EFFECTS OF (VAM) VESICULAR ARBUSCULAR MYCORRHIZAE ON GROWTH PERFORMANCE OF*MENTHA LONGIFOLIA* L. AT VARIOUS LEVELS OF ROCK PHOSPHATE AMENDMENTS

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خلاصہ

راک فاسفیٹ کے مختلف سطحوں پر میتالفولیاایل. کی ترقی کی کارکردگی پر) VAM ویسیکولرار بسکلر مکرورایزی) کے اثرات کی تحقیقات کے لئے ایک کوشش کی گئی تھی. راک فاسفیٹ کے مختلف سطحوں کے ساتھ VAM کے ساتھ یا VAM کے بغیر) RP0 فاسفیٹ کے بغیر 0.05) RP1 (جی(، 0.105) RP2جی) اور RP3 0.157)جی) کے ساتھ مل کر میں استعمال کیا گیا تھا. آواویز پلانٹ سے ریزومپوفرک مٹی کی بڑی تعداد میں مختلف ویم فنگی، گلوموس فاسکلیٹم، گلیوموس ماسسی اور Acalospora ملاتے تھے. انوولوم استعمال کیا گیا تھا جس میں مٹی کی بنیاد پر انوولوم. مطالعہ نے واضح طور پر واضح اختلافات ظاہر کئے ہیں<0.05> مکرورہیز پلانٹ کی پرجاتیوں میں راک فاسفیٹ ترمیم کے مختلف سطحوں پر پلانٹ شو کی لمبائی، جڑ کی لمبائی، پتیوں کی تعداد، تازہ اور خشک وزن کے متعلق علاج اور غیر اہم فرقوں میں MRP3 .اور MRP2 میں سب سے بہترین شوٹ کی لمبائی، تازہ وزن، خشک وزن اور پتیوں کا نمبر ریکارڈ کیا گیا تھا جبکہ ایم ایم پی 1 اور MRP3 میں سب سے زیادہ جڑ کی لمبائی ریکارڈ کی گئی تھی. راک فاسفیٹ کے مختلف سطحوں پر اس کے مجموعی طور پر مکرور حزب گروپوں کو غیر مستکشر گروپوں کے مقابلے میں بہتر بنایا گیا تھا

Abstract

An effort was made to investigate the effects of VAM (Vesicular Arbuscular Mycorrhizae) on the growth performance of *Mentha longifolia* L.at various levels of rock phosphate.Various levels of rock phosphate were applied in combinations with VAM or without VAMsuchasRP_0 (Without Phosphate) RP_1 (0.05 g), RP_2 (0.105 g) and RP_3 (0.157 g).Rhizospheric soil from Agave plant with large number of spores of differentVAM fungii.e.*Glomus fasciculatum,Glomus mosseae* and *Acaulos poramellae* were applied. Inoculum was used as soil based inoculum. The study revealed significant differences<0.05>among treatments and non-significant differences among replications regarding to the plant shoot length, length of roots, numbers of leaves, fresh and dry weight at different levels of the rock phosphate amendments in mycorrhizal plant species. The best shoot length, fresh weight, dry weight and leaves number in terms of the mean were recorded in MRP3 and MRP2 while the highest root length in terms of mean was recorded in MRP1 and MRP3.At various levels of the rock phosphate the overall performance of mycorrhizal groups was better than non- mycorrhizal groups.

Introduction

Vesicular Arbuscular mycorrhizae (VAM) is a mutualistic associations that occurs among majority of the plant species and influence a large number of key processes(Wang *et al.*, 2006; Rilling, 2009).There are many kinds of mycorrhizal associations, involving different fungal and plant symbionts, but the Arbuscular Mycorrhizae is the most wide spread (Redecker, 2005) and present in the roots of more than 80% of higher plants. Transport and absorption of minerals by VAM could increase the biomass production in the soil (Liu *et al.*, 2002). Mycorrhizal plants show higher Biomass, photosynthetic rate, contents of organic matter and responsive phosphate transporter gene in general than non-mycorrhizal plants (Derek *et al*., 2005).

Among the nutrients essential for plants Phosphorus is a very important one. Plants mostly up take phosphate in the form of Orthophosphate (Vance, 2003). As a fact Phosphorus is generally not mobile in the soil, so a narrow depletion zone about a millimeters form around phosphorus absorbing roots (Hinsinger *et al.*, 2005). The very positive performance of VAM for plants is the enhanced supply of mineral nutrients, especially phosphorus, which is mostly immobile one (Strack *et al.*, 2003). The mycellium of VAM fungi have access to these immobile phosphorus sources and transferred them to the colonized plants that are not available to the roots (Smith *et al.*, 2006; Duponnois *et al*., 2005).

Now-a-days due to increase in the s rate of the phosphate containing fertilizers and with the low recovery by plants about (10-30%) from the applied characteristics, the developing countries trying to utilize the indigenous rock phosphate as a cheap alternative source. Utilization of rock phosphate is very useful for the

sustainability of the soil(Zapata and Axmann, 1995). Uses of phosphate solubilizing microrganisms such as arbuscular mycorrhizal fungal association is a very cheap and low energy cycle to enhance the agronomic effectiveness of rock phosphate by changing it into available form (Gyaneshwar *et al.,* 2002; Sabannavar and Lakshman, 2009).

In addition, Mycorrhizal association also enhances the up take of Nitrogen form NH_4-N mineral fertilizers passing it to the host plants. Extensive nitrogen uptake ability of VAM fungal associoation was demonstrated by using in-vitro model system by many workers such as (Jin *et al.,* 2005; Govindarajulu *et al.,* 2005; Howkins *et al.,* 2000).Likewise, the fungi obtain carbon from plants and transfer other mineral nutrients to the plants (Bidartondo *et al.,* 2002).Besides phosphorus, VAM fungi can also improve the uptake of several micro-nutrients like Zinc, Copper, Iron and Manganese (Marschner, 1995). The AM fungi absorb these mineral elements and store them and also prevent their concentration to reaching the toxic level (Cooper and Tinker, 1987).

Non-Nutritional Role of Vam Fungi

The major advantage of VAM symbiosis is an increased tolerance to root pathogens and to environmental stresses (Harries and Watson, 2004). VAM fungi do not directly interact with harmful pathogens but have indirect effects, which may be physiological or physical changes through certain chemicals and morphological alteration in host plants. Mycorrhizal association also increased root length density and also change root morphology preparing the plants to discover more soil volume and to absorb more water as compared to non-mycorrhizal plants during drought conditions(Calvet *et al.,* 2001).

Arbuscular mycorrhizal fungi might be used to increase salt tolerance of plants utilizing such strains we would tend to increase the success of establishing mycorrhizae in crops growing on saline soil with improved production. Many workers such as (Muok and Ishii, 2006; Cho *et al*., 2006) suggested that Arbuscular mycorrhizal fungi enhanced tolerance of different salts. Soil aggregation is very important for maintaining soil porosity, proper gases exchanges, facilitate biogeochemical cycle and water infiltration (Diaz-Zortica *et al.,* 2002). Mycorrhizal fungal association is also very essential for biological and physical properties of soil leading to growth and establishment of many crops, particularly plants of the intensive agricultural system, in which soil texture, soil structure, chemical composition and the micro-flora are mostly disturbed (Borkowska *et al.,*2008).

Materials and Methods

During the experiment clay soil and sand used were obtained from the ground of Botany Department, University of Peshawar. Soil sample was a chemical analysis of (NIFA) by different methods. The concentration of nitrogen in soil samples was determined by the Jeldhal method of Bremmer and Mulvaney (1996). ABDTPA extractable P, Cu, Fe, Zn and Mn and soil PH by Richards (1954) organic matter of the soil by Nelson & Sommer (1982). The clay soil with PH of 7.9, electric conductivity 0.676 ds/m^2, Nitrogen, 0.033% and Phosphorus 0.001 ppm. The sand having PH, 8, electric conductivity 0.325 ds/m^2, Nitrogen, 0.056% and Phosphorus 0%. After the sieving, the clay soil was finely mixed with sand in a ratio of 2:1 resulting in sandy loam textured soil. A total of 32 pots with a diameter of 89cm and the length of 48cm were filled with 7 Kg of these nutrients lacking soil.

Application of inoculums

In the experiment rhizospheric soil of *Agave* plant with high spore number of many VAM fungal species, i.e. *Glomus fasciculatum, Glomus mosseae and Acaulosporamellae.* Inoculum used was soil based and its preparation, placement and application were carried out by using the method of Brundrett *et al.,* 1996.

Evaluation:

Following growth parameters were measured.

i) Shoot length ii) Root length
ii) Fresh weight iv) Dry weight
iii) Number of leaves

Statistical Analysis

ANOVA was carried out for all dependent variable data (root length,shoot length, fresh weight, dry weight and number of leaves) to check weather the F test was significant and means were compared by the Adhoc Turkey test.

Results

1. Shoot length "height" (cm)

Results of Mean, ANOVA and LSD test of shoot length of *Mentha longifolia* L. following 7 treatments are given in table, plates and appendices 1. Analysis of variance revealed significant differences among treatments and non-significant differences among replications regarding to the plant shoot length at different levels of rock phosphate in mycorrhizal and non-mycorrhizal plants. The highest shoot length in term of mean was recorded in MRP3, and MRP2 while lowest in M+. While height of MRP1 was in between above two extreme. The overall performance of mycorrhizal plants was better than non- mycorrhizal plants.

2. Root length in (cm)

The results of the Means, ANOVA and LSD test of root length of *Mentha longifolia* L. following 7 treatments are given in table, figure and appendices 2. Analysis of variance revealed non- significant differences among replications and treatments regarding to the root length at various levels of Rock phosphate .The highest root length in term of mean was recorded in MRP1 and MRP3 and lowest in M+. The root length of MRP2 was in between above, the two extreme. At different levels of rock phosphate plants with VAM association showed better root length than non-mycorrhizal.

3. Fresh weight in "g"

The results of Means, ANOVA and LSD test of fresh weight of *Menthalongifolia* L. following 7 treatments are given table, figure and appendices 3. Analysis of variance showed significant differences among treatments and non-significant difference among replications regarding to the plant fresh weight at various levels of Rock phosphate. The highest fresh weight in term of mean was recorded in MRP3, and MRP2 and lowest in M+. While the fresh weight of MRP1 was in between above two extreme. Overall mycorrhizal plants showed better fresh weight than non-mycorrhiza.

4. Dry weight in "g"

The results of Means, ANOVA and LSD test regarding to dry weight of *Menthalongifolia* L. following 7 treatments are given in the table, figure and appendices4. Analysis of variance exhibited non-significant differences among treatments and replications regarding to the plant dry weight at various levels of Rock phosphate. The highest dry weight in term of mean was recorded in MRP3, and MRP2 and lowest in M+. While the fresh weight of MRP1 was in between above two extreme. Overall the performance of Mycorrhizal was better than non- mycorrhizal at various levels of Rock phosphate

5. Number of leaves

The results of means, ANOVA and LSD test regarding to the number of leaves of *Menthalongifolia*L.following 7 treatments are given in table, figures and appendices 5. Analysis of variance revealed significant differences among treatments and non-significant difference among replications regarding to the number of leaves at various levels of Rock phosphate. The highest number of leaves in term of mean was recorded in MRP3, and MRP2 and lowest in M+, While the number of leaves of MRP1 was in between above two extreme. Regarding to the number of leaves the performance of VAM plants was better than non-mycorrhizal one.

Table.1. Effect of VAM Fungi and Rock Phosphate on Shoot length (cm) of *Mentha longifolia* L.

	Replicates				
TREATMENTS	**R1**	**R2**	**R3**	**R4**	**MEANS± SE**
M+	34.5	27.5	19.5	42.5	**31 ± 0.3**
M-	32.5	23	26	33.5	**28.75± 0.2**
MRP1+	41	49	38	35	**40.75± 0.3**
MRP1-	36	25	39.5	37	**34.375 ± 0.2**
MRP2+	43	31.5	27.5	27	**32.25± 0.3**
MRP2-	29.5	22.5	23	24.5	**24.875± 0.2**
MRP3+	41.5	32	33.5	26	**33.25± 0.3**
MRP3-	26	28.5	15.5	19.5	**22.375 ± 0.2**

Table.2. Effects of VAM Fungi and Rock Phosphate on Root length (cm) of *Mentha longifolia* L.

	Replicates				
TREATMENTS	**R1**	**R2**	**R3**	**R4**	**MEANS± SE**
M+	6	7.5	7.15	7	**6.91± 0.3**
M-	6	5	8.5	8	**6.87± 0.2**
MRP1+	7.5	8	10.25	8	**8.43± 0.3**
MRP1-	7	6	7	6.75	**6.68± 0.2**
MRP2+	5.25	8.25	8	8.75	**7.56± 0.3**
MRP2-	7	7.5	6.5	7	**7± 0.2**
MRP3+	11.5	7.5	6.25	6.5	**7.93± 0.3**
MRP3-	6.25	8	4.55	7.25	**6.51± 0.2**

Table.3. Effect of VAM Fungi and Rock Phosphate on Fresh weight (g) of *Mentha longifolia* L.

	Replicates				
TREATMENTS	**R1**	**R2**	**R3**	**R4**	**MEANS± SE**
M+	2.55	1.9	1.15	5.05	**2.663 ± 0.3**
M-	3	1.11	1.6	3	**2.170 ± 0.2**
MRP1+	3.4	5.1	2.8	4.75	**4.012 ± 0.3**
MRP1-	3.25	1.8	4	3.95	**3.25± 0.2**
MRP2+	5.15	3.55	2.4	2.45	**3.38± 0.3**
MRP2-	2.35	1.3	2.3	1.3	**1.812 ± 0.2**
MRP3+	5.1	4.15	2.35	1.3	**3.457 ± 0.3**
MRP3-	2.15	1.25	0.95	0.65	**1.25± 0.2**

Table.4 Effect of VAM Fungi and Rock Phosphate on Dry weight (g) of *Mentha longifolia* L.

	Replicates				
TREATMENTS	**R1**	**R2**	**R3**	**R4**	**MEANS± SE**
M+	0.55	0.55	0.35	1.35	**0.7± 0.2**
M-	1.1	0.15	0.55	0.9	**0.67± 0.3**
MRP1+	0.75	1.3	0.75	1.55	**1.08± 0.2**
MRP1-	0.65	0.5	1.2	1.05	**0.85± 0.3**
MRP2+	1.4	0.9	0.65	0.55	**0.87± 0.2**
MRP2-	0.55	0.25	0.5	0.25	**0.38± 0.3**
MRP3+	2.75	2.1	0.5	0.35	**1.42± 0.3**
MRP3-	0.6	0.4	0.3	0.25	**0.38± 0.2**

Table.5. Effect of VAM Fungi and Rock Phosphate on number of leaves of *Mentha longifolia* L.

	Replicates				
TREATMENTS	**R1**	**R2**	**R3**	**R4**	**MEANS± SE**
M+	51	27	16	62	**39± 0.2**
M-	42	28	37	47	**38.5± 0.2**
MRP1+	62	87	46	57	**63± 0.3**
MRP1-	51	42	56	48	**49.25 ± 0.3**
MRP2+	67	51	52	47	**54.25± 0.2**
MRP2-	50	39	26	41	**39± 0.2**
MRP3+	61	41	58	48	**52± 0.3**
MRP3-	50	35	20	15	**30± 0.2**

SE = Standard error

Plate.1 Effect of VAM and RPO (control) on growth of *Mentha longifolia* L.

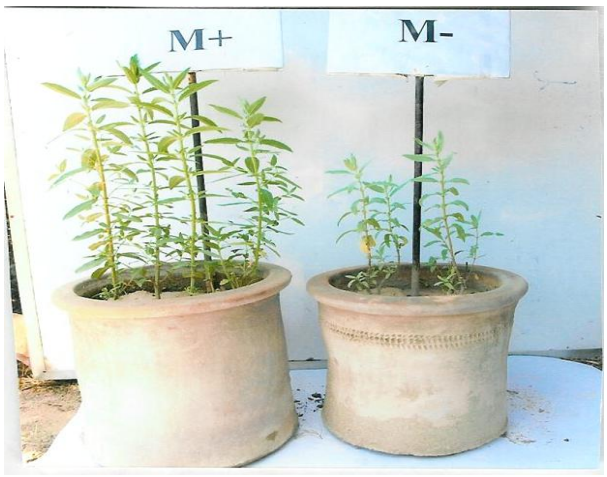

Plate.2 Effect of VAM and RP1 on growth of *Mentha longifolia* L.

Plate.3 Effect of VAM and RP2 on growth of *Mentha longifolia* L.

Plate.4 Effect of VAM and RP3 on growth of *Mentha longifolia* L.

Appendices: Analysis of variance effect of AM fungi and rock phosphate with different variables.

Variable.1Effect of AM Fungi and Rock Phosphate on shoot length of *Mentha longifolia* L.

Analysis of variance table

Source	Degree of. the freedom	Sum of the .squre	Mean-squre	F.Value	Probi
Replications	3	254.46	84.820	2.31	0.1052
Treatments	7	920.12	131.445	3.59	0.0107
Error	21	769.60	36.648		
Total	31				

Grand Mean = 30.953 Grand Sum = 950. 500 Total Count = 32
Coefficient of Variation= 19.56%

Variable. 2(c) Effect of AM Fungi and Rock Phosphate on root length of *Mentha longifolia* L

Analysis of variance table

Source	Degree of .freedom	Sum of squre	Mean squre	F.Value	Prob
Replications	3	0.49	0.162	0.07	0.9737
Treatments	7	12.63	1.804	0.81	0.5861
Error	21	46.56	2.217		
Total	31	59.67			

Grand Mean= 7. 241 Grand Sum = 231.700 Total Count = 32
Coefficient of Variation= 20.56

Variable. 3 (b). Effect of AM Fungi and Rock Phosphate on a fresh weight of *Mentha longifolia* L

Analysis of variance table

Source	Degree of. freedom	Sum of squre	Mean squre	F.Value	Prob
Replications	3	5.92	1.974	1.41	0.2683
Treatments	7	23.48	3.354	2.39	0.0576
Error	21	29.45	1.402		
Total	31	58.85			

Grand Mean= 2.714 Grand Sum = 86.840 Total Count= 32
Coefficient of Variation= 43.64

Variable. 4 (b). Effect of AM Fungi and Rock Phosphate on dry weight *Menthalongifolia*L.

Analysis of variance table

Source:	Degree of -freedom	Sum of-square	Mean –square	F.Value	Probi
Replications	3	00.81	00.269	0.95	0.4333
Treatments	7	3.39	0.484	1.72	0.1592
Error	21	5.92	0.282		
Total	31	10.12			

Grand Mean= 0.798 Grand Sum= 25.550 Total Count= 32
Coefficient of Variation= 66.51

Variable. 5 Effect of AM Fungi and Rock Phosphate on number of leaves of *Mentha longifolia* L

Analysis of variance table

Source:	Degree; of freedom	Sum -square	Mean-Square	F.Value	Probi
Replications	3	987.75	329.250	2.24	0.1136
Treatments	7	3251.00	464.429	3.16	0.0192
Error	21	3088.75	147.083		
Total	31	7327.50			

Grand Mean= 45.625 Grand Sum= 1460.000 Total Count = 32
Coefficient of Variation= 26.58%

Discussion

The results of Means, ANOVA and LSD test of *Mentha longifolia* L. showed that mycorrhizal plants shows better growth rate regarding to root length, shoot length, fresh weight, dry weight and number of leaves than non-mycorrhizal one at various levels of rock phosphate. The possible explanation may be that mycorrhizal association significantly enhanced the uptake of N and P then control one (Rehman *et al*., 2006). The fungal hyphae covered large areas of soil and uptake P which are out of nutrient depletion zone that largely build up about the root surface at lesser carbon cost leading to increased root growth in inoculated plants and also root length than control one (Azcon *et al*., 2003).Mycorrhizal inoculation increases transpiration and photosynthetic rate and chlorophyll concentration in plant than control one. It was hypothesized that AM inoculation enhance the growth and secondary metabolism. Overall VAM colonization drastically increases the biomass of the shoot and root and also increase concentration of Protein and most of the Phenol contents in the roots (Araim *et al*., 2009).

Lot of works had been done on the role of AM fungal association which enhanced tremendously the productivity, growth, nutrient uptakes and environmental stresses of plants in medicinal plants such as (Jackobsen *et al*., 2000; Duponnois *et al.*,2005; Derek *et al*., 2005; Inouce *et al*., 2001; Nowk, 2004; Techapinyawat *et al.*, 2003; Kanno *et al.*, 2006; Kerur and Lakshman, 2006; Rapparini *et al*., 2008; Aher *et al*., 2009; Cigar *et al*., 2000; Gupta *et al*., 2002; Rydlova *et al*., 2010; Ndiaye *et al*., 2009;Caravaca *et al*., 2005;Azcon *et al.*, 2003;Harrison *et al*., 2002; Paszkowski *et al*., 2007; Parras-Sariano *et al*., 2009; Jeffries *et al*., 2003; Bucher *et al*., 2009).

Mycorrhizal association can enhance in successful use of the rock phosphate by varying it into obtainable form, and uptake by the plants for enhanced growth and development (Sabannavar and Lakshman, 2009). Mycorrhizal association and plant growth is related because of high uptake of P, Zn and Mn (Cigar *et al.*, 2000). AM inoculation also enhanced plant biomass and total uptake of the P, N and many other nutrients through the activities of dehydrogenase, phosphatase and nitrogen as enzymes (Rao and Tak, 2001). VAM associations increased P and N uptake of the plants by enthralling Phosphate, Nitrate and Ammonium in the soil(Khan *et al.*, 2008).VAM fungi enhanced uptake of nutrients such as K, N, P, Ca and Mg contents and also increases the number of leaves (Satter *et al.*, 2006).As AMF association is very crucial for plant growth, productivity, secondary metabolites and nutrient uptake. So the present research work was carried out to find the outcome of VAM immunization on *Mentha longifolia* L.

Reference

Aher, R.K. (2009). Effect of AM Fungi on mycorrhizal colonization, growth and nutrition of *Arachis hypogea*.*International. J. Plant Sci.,* 4(1): 245-247.

Araim, G.,A. Saleem, J.T. Arnason and C. Charest. (2009). Root colonization by AM fungus increase growth and secondary metabolism of purple Cone flower,*Echinaceaepurpuria* (L). Moench. *J. Agri. Food Chem*., 57(6): 2255-2258.

Azcon, R., E. Ambrosano and C. Charest. (2003). Nutrient acquisition in mycorrhizal lettuce plants under different P and N concentration. *Pl. Sci.,* 165: 1137-1145.

Bidartando, M.I., D. Redecer, I. Hijri, A. Wiemken, T.D. Bruns, L. Dominguer, A. Leake and D.J. Read. (2002). Epiparasitic plants. Specialised on AM Fungi.*Nature.*4(19): 389- 392.

Borowska, B., I. Balla, E. Szucs and B. Michaczuk. (2008). Evaluation of the response of Micro-propagated Peach root stock "Cadaman" and Cv. Cresthaven to mycorrhization using chlorophyll a fluorescence method. *J. of Frt. and Orna.Pl. Res*., 16: 243-260.

Bremmer, J.M and C.S. Mulvaney. (1996). Nitrogen-total.In: A.L. page, R.H. Miller and D.R. Keeney(ed.). Methods of soil analysis part 2. 2nd ed., *Agronomy.,* 9: 595-621.

Brundrett, M., N. Beegher, B. Dell, T. Groove and N. Malajczuk. (1996). Working with mycorrhizas in Forestry and Agriculture. ACIAR. Monograph 32: 374.

Bucher, M., S. Wegmuller and D. Drissner. (2009). Chasing the structures of small molecules in AM signaling, current opinion in plant Biology 12: 500-507.

Calvet, C., J. Pinochet, A. Hernandez-Dorrego, V. Estaun and A. Camprubi. (2001). Field microplot performance of the Peach-Almond hybrid GF-677 after inoculation with AM Fungi in a replant soil infested with root-knot Nematodes. *Mycorrhiza*., 10: 295-300.

Caravaca, F., M.M. Alguaeil, P. Torres and A. Roldan. (2005). Survival of inoculation and native AM fungi spps associated with shrubs in a degraded Mediterranean ecosystem. *Soil Biol.Biochem.,* 37: 227-233.

Cho, K., H.D. Toler, J. Lee, B.H. Ownley, C. Jean, J.C. Stutz, L.J.Moore and R.M. Auge. (2006). Mycorrhizal *Symbiosis* and response of Sorghum plants to combined drought and salinity stresses. *J. of Pl. Phys*., 163: 517-518.

Cigar, S., N. Sari and I. Ortas. (2000). The effect of AM Fungi on the plant froth and nutrient uptake of Cucumber. *Truk. J. Agri. Forest*., 24(5): 571-578.

Cooper, K.M and P.B. Tinker.(1987). Translocation and transfer of nutrients in VAM Fungi. 11.Effect of environmental variable on movement of Phosphorus.*New Phyt.,* 88: 327-398.

Derek, P.W., J.D. Scholes, D.J. Read and S.A. Rolfe. (2005). European and African maize cultivars differ in their Physiological and molecular responses to mycorrhizal infection. *New Phytologist.*,167: 881-896.

Diaz-Zortica, M., E. Perfect, H.J. Grove. (2002). Disruptive methods for assessing soil structure. *Soil and Tillage Research*. 64: 3-22.

Duponnois, R., A.H. Colombet and J. Thioulouse. (2005). The mycorrhizal fungus G.intraraices and root Phosphate amended influence plant growth and microbial activity in the rhizosphere of *Acacia holosericeae*. *Soil. Biol.Biochem.*, 37: 1160-1168.

Govindarajulu, M., P.E. Pfeffer, H. Rjin, J. Abubaker, D.D. Douds, J.W. Allen, H. Buckin, P.J. Lammers and Y. Shachar-Hill. (2005). Nitrogen transfer in the AM Symbiosis. *Nature* 4(35): 819-823.

Gupta, M.L., A. Prasad, M. Ram and S. Kumal. (2002). Effect of the AM Fungus *G.fasiculatum*on the essential oil yield related characters and nutrient acquisition in the crops of different cultivars of menthol under field condition. Luknow.*Bioresourse technology* 81: 77-79.

Gyaneshwar, P., G.N. Kumar, L.J. Parech and P.S. Poole. (2002). Role of soil microorganism in improving P nutrition of plants. Plant Soil. 245: 83-93.

Harries, L.A and C.A. Watson. (2004). The potential role of AM fungi in the bioprotection of plants against soil brone pathogens in organic and or other sustainable forming systems.*Pest management Sci*., 60: 149-157.

Harrison, M.J., G.R. Dewbre and J. liu. (2002). A phosphate transporter from Medicagotrunculata involved in the acquisition of phosphate released by AM Fungi.*Plant Cell,* 14: 1-17.

Hinsinger, P., G.R. Gobran, P.J. Gregory and W.W. Wenzwl. (2005). Rhizosphere geometry and heterogeneity arising from root mediated physical and chemical prosses. *New Phyt*.,168: 293-303.

Howkins, H.J., A. Johansen E. George. (2000). Uptake and transport of organic and inorganic nitrogen by AM Fungi. *Plants and Soil*., 226: 275-285.

Inoue, S., I. Kheoruenrome, S. Anchalea and T. Supicha. (2001). Effect of AM Fungi on Phosphorus uptake and growth of Baby corn on a sand soil. KasetSart Uni. of Bangkok.

Jakobsen, I., E.J. Jones and J. Larsen. (2000). Hypal Phosphorus transport, a keystone to mycorrhizal enhancement of plant "Growth"In: Impact of Arbuscular mycorrhiza on sustainable agriculture and natural ecosystems. Switzerland.5: 133-145.

Jeffries, L.P.B., T. David, T. Roger and G.S. Andrew. (2003). Mycorhizal infection and high soil Phosphorus improve vegetative growth and the female and male function in Tomato. *New Phyt*., 154: 255-264.

Jin, H., P.E. Pfeffer, D.D. Douds, E. Piotrowski,P.J. Lammers and Y. Shachar-Hill. (2005). The uptake, metabolism, transport and transfer of N in an AM Symbiosis. *New Phyt., 168*: 687-696.

Kanno, T., M. Saito,Y. Ando, M.C.M. Maledo, T. Nakamura and C.H.B. Miranda. (2006). Importance of indigenous AMF for growth and Phosphate uptake in tropical forage grasses growing on an acid,infertile soil from the Brazilian Savannas.Tropical grasslands. 40: 94-101.

Kerur, A and S. Lakshman. (2006). Effect of phosphate fertilizer and VA Mycorrhiza on two floricultural plants. *J.Curr. Sci*., 5(1): 321-326.

Khan, L.A., N. Ayub, S.N. Mirza, S.M. Nizami and M. Azam. (2008). Synercristic effect of dual inoculation (VAM) on the growth and nutrient uptake of *Medicogo sativa. Pak. J. Bot.,* 40 (2): 939-945.

Liu, R.J., F.Y. Wang and X.X. Meng. (2002). AM Fungi on the islands of BohaiBay.*Mycosystems.*, 21:525-532.

Marschner, H. (1995). Mineral nutrition of higher plants.Academicc Press. UK. London 888.

Muok, B.O and T. Ishii. (2006). Effect of AM Fungi on tree growth and nutrient uptake of *Selerocaryabirrea* under water stress, salt stress and flooding. *J. Japanese. Soc. Hort. Sci.*, 75: 26-31.

Ndiaye, F., A. Manga, G. Diagnelaye, S.N.A. Samba and T.A. Diop. (2009). Effects of Rock Phasphate and AM Fungi on growth and nutrition of *Sesbaniasesban* and *Gliricidasepium*. *Afri.J. of Micro. Res*., 3 (5): 305-309.

Nelson, D.W and L.E. Sommers. (1982). Total carbon and organic matter. In: A. L. Page., R. H. Miller and D. R. Keeney(ed.). Methods of soil analysis part 2.2nd ed., *Agronomy*, 9: 539-577.

Nowak, J. (2004). Effects of AM Fungi and Organic fertilization on growth, flowering, nutriets uptake, photosynthesis and transpiration of Geranium (*Pelargonium hartorum).*Poland. *Symbiosis*., 37(1-3): 259-266.

Parras-Soriano, A., M.L. Soriano-Martin, A. Parras-Piedra and R. Azcon. (2009). AM Fungi increased growth, nutrient uptake and tolerance to salinity in Olive trees under nursery conditions. Ciudad Real, *Spain. J. Pl. Physi*., 166 (13): 1350-1390.

Paszkowski., S. Mazurier , P. Lemanceau, S. Siblot, G. Berta ,G. Mougel and D. Tuinen. (2007). Medicago species effect the community composition of AM Fungi associated with roots. *New Phyt*., 175: 913-921.

Rahman, M.K., S.M. Kabir, G.M. Mohsin and M. Didarul-Alam. (2006). Interaction of AM Fungus, Glomus mosseae and Phosphorus on growth and nutrient uptake of Maize plants grown under different soil conditions. *Bangladesh. J .Bot.,*35(1): 1-7.

Rao, A.V and R. Tak. (2001). Influence of mycorrhizal fungi on the growth of different tree species and their nutrient uptake in gypsum mine spoil in India. *Soil Ecol.,* 17(3):279-284.

Rapparini, F., J. Liousia and J. Penuelas. (2008). Effect of AM colonization on Terpen emission and content of *Artimisiaannua.*L. German Botanical Society and the Royal Botanical Society of Netherlands.*Plant Biology* 10: 108-122.

Redecker, D. 2005.Glomeromycota.AM Fungi and their relatives.In the tree of web projects.http. lltolweb. org/ Glomeromycota/28715.

Richard, L.A. (1954). Diagnosis and improvement of saline and alkali soil, USDA agric. Handbook. No. 60. Washington. D.C.

Rilling, M. C. (2009). Arbuscular mycorrhizae and terrestrial ecosystem processes. *Ecol. Lett.*, 7: 740-754.

Rydlova, J., D. Puschel, R. Sudova, M. Gryndler, O. Mikanova and M. Vosatka. (2010). Interaction of AM Fungi and Rhizobia and its effect on flax yield in spoil bank clay.Czech Republic.*J. of Pl. Nut.and Soil Sci*., *253*.

Sabanavar. S. J and H. C. Lakshman. (2009). Effect of Rock Phosphate solubilization using Mycorrhizal fungi and Phospho-bacteria on two high yielding varities of *Sesamumindicum*L.*World Journal of Agri. Sci*., 5(4): 470-479.

Satter, M.A., M.M. Hanafi, T.M.M. Mehmud and H. Azizah. (2006). Influence of AM Fungi and Rock Phosphote on uptake of major nutrients by *Acacia mangium. Biology and Fertility of Soils.*, 42(4): 345-349.

Smith, S.E., R.E. Holloway, Y. Zhu and F.A. Smith. (2006). AM Fungi contribute Phosphorus uptake by wheat grown in a Phosphorus fixing soil even in the absence of positive growth responses. *New Phyt*.,172:536-543.

Strake, D., T. Fester, B. Hause, W. Schleimann and M.H. Walter. (2003). VA Mycorrhiza: Biological, Chemical and molecular aspects. *J. of Che. Ecol.,* 29: 1955-1979.

Techapinyawat, S., P. Pakkong, P. Suwanarit and P. Sumthong. (2003). Effect of AM Fungi and Phosphate fertilizer on P uptake of Vetiver using nuclear technique. Dept. of Botany, faculty of Sci. Kasetsart Uni. Bangkok 10900.

Vance, C.P. (2003). Phosphorus acquisition and use: Critical adaptation by plants for securing a non-renewable resources. *New Phyt*., 157: 423-447.

Wang, S.F., X.L. He. T.S. Chen and J. Wang. (2006). Temporal and spatial distribution and colonization of AM Fungi round the rhizosphere of Raspberry.*Agri. Res.In the arid areas*. 24 (3): 214-219.

Zapata, F and H, Axmann. (1995). P isotopic techniques for evaluating the agronomic effectiveness of rock phosphate materials. *Fert. Res*., 41: 189-195.