the interactive effect of levels of factor a (with and without mycorrhiza) and Factor B (densities of Nacl) using Duncan multiple range test.

Trait	Stem height	Property related to aerial organ plant			Dry weight	Property related to root plant		
		Sodium	Nitrogen	Phosphor		Potassium	Nitrogen	Phosphor
Interaction effect	(cm)	(mg/100 gD.W)			(mg)	(mg/100 gD.W)		
Non Mycorrhiza*0	22.9^{c}	1100^{h}	2913^{f}	170^{b}	0.13^{ab}	370^{bc}	2148^{d}	155^{cd}
Non Mycorrhiza*50	20.9^{d}	1181^{g}	2620^{h}	147^{cd}	0.13^{ab}	353^{bcd}	1972^{f}	145^{de}
Non Mycorrhiza*100	18.2^{e}	1290^{ef}	2532^{i}	122^{e}	0.12^{ab}	312^{de}	1736^{g}	134^{e}
Non Mycorrhiza*150	16.2^{f}	1316^{de}	2218^{j}	110^{e}	0.11^{ab}	327^{cde}	1574^{h}	111^{f}
Non Mycorrhiza*200	13.3^{g}	1340^{de}	1923^{k}	97^{f}	0.10^{ab}	316^{de}	1449^{i}	75^{h}
Non Mycorrhiza*250	12.1^{h}	1357^{d}	1672^{l}	64^{g}	0.39^{a}	260^{f}	1251^{j}	63^{i}
Mycorrhiza*0	28.3^{a}	1260^{f}	3700^{a}	210^{a}	0.15^{ab}	478^{a}	2785^{a}	210^{a}
Mycorrhiza*50	27.2^{a}	1400^{c}	3565^{b}	199^{a}	0.14^{ab}	439^{a}	2651^{b}	180^{b}
Mycorrhiza*100	25.0^{b}	1573^{b}	3410^{c}	155^{c}	0.12^{ab}	391^{b}	2325^{c}	161^{c}
Mycorrhiza*150	22.0^{c}	1623^{ab}	3214^{d}	142^{d}	0.12^{ab}	342^{cd}	2053^{e}	141^{e}
Mycorrhiza*200	17.8^{e}	1624^{ab}	2967^{e}	111^{e}	0.11^{ab}	322^{cde}	1975^{f}	111^{f}
Mycorrhiza*250	15.9^{f}	1643^{a}	2740^{g}	90^{f}	0.09^{b}	293^{ef}	1749^{g}	91^{g}

Mean followed by similar letters in each column are not significantly different.

line will increase too. Since this element is poisonous for the plant, it is better to prevent Nacl density to be increased in plant medium. In the case of the existence of the salts in medium, it is recommended to wash the soil with heavy irrigation. Or in the case of row cultivation, the plants should be cultivated a bit lower than the top row. Since the amount of salt in the top row will significantly increase by evaporation during the season. It has also been recommended in other researches too (Ghanadha, 2002).

Measuring the amount of potassium, nitrogen and phosphor in aerial organs and root showed that the highest amount of these elements in aerial organs and root was at the time of zero density of Nacl (Table 3). However, with the increase of salt in the root medium, the amount of potassium, nitrogen and phosphor has decreased significantly in both root and aerial organs. The highest decrease was at the density of 250 (Figures 1 and 2). So the increase in Nacl density is equal to the decrease of these essential elements of the plant. This shows the negative effect of Nacl on absorption and the reservation of these elements by plant. By taking Figures 1 and 2 and the slope of the line into account, the highest decrease in nitrogen was especially in aerial organs of the plant and phosphor and potassium in root. So with the increase in Nacl density, the amount of potassium, nitrogen and phosphor, which are essential to plant life, decrease significantly and the plant faces a severe tension of nutrition. Based on the observations and results, it can be mentioned that Sorghum can tolerate salinity and aridity of soil, but the salinity tension decreases the relative speed rate of the plant. This is due to lack of essential ions and imbalance of ions in plant and increase in osmotic power of medium and low water absorption (Dolati and Almors, 2001; Khajehzadeh, 1996).

The dry weight of the aerial organs will be affected by the salinity tension more than other organs (Stribley, 1987). The measurement of the elements in the plant showed that the increase in salt density will lead to a significant decrease in potassium in aerial organs and root in the densities over 50 mmol. In lower salt densities, there was a significant difference between the amount of potassium in mycorrhiza and control plants. In all the cases, the increase in salt density will significantly decrease the amount of phosphor in root and aerial organs. But its amount between the mycorrhiza plants and control plants was significantly different. The increase in salt density will increase sodium absorption. The increase in sodium in aerial organs was significant in densities of 0 to 100 mmol but not in higher densities.

Table 1 of analysis of variance shows that the interactive effect between levels of factor A (with and without mycorrhiza) and factor B (different densities of Nacl) for stem length, amount of sodium, nitrogen and phosphor in aerial organs and the amount of potassium, nitrogen in root (at the level of 1%) and phosphor (at the level of 5%) were significantly different. But no significant difference was observed for potassium and the dry weight of aerial organs and also dry weight and sodium in the root.

Table 4 of mean comparison shows that in the interactive effect of factors on stem length, amount of nitrogen and phosphor in aerial organs, amount of potassium, nitrogen and phosphor in the root was in the best situation in the case of using mycorrhiza zero density of salt, while the worst situation was in the case of without mycorrhiza and density of 250. Based on Table 4, it can be seen that by using mycorrhiza, the absorption of nitrogen in aerial organs and root will increase and it will be used in the construction of proteins in plants,

Table 5. Correlation coefficient of the studied characters in Sorghum.

Character		NaCl density	Stem height	Property related to aerial organs plant				Property related to root plant					
				Dry weight	Sodium	Potassium	Nitrogen	Phosphor	Dry weight	Sodium	Potassium	Nitrogen	Phosphor
NaCl density		1.00											
Stem height		-0.83**	1.00										
Properties related to aerial organs plant	Dry weight	-0.94**	0.95**	1.00									
	Sodium	0.62*	-0.11^{ns}	-0.38^{ns}	1.00								
	Potassium	-0.32^{ns}	0.78**	0.56^{ns}	0.52^{ns}	1.00							
	Nitrogen	-0.62*	0.93**	0.79**	0.21^{ns}	0.94**	1.00						
	Phosphor	-0.90**	0.97**	0.96**	-0.29^{ns}	0.66*	0.85**	1.00					
Properties related to root plant	Dry weight	-0.26^{ns}	0.05^{ns}	0.26^{ns}	-0.36^{ns}	-0.20^{ns}	-0.08^{ns}	0.08 ^{ns}	1.00				
	Sodium	0.91**	-0.55^{ns}	-0.74**	0.83**	0.05^{ns}	-0.28^{ns}	-0.66*	-0.34^{ns}	1.00			
	Potassium	-0.81**	0.93**	0.90**	-0.22^{ns}	0.69*	0.83**	0.96**	0.01^{ns}	-0.55^{ns}	1.00		
	Nitrogen	-0.75**	0.97**	0.89**	-0.02^{ns}	0.84**	0.95**	0.95**	-0.01^{ns}	-0.45^{ns}	0.94**	1.00	
	Phosphor	-0.89**	0.98**	0.96**	-0.23^{ns}	0.68*	0.88**	0.97**	0.09^{ns}	-0.67*	0.93**	0.94**	1.00

ns,* and**:non significant, significant at 5 and 1% levels, respectively.

which leads to the increase in plant growth and function.

The highest amount of sodium in aerial organs in the case of the existence of mycorrhiza was at the density of 250. This is because of the symbiosis of plant and mycorrhiza. Mycorrhiza increases the dry weight, growth rate and the plant salinity tolerance (Trappe, 1962). This may be because of hormone production in mycorrhiza cells and the role of mycorrhiza in host plant nourishment especially absorption of nitrogen and potassium ((Khajehzade, 1996; Amerian, 1992; Brown, 1992).

Considering Table 5, correlation coefficient among densities of Nacl with amount of sodium in aerial organs (r= 0.62*) and root sodium (r= 0.91**) was positive and significant. With the increase in Nacl density in medium, its amount in root and aerial organs increases too. By overcoming osmotic power, more water can be absorbed but the relationship between Nacl densities and stem length, dry weight, nitrogen and phosphor in aerial organs and potassium, nitrogen and phosphor in root was negatively significant. The increase in Nacl density leads to the decrease in potassium, nitrogen and phosphor absorption. The decrease in the absorption of these elements decreases the aerial organs weight. The relationship between stem length with the dry weight, potassium, nitrogen and phosphor in aerial organs and potassium, nitrogen and phosphor in root was positively significant at the level of 1%.

A positive significant relationship among potassium, nitrogen and phosphor in aerial organs and root with the plant growth shows the essential need of the plants to them for growth. If an increase in Nacl density decreases the absorption of any of these elements, it will definitely lower the performance and function of the plant. Studying the root of germinated seeds after 14 weeks showed the existence of symbiosis vesicular-

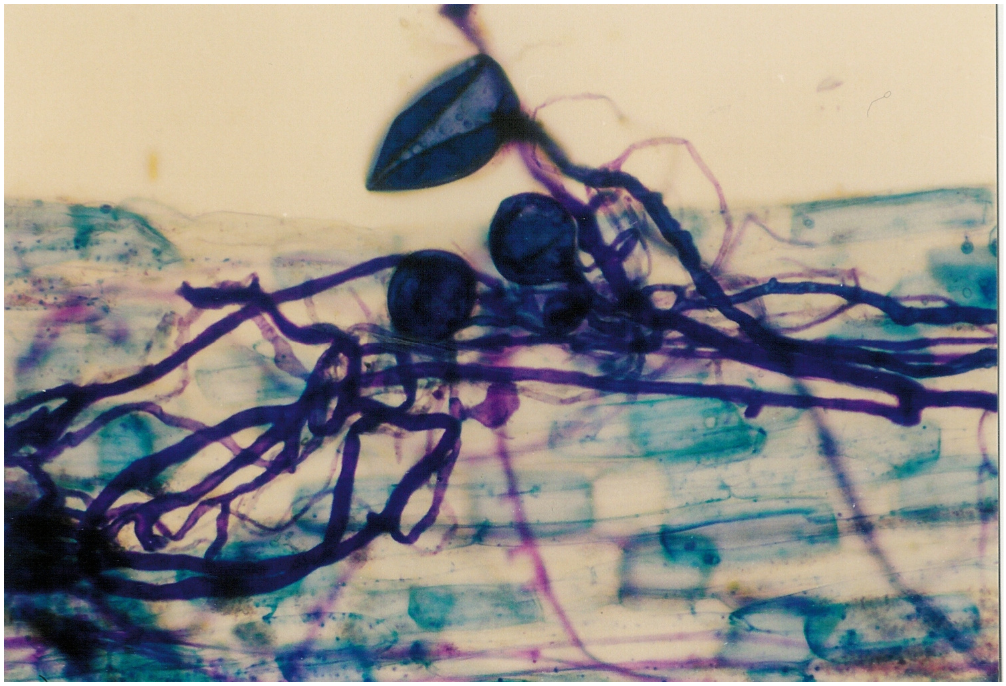

Figure 5. The root of plant infected by endomycorrhiza fungi spore is growing along with the thallus.

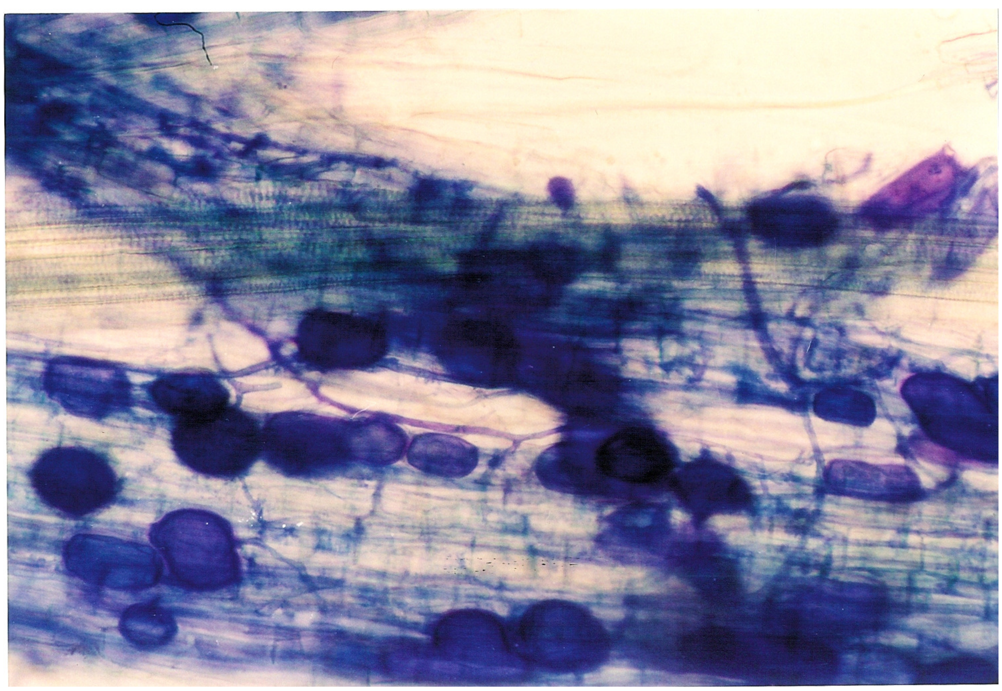

Figure 6. The root of plant infected by endomycorrhiza fungi vesicle.

arbuscular mycorrhiza (Figures 5 and 6).

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