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Evaluation Effect of Water Stress and Nitrogen Rates on Amount of Absorption Some Macro and Micro Elements in Corn Plant Mycorrhizae and Non-Mycorrhizae

[1]Omid Alizadeh and [2]Habib Allah Nadian
[1]Islamic Azad University of Firuzabad, Postal Code 74715-117, Iran
[2]Mollasane University Ahvaz, Ahvaz, Iran

Abstract: In order to determine the effect of mycorrhizae in some macro and micro elements in water stress condition and different nitrogen rate. The experiment was carried out by using a randomized complete block design in 3 replications in 2008 in research and education station of Islamic azad university of firouzabad on corn KSC 704. The results showed that mycorrhizae increased significantly the absorbtion of nitrogen, phosphorous and potassium in shoot and in root too. Treatment of irrigation levels affected in 1% probability on absorbtion of all elements of nitrogen, phosphorous, zinc copper, iron and manganese with increase of water stress intensity nitrogen, phosphorous and manganese absorption was decreased. But potassium, iron, copper, zinc absorbtion was increased in similar water stress, mycorrhizae treatment showed an increasment in relative absorbtion of nitrogen, phosphorus, potassium, copper and zinc. With increase of nitrogen in mycorrhizae and nonmycorrhizae treatments absorbtion of nitrogen, phosphorous manganes and a little potassium increased but iron decreased and it has not any certain process about other elements.

Key words: Water stress, nitrogen, corn, macro and micro elements, mycorrhizae, Iran

INTRODUCTION

Water stress is one of the main problems of agriculture in arid and semiarid areas (Amerian *et al*., 2001). Since, water plays a very important role among environmental factors (Aliasgharzad *et al*., 2006). Lack of water influences on most of plant physiological processes such as photosynthesis, photosynthetic materials transmission to seeds, cleavage and cellular development, coalescence and transmission of nutrients in plants (Davis *et al*., 2007). Now, researchers can eliminate negative impacts of drought stress on crops someway, researchers gain a great accomplishment in the field of agriculture mycorrhizae fungi are able to moderate unpleasant impacts of drought stress in plants. They do that in many ways.

First, external mycelia of these fungi spreads in soil and penetrates small soil porosity in which there is no possibility for enter of hairs to absorb water and absorb it and transfer to the host plant (Avge *et al*., 1992; Davies *et al*., 1992). Second, they influence on the hormone surfaces of plant especially. ABA and cytokinin and stomatal conductivity (Druge and Schonbeck, 1993). Third, they influence on turger pressure and increas it through decreas of the leaf osmotic potential (Davies *et al*., 1993). One of the most important reasons of micorrhizae protection in drought stress conditions from the host plant is increase of nutrients absorbtion in soil and better feeding of plant (Johnson and Hummel, 1985). One of the most important elements absorbed by micorrhizae widly and actively is phosphore. The results of some research show that the speed of phosphore flow into micorrhizae plants (Jakobsen, 1995; Bolan, 1991; Sanders and Tinker, 1973). Inadditionto phosphore, nitrogen is one of elements whose absorbtion is increased by micorrhizae plants according to the research (Hamel and Smith, 1991; Caravaca *et al*., 2005). This absorption increase can be seen in mycorrhizae plants hypha have ability to absorb the soil nitrogen and transfer it to plants roots (George *et al*., 1992; Bago *et al*., 1996). Of course, it has been that fungi hyphe prefer nitrogen absorption of amunium kind to nitrate (Marschner and Dell, 1994; Barea *et al*., 1993).

Regading two elements sulfur abd boron, study results demonstrate that micorrhizae fungi do not have roles in sulfur transfer as much as phosphore (Cooper and Tinker, 1978; Shah *et al*., 2006). Reports about boron are contradictory but it is observed in mize that fungi have positive role in boron absorption increase (Kothari *et al*., 1991). The results demonstrate about elements potassium, calcium, magnesium and sodium that in some peinds of soil and plants and mycorrhizae of special types of fungi, there is absorption increase but in others, there is not an exact reaction or plant has not shown any reaction

Corresponding Author: Omid Alizadeh, Islamic Azad University of Firuzabad, Postal Code 74715-117, Iran

(Barea, 1992; Lembert *et al*., 1979). Most of studies regarding two elements zinc and copper comparing to non-micorrhizae plants (Gildon and Tinker, 1983; Swaminathan and Verma, 1979). Most of studies demonstrate an elimination of manganese absorption in micorrhizae plants (Arines *et al*., 1989; Kucey and Janzen, 1987). Some studies show absorption increase about iron in the presence of micorrhiza (Treeby, 1992; Raju *et al*., 1990a, b).

MATERIALS AND METHODS

This experiment was carried out in agricultural research college of Islamic Azad University of Firouzabad in 2008. The experiment was carried out besed on factorial design in randomized complete block design in 3 replication. Treatments were consisted of nitrogen fertilizers in amount of 150, 300 and 450 kg nitrogen from urea supply (46% nitrogen) and mycorrhizae treatment (M) consist of M1: inoculate whit mycorrhiza M0: not inoculate whit mycorrhizae and irrigation level consisted of:

I1: Reirigation time 25% of available water was used
I2: Reirigation time 45% of available water was used
I3: Reirigation time 65% of available water was used
I4: Reirigation time 85% of available water was used

In this exprement, 72 main pot and 15 sub pot for measuring moisture was used. Plant water necessity and amount of water required to plant is determined by measuring (fc) and (pwp) and soil (pb) and then available water was determined. Available water in fc condition was theorized 100. For appointment soil moisture sampling of sub pot each 2 days and then each sample was draied 24 h in 105°C in oven. For seedling inoculation used of propagol. Thus in each pot 3 hole stave and seedling and propagol dust in hole.

After seedling emergence only 1 seedling in pot was protect. Plant samples were sent to the laboratory instantaneously. They were clean thoroughly after being washed with ordinary and distilled water in the laboratory. Then they were dried in oven for 72 h and in 70°C and grinded afterwards. To measure nitrogen, 0.3 g of the plant sample were digested using sulphuric acid, salcilic acid and distilled water and then, its amount was specified with kejeldal. For other elements, 1 g of samples put in the electrical kiln in the temperature of 550°C for 5 h to become ash and then, it was digested with chloridric acid two normal. The elements were measured as follows:

- Iron, zinc, copper and manganese with the atomic absorbtion machine (model GBC932 made in Australia)
- Potassium with the film photometer machine (fater electric, model 405-made in Iran)
- Phosphore, using the method of calorimetry with spectrophotometer machine, wavelength of 880 (nm) (ERMA PHOTIC 100-made in Japan)

The results were analysed after classification using the softwares; MINITAB and SPSS.

RESULTS AND DISCUSSION

The results demonstrated that the influence of nitrogen fertilizer, micorrhizae and irrigable areas on nitrogen absorption are significant in the level of 1% the irrigation areas impact in both micorrhizae and non-micorrhizae demonstrates a decreas in absorption of 2 elements phosphore and nitrogen. In maize as absorption stress increases. There was a difference and it was the mean average of absorption of these elements was higher in the micorrhizae and similar treatments which shows a positive impact of micorrhizae in absorbing these elements. Moreover, increasing the amount of nitrogen fertilizer, phosphor absorption increased in addition to nitrogen absorption. It was observed in both micorrhizae and non-micorrhizae plants but in micorrhizae plants, the amount of these 2 elements absorption was higher.

The reason why micorrhizae absorbs phosphore more quickly and violently is because of external mycelia scatetring of micorrhiza fungi in soil that eventfully enhances absorption level, mycelia are able to absorb phosphore from inaccessible areas of the plant roots and transfer it to the plant roots since, among all different ways of nutrients absorption, phosphore is absorbed through diffusion generally but in the presence of micorrhizae fungi, mycelia fungi are able to absorb these elements actively and consequently, phosphore absorption rath eliminates (Al-Karaki and Al-Raddad, 1997; Fomina *et al*., 2007).

Synergistic impacts between external mycelia of micorrhizae fungi and phosphate solvent bacteras which in this condition unavailable mineral phosphore transforms to available mineral phosphore transforms to available minral phosphore can increase. Usable phosphate for plant diffusion increase of H^+ or hydoxidaz by hyphae (Marschner, 1991; Bolan, 1991; Isaac, 1992).

Increase of P absorption by micorrhizae plants hyphae may be because of increase of P absorbtion in the root length unit. This increased speed of absorption is 2-3 times more than non-micorrhizae plants (Tinker *et al*., 1992). Micorrhizae fungi discharge enzymes and materials in soil cansing transformation of unavailable organic phosphore to available one (Tarafdar and Classen, 1988; Tarafdar and Marshner, 1994;

Nurlaeng *et al*., 1996) but many studies demonstrated that micorrhizae plants have higher phosphore absorption in the drought stress condition comparing to non-micorrhizae plants which has a harmony with this experiment results (Sieverding, 1983; Clark *et al*., 1999; Sieverding and Toro, 1988; Bethlenfalvay *et al*., 1987). In addition to phosphore absorption, the increase of nitrogen absorption in the micorrhizae plants has been frequently reported as well (George *et al*., 1995; Hamel and Smith, 1991).

The results of study on Cle demonstrate an increased nitrogen absorption of micorrhizae plants comparing to non-micorrhizae plants even when there is equal phosphore for them.

The results of studies on maize an in presence of micorrhizae fungi *G. intraradieces* demonstrate that more nitrogen has been absorbed by micorrhizae plants comparing to non-micorrhizae plants having access to not only non-organic resources $(NH4)_2$ So_4 but also organic resources of nitrogen. The results show that micorrhizae maize has used 17% and ordinary maize (non-micorrhizae) has used 5% of the nitrogen resources (Frey and Schuepp, 1993). Micorrhizae was sigmificant in potassium absorption in the level of 5% but the impact of irrigation areas and different amount of nitrogen was significant in the level of 1% (Table 1).

The results have also demonstrated an increased potassium absorption in both micorrhizae and non-micorrhizae plants as stress increased (Table 2). Also, increasing nitrogen, phosphor and kali absorption increased (Table 3). Other researchers report the micorrhizae impact on absorbing cations like K, Mg, Ca is contradictory so that somewhere increase of absorption, sometime decrease and sometime without impact has been reported (Azcon and Barea, 1992).

It seems the reasons of difference in results of these elements would be the type of soil (acidic or alkaline), soil Ph, the type of plant, the type of micorrhizae fungi, temperature but in maize root the impact of micorrhizae on nitrogen and phosphore absorption in the level of 1% became significant but regarding kali, it was significant in the level of 5%.

Table 1: Mean square for the effect of water stress, different nitrogen rates and mycorrhizae on rate of absorbtion, nitrogen, phosphorus, potassium, iron, copper, zinc and manganese in shoot corn KSC 704

SOV	d.f	N (%)	P (%)	K (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
REP	2	0.0076 ns	0.00006 ns	0.00740ns	4.18ns	1.542ns	9.72ns	1.3ns
Nitrogen	2	12.5800**	0.02450**	0.08450**	1504.6**	0.79ns	7.72ns	34236**
Micorrhizae	1	3.9300**	0.26760**	0.01780*	5.01ns	138.8**	5688.8**	2.0ns
irrigation	3	10.4700**	0.07680**	0.46450**	716.9**	32.48**	842.3**	453.8**
N×m	2	0.1310**	0.00160**	0.03420*	69.35**	11.347**	14.89ns	1.5ns
N×I	6	0.1260**	0.00055*	0.02090ns	40.12**	0.829ns	5.56ns	33.3**
M×I	3	0.0210*	0.00037*	0.00347ns	11.94*	1.296ns	22.26*	12**
M×N×I	6	0.0780**	0.00127**	0.00990ns	3.5ns	1.199ns	6.20ns	4.7ns
Error	46	0.0065	0.00100	0.00750	2.12	0.571	6.79	1.6

Ns, *, **Not significant, significant at the 5 and 1% levels of probability, respectively

Table 2: Mean square for the effect of water stress, different nitrogen rates and mycorrhiza on rate of absorbtion, nitrogen, phosphorus, potassium in root corn KSC 704

SOV	d.f	N (%)	P (%)	K (%)
REP	2	0.0162 ns	0.0092 ns	0.0087 ns
Nitrogen	2	11.978**	0.0487*	0.0004 ns
Micorrhizae	1	3.42**	0.159**	0.066*
irrigation	3	9.88**	0.0398*	0.2538**
N×m	2	0.0151 ns	0.0141 ns	0.0393 ns
N×I	6	0.181 ns	0.0055 ns	0.0107 ns
M×I	3	0.064*	0.016 ns	0.006 ns
M×N×I	6	0.0204 ns	0.0122 ns	0.0197 ns
Error	46	0.0123	0.0088	0.0192

Ns; *, **Not significant, significant at the 5 and 1% levels of probability, respectively

Table 3: The effect of different irrigation levels on amount of absolution, nitrogen phosphorus, potassium, iron, copper, zinc and manganes in shoot corn mycorrhizae and non mycorrhizae KSC 704

Nitrogen levels	Mycorrhizae	N (%)	P (%)	K (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
n1	-M	2.025^{f}	0.189^{d}	2.80^{b}	216.67^{a}	14.167^{c}	28.660^{b}	183.58^{c}
n2		2.85^{d}	0.238^{c}	2.87^{ab}	206.42^{c}	13.500^{d}	30.080^{b}	215.75^{b}
n3		3.55^{b}	0.267^{c}	2.84	202.92^{d}	13.160^{d}	29.417^{b}	259.33^{a}
n1	+M	2.64^{e}	0.320^{b}	2.85^{ab}	217.67^{a}	15.417^{b}	47.000^{a}	184.42^{c}
n2		3.17^{c}	0.365^{a}	2.86^{ab}	210.08^{b}	16.670^{a}	46.080^{a}	216.08^{b}
n3		4.01^{a}	0.371^{a}	2.89^{a}	199.83^{e}	17.080^{a}	48.417^{a}	259.17^{a}

Means followed by the same letter are not significantly different (Duncan 5%)

Table 4: The effect of different irrigation levels on amount of absolution, nitrogen phosphorus, potassium, iron, copper, zinc and manganes in shoot corn mycorrhizae and non mycorrhizae KSC 704

Irrigation levels	Mycorrhizae	N (%)	P (%)	K (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
I1	-M	3.488^{c}	0.300^{b}	2.74^{c}	204.00^{d}	12.00^{e}	23.11^{f}	224.22^{a}
I2		3.366^{c}	0.260^{c}	2.61^{d}	203.00^{e}	12.77^{e}	25.88^{f}	224.33^{a}
I3		2.444^{d}	0.198^{d}	2.92^{b}	211.44^{b}	14.33^{d}	32.33^{d}	217.00^{c}
I4		1.933^{f}	0.161^{e}	2.92^{b}	215.78^{b}	15.33^{c}	36.22^{d}	212.67^{e}
I1	+M	4.010^{f}	0.418^{a}	2.82^{c}	205.22^{d}	15.55^{c}	39.78^{c}	224.11^{a}
I2		3.790^{b}	0.398^{a}	2.67^{c}	203.11^{e}	15.33^{c}	42.67^{c}	222.56^{a}
I3		2.960^{d}	0.324^{b}	2.94^{b}	210.11	16.66^{b}	48.89^{b}	218.44^{b}
I4		2.320^{e}	0.272^{c}	3.04^{a}	218.22^{a}	18.00^{a}	57.33^{a}	214.44^{d}

Means followed by the same letter are not significantly different (Duncan 5%)

Also, the treatment impact of nitrogen on phosphore and nitrogen absorption become significant in the level of 1% but not about kali. The irrigantion areas were also significant on nitrogen and kali absorption in the level of 1% and on phosphore absorption in the level of 5% (Table 4).

Generally, the more stress, the less nitrogen and phosphore absorption in roots like shoot but kali absorption increases. Besides, nitrogen increase could enhance phosphore and kali absorption in plant (Table 5). Other researchers also believe that one of the impacts of nitrogen increase is the increase of cations absorption which is due to the increase of the plant metabolic activity, acceleration in most of processes and increas of the plant absorption power (Adeairan and Bonjorko, 1995; Staal *et al*., 1991).

But the impact of nitrogen treatment on absorbing micro elements like iron and manganese was significant in the level of 1% while its impact on copper and zinc was not saignificant. On the other hand, micorrhiza impact on copper and zinc was significant in the level of 1% but it was not significant on iron and manganese. The impact of irrigatition areas on these elements absorption become significant in the level of 1% (Table 1).

As stress increases in both micorrhizae and non-micorrhizae a plants; absorption of iron, copper and zinc increases but absorption of manganese dcreases (Table 3). Increasing nitorgen, absorption of manganese increases (Table 4). Many researchers declared micorrhizae increases zinc and copper absorption (Manjonath and Habte, 1988; Kucey and Janzen, 1987; Pacovsky *et al*., 1986).

In study on maize, it was observed that plant inoculation with micorrhizae could increase zinc absorption 48% comparing to treatment without micorrhizae (Kothari *et al*., 1991). Absorption increase of zinc and copper in the drought stressed plants but inoculated with micorrhizae has also been reported comparing to non-micorrhizae plants (Al-Karaki and Clark, 1998; Al-Karaki and Al-Raddad, 1997; Al-Karaki, 1998; Mohammad *et al*., 1995; Gao *et al*., 2007).

Table 5: The effect of different irrigation levels on amount of absorption, nitrogen, phosphorus, potassium in root corn KSC 704 mycorrhizae and non mycorrhizae

Irrigation levels	Mycorrhizae	N (%)	P (%)	K(%)
I1	-M	2.51	0.210^{c}	3.22^{a}
I2		2.40	0.017^{cd}	3.16^{a}
I3		1.46	0.100^{d}	3.37^{a}
I4		1.06	0.170^{cd}	3.45^{a}
I1	+M	3.07^{a}	0.320^{a}	3.30^{a}
I2		2.77^{a}	0.300^{ab}	3.30^{a}
I3		1.96	0.230^{bc}	3.43^{a}
I4		1.36	0.170^{cd}	3.51^{a}

Means followed by the same letter are not significantly different (Duncan 5%)

Moreover, many studies demonstrate the lack of iron an mangenese absorption increase in plants. On such condition, micorrhizae absorbs manganese and eliminates its toxicity in the plant.

Of course, the resutls are a little different in acidic and alkaline soil (Posta *et al*., 1994; Arines *et al*., 1989; Pacovsky, 1986; Ipsilantis and Sylvia, 2007). In this study, increase of nitrogen enhances manganese absorption but increase of manganes absorption; reduced iron absorption in the plant.

CONCLUSION

The results of this study clarifies properly that micorrhizae can increase absorption of some nutrients in plants in the drought stress conditions and moderate impacts of the stress. Most of these materails are elements having low motion power and less solubility in soil and drought stress conditions can restrict their absorption.

REFERENCES

Adeairan, J.A. and V.A. Bonjorko, 1995. Response of maize to nitrogen phosphorous and potassium fertilizer in the Savanna zones of Nigeria. Commun. Soil Sci. Plant Anal., 26: 593-606.

Al-Karaki, G.N. and A. Al-Raddad, 1997. Effects of arbuscular mycorrhizal fungi and drough stress on growth and nutrient uptake of wheat genotypes differing in drought resistance. Mycorrhiza, 7: 83-88.

Al-Karaki, G.N. and R.B. Clark, 1998. Water stress and mycorrhizal isolate effect on growth and nutrient acquisition of wheat. J. Plant Nutr., 21: 891-902.

Al-Karaki, G.N., 1998. Benefit cost and water use efficiency of arbuscular mycorrhizal durum wheat grown under water stress. Mygorrhiza, 8: 41-45.

Aliasgharzad, N., M.R. Neyshabouri and G. Salimi, 2006. Effects of arbuscular mycorrhizal fungi and *Bradyrhizobium japonicum* on drought stress of soybean. Biologia, 61: S324-S328.

Amerian, M.R., W.S. Stewart and H. Griffiths, 2001. Effect of two species of arbuscular mycorrhizal fungi on growth assimilation and leaf water relations in maize (*Zea mays*). Aspects Applied Biol., 63: 73-76.

Arines, J., A. Vilarijo and Sainz, 1989. Effect of different inocla of VAM fungi on manganese content and concentration in clover plants. New Phitol., 112: 215-219.

Avge, R.M., A.J.W. Stodola, M.S. Brown and G.J. Bethlenfalvay, 1992. Stomatal response of mycorrhizal cowpea and cowpea and soybean to short-term osomotic stress. New phytol., 120: 117-125.

Azcon, R. and J.M. Barea, 1992. Nodulation N2 Fixation (N) and N Nntrition relationships in mycorrhizal and phosphate-amended alfalfa plants. Symbiosis, 12: 33-41.

Bago, B., H. Vierheilig, Y. Piche and C. Azcon-Aguilar, 1996. Nitrate depletion and pH changes induced by the extraradical mycelium of the arbuscular mycorrhizal fungus *Glomus intraradices* grown in monoxenic culture. New Phytologist, 133: 273-280.

Barea, J.M., 1992. VAM as modifier of soil fertility. Adv. Soil Sci., 15: 1-40.

Barea, J.M., R. Azcon and C. Azcon-Aguilar, 1993. Mycorrhizal and Crops. In: Advances in Plant Pathology, Tommerup, I.C. (Ed.). Academic Press, London.

Bethlenfalvay, G.J., M.S. Brown, K.L. Mihara and A.E. Stafford, 1987. Glycine-glumus-rhyzpbium symbiosos. Plant Physiol., 85: 115-119.

Bolan, N.S., 1991. A critical review on the role of mycorrhizal fungi in the uptake of phosphorus by plants. Plant Soil, 134: 189-207.

Caravaca, F., M.M. Alguacil, G. Diaz, P. Marin and A. Roldan, 2005. Nutrient acquisition and nitrate reductase activity of mycorrhizal *Retama sphaerocarpa* L. seedlings afforested in an amended semiarid soil under two water regimes. Soil Manage., 21: 10-16.

Clark, R.B., S.K. Zeto and R.W. Zobel, 1999. Effectiveness of arbuscular mycorrhizal fungal isolato on mineral acuistion of panicum virgratum grown in acidic soil. Mycorrhizal, 9: 167-176.

Cooper, K.M. and P.B. Tinker, 1978. Translocation and transfer of nutrients in vesicular-arbuschular mycorrhizals. New Phytol., 81: 43-52.

Davies, Jr. F.T., J.R. Potter and R.G. Linderman, 1992. Mycorrhizal and repated drought exposure effect drought resistance and extra-radical hyphae development pepper plant independently of plant size and nutrient content. J. Plant Physiol., 139: 289-294.

Davies, Jr. F.T., J.R. Potter and R.G. Linderman, 1993. Drought resistance of mycorrhizal pepper plants indepent of leaf P conceration-response in gas exchange and water relations. J. Physiol. Plant, 87: 45-53.

Davis, M.R., G. Coker, R.L. Parfit, R. Simcock, P.W. Clinton, L.G. Garrett and M.S. Watt, 2007. Relationships between soil and foliar nutrients in young densely planted mini-plots of *Pinus radiata* and *Cupressus lusitanica*. Forest Ecol. Manage., 240: 122-130.

Druge, U. and F. Schonbeck, 1993. Effect of VAM infection on transpiration, photosenthesis and growth of flax.in relation to cytokinin levels. J. Plant Phisiol., 141: 40-48.

Fomina, M., J. Charnock, A.D. Bowen and G.M. Gadd, 2007. X-ray Absorption Spectroscopy (XAS) of toxic metal mineral transformations by fungi. Environ. Microbiol., 9: 308-321.

Frey, B. and H.I. Schuepp, 1993. Acquisition of nitrogen by external hyphae of arbuscular mycorrhizal fungi associated with *Zea mays*. New Phytol., 124: 221-230.

Gao, X.P., T.W. Kuyper, C.Q. Zou, F.S. Zhang and E. Hoffland, 2007. Mycorrhizal responsiveness of aerobic rice genotypes is negatively correlated with their zinc uptake when nonmycorrhizal. Plant Soil, 290: 283-291.

George, E., K. Haussler, S.K. Kothari, X.L. Li and H. Marshner, 1992. Contribution of Mycorrhizal Hypae to Nutrient and Water Uptake of Plant. In: Mycorrhizalin Ecosystems, Read, D.J., D.H. lewrs and I.J. Alexander (Eds.). CAB. International Walling Ford, England, pp: 42-47.

George, E., H. Marschner and I. Jakobsen, 1995. Role of arbuscular mycorrhizal fungi in uptake of phosphorus and nitrogen from the soil. Crit. Rev. Biotechnol., 15: 257-270.

Gildon, A. and P.B. Tinker, 1983. Interations of VAM infection and heavy metals in plants II. The effects of infection on uptake of copper. New Phitol., 95: 263-268.

Hamel, G. and D.L. Smith, 1991. Interspecific N-transfer and plant development in a mycorrhizal field-grown mixtyr. Soil Biol Biochem., 23: 661-665.

Ipsilantis, I. and D.M. Sylvia, 2007. Abundance of fungi and bacteria in a nutrient-impacted florida wetland. Applied Soil Ecol., 35: 272-280.

Isaac, S., 1992. Fungal-Plant Interactions. Chapman and Hall Publisher, London, PP: 418.

Jakobsen, I., 1995. Transport of Phosphorus and Carbon in VA Mycorrhizas. In: Mycorrhiza: Structure, Function, Molecular Biology and Biotechnology, Varam, A. and B. Hock (Eds.). 1st Edn., Springer, USA., pp: 297-324.

Johnson, C.R. and R.L. Hummel, 1985. Influence of mycorrhizae and drought stress on growth of Poncirus X Citrus seedlings. HortScience, 20: 754-755.

Kothari, S.K., H. Marschner and V. Romheld, 1991. A contribution of VA mycorrhizal hype in acquisition of phosphorus and zinc by maize. New Phytol., 117: 649-655.

Kucey, R.M.N. and H.H. Janzen, 1987. Effects of VAM and reduced nutrient availability on growth and phosphorus and micronutrient uptake of wheat and field beans under greenhouse conditions. Plant Soil, 104: 71-78.

Lembert, D.H., D.E. Baker and H. Jr. Coler, 1979. The role of mycorrhizal in the intractions of phosphorus with zinc cooper and other elements. Soil Sci. Soc. Am. J., 43: 976-980.

Manjonath, A. and M. Habte, 1988. Development of VAM iuptake of immobile nutrient in levcaena leu co cephala. Plant Soil, 106: 97-103.

Marschner, H. and B. Dell, 1994. Nutrient uptake in mycorrhizal symbiosis. Plant Soil, 159: 89-102.

Marschner, H., 1991. Mechanisms of Adaptation of Plants to Acid Soils. In: Plant-Soil Interactions at Low pH, Wright, R.J., V.C. Baligar and R.P. Moorman (Eds.). Kluwer Academic Publisher, Dordrecht, The Netherlands, pp: 683-702.

Mohammad, M.J., W.L. Pan and A.C. Kennedy, 1995. Wheat responses to VAM fungal inoculation of soils from eroded toposequence. Soil Sci. Soc. Am. J., 59: 1086-1090.

Nurlaeng, N., H. Marschner and E. George, 1996. Effects of liminig and mycorrhizal Golozination on soil phosphate deplation and phosphate uptake by maize and soybean grown in two tropical acid soil. Plant Soil, 181: 275-285.

Pacovsky, R.S., 1986. Micronutrient uptake and distribution in mycorrhizal or phosphorus-fertilized soybeans. Plant Soil, 95: 379-388.

Pacovsky, R.S., G.J. Belhlenfalvay and E.A. Paul, 1986. Comparisons between-p-fertilized and mycorrhizal plant. Crop. Sci., 26: 151-156.

Posta, K., H. Marzchner and V. Romheld, 1994. Mangunese reduction in the rhizosphere of mycorrhizal and nonmycorrhizal maize. Mycorrhizal, 5: 119-124.

Raju, P.S., R.B. Clark, J.R. Ellis and J.W. Maranville, 1990a. Mineral uptake and growth of sorghum colonized with VA mycorrhizal at varied soil phosphorus Levels. J. Plant Nutr., 13: 843-859.

Raju, P.S., R.B. Clark, J.R. Ellis and J.W. Maranville, 1990b. Effects of species of VA-Mycorrhizal fungi on growth and mineral uptake of sorghum at different temperatures. Plant Soil, 121: 165-170.

Sanders, F.E. and P.B. Tinker, 1973. Phosphorus flow into mycorrhizal roots. Pestic. Sci., 4: 385-395.

Shah, S.K., R.P. Shah, H.L. Xu and U.K. Aryal, 2006. Biofertilizers: An alternative source of nutrients for sustainable production of tree crops. J. Sustainable Agric., 29: 85-95.

Sieverding, E. and T.S. Toro, 1988. Influence of soil water regimes on VA mycorrhizal. J. Agron. Crop Sci., 161: 322-332.

Sieverding, E., 1983. Influence of soil water regimes on VA mycorrhizal II Effect of soil temperature and water regine on growth nutrient uptake and water utilization of *Eupatorium odoratum* L. Z. acker-und pflanzenbau. J. Agron. Crop Sci., 152: 56-67.

Staal, M.F., J.M. Maathvis and T.M Elzenga, 1991. Na+/K+ antiport activity an tonoplast vesicles from roots of roots of the salt tolerant plantago maritina and the salt sensitive plantago madia. Phisoil Plant, 82: 179-184.

Swaminathan, K. and B.C. Verma, 1979. Response of three crop speciese to VAM infection on zinc-deficienct indian soils. New Phytol., 82: 481-487.

Tarafdar, J.C. and H. Marshner, 1994. Effictiencey of VAM hyphae in utilization of organic phosphorus by wheat plants. Soils Sci. Plant Nutr., 40: 593-600.

Tarafdar, J.C. and N. Classen, 1988. Organic phosphorus compounds as a phosohatases produced by plant roots and micro organisms. Biol. Fert. Soils, 5: 308-312.

Tinker, P.B., M.D. Johns and D.M. Durall, 1992. A Functional Comparison of Ecto and Endomycorrhizas. CAB. International, Welling Ford, UK., pp: 303-310.

Treeby, M.T., 1992. The role of mycorrhizal fungi and non-mycorrhizal micro organisms in iron nutrition of citrus. Soil Biol. Biochem., 24: 857-864.