Effects of mycorrhiza on quantitative and qualitative traits of Aloe Vera

Mojtaba Yousefi Rad*

Department of Agronomy, Faculty of Agriculture, Saveh Branch, Islamic Azad University, Saveh, Iran

Abstract

This study evaluated the effect of mycorrhizal inoculation on growth characteristics and gel quality of *Aloe Vera*. Research was conducted as a randomized complete block design with three replications. Eight treatment of experiment were plant inoculation by different strains of mycorrhiza, namely, *Glomus fassiculatum, G. interaradise, G. mosseae,* combination of two strains of *G. fasiculatum* and *G. mosseae,* combination of two strains of *G. Fasiculatum* and *G. interaradise,* combination of two strains of G. *Interaradise* and *G. mosseae*, combination of three strains of *G. fasiculatum*, *G. interaradise*, and *G. mosseae*, and control treatment (without inoculation). The research results indicated mycorrhizal inoculation decreased gel pH and leaf area index, whereas mycorrhiza fungi increased the content of vitamin C, aloin and barbaloin content, relative growth rate, and ratio of mature leaf gel to weight of mature leaf skin compared to control treatment. Results of the present research revealed highest and lowest effects on studied traits was seen in combination of three strains and control treatment, respectively.

Keywords: Aloin; Barbaloin; Leaf area; Leaf gel; Mycorrhiza strains; Relative growth rate

Yousefi Rad, M. 2016. 'Effects of mycorrhiza on quantitative and qualitative traits of Aloe Vera'. *Iranian Journal of Plant Physiology* 6 (2), 1637-1642.

Introduction

Aloe Vera is a plant of Liliaceae family, which is native of North Africa. This plant has thick gray-green leaves with serrated edges. Aloe as an ornamental and medicinal plant is grown in dry tropical and subtropical regions of world (Gupta et al.,1997).Today, the active ingredients of Aloe leaves are used to treat wounds, burns, skin sensitivity (Kolata, 1995). The plant gel increases fruits storage time and maintains their quality (Martinez et al., 2006). Production of active ingredients in medicinal plants is influenced by genotype and environmental factors (Omidbaigi, 1997).

Nutrition of plants is an important environmental factor. Mycorrhiza fungi are a type of bio-fertilizers. Mycorrhizal fungi play a very important role in plant growth. They increase crop yield especially in soils with low fertility. This increase in yield may be result of increase in absorption levels of root through penetration of fungi Hyphae in a greater volume of soil (Mandal et al., 2007). Mycorrhizal inoculation in fennel increased availability of phosphorus in soil and also improved growth and essential oil yield (Kapoor et al., 2002b). In inoculated plants, absorption of nutrients such as phosphorus and sulfur increase from the soil because of active level improvement of root system (Astaraei and

*Corresponding author
E-mail address: m.yousefirad@iau-saveh.ac.ir
Received: October, 2015
Accepted: January, 2016

Koochaki, 1990). Many studies have pointed to higher uptake of nutrients in inoculated plants with mycorrhiza than non-inoculated plants (Yassen et al., 2012; Tavsolee et al., 2011; Chu, 1999; Guissou et al., 1999; Marschner and Dell, 1994). However, few studies have been carried out to establish role of mycorrhizal fungi in enhancing content of essential oil of medicinal plants (Copetta et al., 2006; Gupta et al., 2002; Kapoor et al., 2002a, b, Kapoor et al., 2004; Morone-Fortunato and Avato, 2008). Khaosaad et al., (2006) stated mycorrhizal inoculation increased amount of shoot biomass of oregano, but this effect on essential oil yields were variable. Aeini and Yousefi Rad (2014) showed quantity and quality of aloe gel improved by bacterial inoculation.

Therefore, due to importance of plant nutrition management in order to increase production, the present research investigated effects of different strains of mycorrhiza on quality and quantity of Aole Vera gel.

Materials and Methods

This study investigated the effect of different strains of mycorrhiza fungus on yield and quality of medicinal plant of Aloe Vera. Research was conducted at the greenhouse of Islamic Azad University, Saveh branch. The results of physico-chemical analysis of soil samples are shown in Table 1.

In this study 8 inoculation treatments of Aloe Vera were used with different strains of mycorrhiza, namely, *Glomus fassiculatum* (F)*, G. interaradise* (I*)*, G. *mosseae*(M)*,* combination of two strain *G. fasiculatum* and *G. mosseae* (F+M)*,* combination of two strains *G. fasiculatum* and *G. interaradise* (F+I)*,* combination of two strains of *G. interaradise* and *G. mosseae* (I+M)*,* combination of three strains of *G. fasiculatum, G. interaradise*, and *G. mossea*e (F+I+M), and control treatment (no inoculation). For each pot 5 kg soil was provided and 100 g fungal inoculum was poured into each pot (each gram of inoculum had 100 fungi spore). Offshoots were washed with water and after weighing in each pot were planted and roots were carefully placed on fungi inoculum. Then soil was slightly poured around offshoots. Plants were harvested 6 months after implantation. The studied traits included leaf area index, relative growth of plants, gel barbaloin (GB), gel aloin (GA), vitamin C per 100 grams of drying gel (VC), gel pH, weight of mature leaves gel (DWG) (plant leaves with greater weight, length, width, and thickness than other leaves), and ratio of gel weight of mature leaf to weight of mature leaf skin (GW/WS) were. Due to the meaty leaves, leaf area index was measured by copy (Tracing) method using graph paper. Gel pH was measured with pH meter. Relative growth rate was calculated by the following formula (Sarmadnia and Koochaki, 1984):

Ln plant dry weight at second harvest - Ln plant dry weight at first harvest / distance of time between the two harvests.

Barbaloin and aloin were well separated by MEKC and as little as 5.5 pg/11 nl of the two compounds could be detected. The determination took around 14 min (Kuzuya et al., 2001). Vitamin content was measured by method suggested by Association of Official Analytical Chemists (2000):

2, 6 dichlorophenol pulverize - indophenol

The statistical analysis was conducted by SAS software (Version 9.2) and average comparing of treatments was conducted via Duncan Multiple Range Test ($P<0.05$).

Table1
The physical and chemical characteristics of soil

Texture	Sand%	Silt %	Clay %	K(available) ppm	P (available) ppm	Total N%	D.C.%	T.N.V%	PH	EC ds/m
Sandy clay loam	88	10	2	398	47	0.07	0.7	16.8	7.8	9.95

Table 2
Results of variance analysis of research factors on the studied traits

SOV	df	Mean of squares							
		LAI	R.G.R	GA	GB	VC	Gel pH	DWG	DWG / WS
Block	2	1.9904**	0.0008**	44636.4**	22484.3**	5193.6**	0.0001n.s	0.0699**	2885769.4**
Fungi	7	0.0890n.s	0.00002n.s	20291.6**	12779.2**	2614.5**	0.1148**	0.0034n.s	1033397**
Error	14	0.0899	0.00001	599.9	1645.1	106.7	0.0007	0.0101	216788.4
cv%	--	14.92	12.46	4.88	12.51	7.18	0.52	11.15	14.85

* and **: significant at 5% and 1% probability levels, respectively; ns: non-significant

Table 3
Results of mean comparison of effects of inoculation treatments on studied traits

Traits / Treatment	LAI	RGR g/g .day	GA Mic g/g wet gel	GB Mic g/g wet gel	VC (in each 100 g dry gel)	Gel pH of mature leaf	DWG g	DWG / WS
G. fasicolatum (F)	0.381c	0.02ab	444.3de	151.7cdf	132.3c	5.39b	0.327a	2.13bcd
G. interaradise (I)	0.451cb	0.018ab	467d	141.7de	108d	5.05e	0.387a	2.49ab
G. mosseae (M)	0.412 cb	0.021a	421ef	113.3e	122.7cd	5.2d	0.29a	1.97cd
F+M	0.52 ab	0.018 ab	518c	199.3cd	161.3b	5.06e	0.33a	2.33cb
I+F	0.371c	0.018 ab	573.3b	254.7ab	150.3b	5.54a	0.32a	2.22 bcd
I+M	0.451cb	0.024 a	546.3bc	221.7abc	161b	5.27c	0.3a	2.49ab
I+F+M	0.374c	0.015 b	631.7a	221.7a	193.7a	5.24cd	0.283a	2.85a
Control	0.617a	0.016 b	397.7f	119.3d	106.7d	5.55a	0.35a	1.89d

Means with the same letter are not significantly different (P ≤ 0.05).

Results

Effect of mycorrhiza inoculation on dry weight of mature leaf gel was not significant (Table 2). Table 3 shows that different strains of mycorrhiza fungi and control treatments had no significant difference in dry weight of mature leaf gel. Table 2 shows that the effect of mycorrhizal inoculation on ratio of mature leaf gel to weight of leaf skin was significant (P <0.01). Moreover, Table 3 shows combination of three strains (I + F + M) had the maximum and the control treatment showed the minimum ratio of mature leaf gel to weight of leaf skin.

Analysis of variance (Table 2) showed the effect of mycorrhiza inoculation on barbaloin and aloin was significant (P <0.01). Mycorrhiza inoculation improved gel aloin and barbaloin. Maximum barbaloin was 295.83 (Microgram in fresh gel (g)) in combination of three strains and minimum of barbaloin were 118.5 and 112 (Micro g/g) in control treatment and strain *G. mosseae* treatment, respectively. Maximum aloin was observed in combination of three strains (633.83 Microgram in fresh gel (g) and control treatment (393.83 Microgram in fresh gel (g)) had the lowest aloin (Table 3).

Results of analysis of variance (Table 2) showed that the effect of mycorrhiza inoculation on vitamin C content was significant (P<0.01). In Table 2 it is seen that combined treatment of three strains with an average 66.197 mg per 100 g dry gel had most vitamin C and control treatment with mean of 110 mg per 100 g dry gel and inoculation with strain *G. interaradise* established least amount of vitamin C.

Table of variance analysis (Table 2) shows that the effect of mycorrhizal inoculation on leaf area index (LAI) was significant ($P < 0.01$). The mean comparison results (Table 3) indicates control treatment had highest mature leaf area and mycorrhizal inoculation had negative effect on this trait.

Also, Table (2) shows the effect of mycorrhiza on relative growth rate was significant ($P < 0.05$). Table 3 shows treatment (F), (I), (M), and combined treatment of two strains (I + M) had maximum relative growth rate, and control treatments, combined treatment of three strains (I + M + F), and combined treatment of two strains (I + F) showed the lowest RGR.

Table of variance analysis (Table 2) shows the effect of inoculation by mycorrhizal fungi on gel pH of mature leaf was significant ($P < 0.01$). Table 3 shows the highest gel pH of mature leaves (5.55) in control treatment and combination of two strain (F + I) and the lowest gel pH of mature leaf (5.046) in combination of two strains (F + M) and G. (I) was obtained. Overall, except the combined treatment of two strains (I + F), inoculation of mycorrhizal had no positive effect on gel pHof the mature leaves.

Discussion

The present research showed mycorrhizal inoculation increased growth indices, qualitative traits, and gel yield. The plants under sufficient lighting and food sources had more growth compared to plants in shadow and food deficit conditions (Alagukannan et al., 2008). Studies have shown that the active ingredients of medicinal plants were influenced by genotype and environmental factors. Application of bio-fertilizer was a major environmental factor in growing success of medicinal plants (Omidbaigi, 1989). Mycorrhiza because of extensive mycelium coverage in the root zone increased the plants absorption surface and therefore caused increasing quality and quantity of plants yield (Azcon-Aguilar and Barea, 2002). Mycorrhiza can create an association relationship with the roots of Aloe and cause the transfer of nutrient from the pot soil to the plant root. Hyphae of fungi can increase the absorption of water and minerals of soil and thus increase plant yield (Mandal et al., 2007). Mycorrhizal inoculation on roots of mint doubled the essential oil in plant (Freitas et al., 2004). Mycorrhizal fungi, possibly through mechanisms such as production growth regulators, inhibition of plant pathogens, and improving plant nutrition are effective in increasing dry weight (Celebi et al., 2010). Mycorrhizal inoculation improved yield and quantity and quality of essential oil of fennel (Kapoor et al. 2004), coriander (Kapoor et al. 2002a). This study also showed mycorrhizal inoculation increased aloin, barbaloin and vitamin C of Aloe plant gel.

High LAI caused increase in the average growth rate of plants during growth season and therefore led to increased plants production (Karimi and Siddique, 1991). Khorramdel et al. (2008) showed in response to a biological fertilizer, changes in leaf area index of black cumin (*Nigellasativa* L.) were rather similar for all the treatments and treatments at the same time reached to maximum LAI. Hormonal changes in inoculated plant caused leaf morphological changes (Allen et al., 1980).

The present study indicated that strains of mycorrhiza improved relative growth rate compared to non-inoculated plants. This increase in growth may be due to improving nutrients and water absorption through penetrating of mycorrhiza hyphae in greater soil volume (Sarmadnia and Koochaki, 1984). Mycorrhiza in inoculated plants increased nutrient uptake and caused the rapid growth of corn (Wu and Xia, 2006; Chu, 1999).

Conclusion

Results of the present research reveal mycorrhizal inoculation treatments increased gel quality and growth characteristics of Aloe Vera. Also, combination of the three strains had the maximum effects on the traits under study compared to other treatments.

References

Acosta M., P. M. Lcivello, A. R. Chaves and **G. A. Martinez.** 2005. 'Effect of ethephon and 6-benzylaminopurine on chlorophyll degrading enzymes and peroxidase-linked chlorophyll

bleaching during post-harvest senescence of broccoli (*Brassica oleracea* L.) at 20 ˚C'. *Postharvest Biology and Technology* 35: 191–199.

Aeini, M. and **M. Yousefirad**, .2014. Effect of bacterial bio- fertilizers on growth traits and quantity and quality of aloe (*Aloe vera*) gel. *Research on crop*, 15(3). 697-700.

Alagukannan,G., S. Ganesh,S. and **K. Gopal** .2008. 'Characterization and Screening of Different Ecotypes of *Aloe vera* for Growth, Yield and Quality'. *International Aloe Science Council Texas*,302-624.

Allen, M.F., T.S. Moore and **M. Chrisrensen**. 1980. 'Phytohormone, changes in *Boutelou agracilis* infected by vesicular-arbuscular mycorrhiza. Cytokinin increase in the host plant'. *Canadian Journal of Botany*,58:371-374.

AOAC (Association of Official Analytical Chemists). 2000. Official method of analysis (17th ed.). Gaithersburg, MD, USA: Association of Official Analytical Chemists (no. 967.21 ascorbic acid in vitamin preparation and juice).

Astaraei, A. and **A. Koochaki**.1990.Application of biological fertilizers in sustainable agriculture, Jihad daneshgahi of mashad press, Iran, 168p.

Azcon-Aguilar, C. and **J.M. Barea.**2002. 'Appling mycorrhiza biotechnology to horticulture: significance and potentials'. *Scientia Horticulture*, 68(1-4): 1-24.

Celebi, S.Z., S. Demir, R. Celebi, E.D. Durak and **I.H. Yilmaz**. 2010.'The effect of Arbuscular mycorrhizal fungi (AMF) Applications on The silage maize (*Zea mays* L.) Yield in different irrigation regimes'. *European Journal of soil Biology*, 46(5). 302-305.

Chabot, R., H. Antoun and **M. P. Cescas**. 1996. 'Growth promotion of maize and lettuce by phosphate- solubilizing *Rhizobium leguminosarum* biovar. Phaseoli'. *Plant and Soil*. 184(2):311-321.

Chu, E.Y. 1999. 'The effect of arbuscular mycorrhizal fungi inoculation on *Euterpe oleracea* Mart. seedlings'. *Pesquisa Agropecuaria Brasileira*, 34:1019–1024.

Copetta, A., G. Lingua and **G. Berta**.2006. 'Effects of three AM fungi on growth, distribution of glandular hairs, and essential oil production of *Ocimum basilicum* L. var. Genovese'. *Mycorrhiza*, 16:485–494.

Freitas, M.S.M., M.A. Martins and **I.J.C. Vieira**. 2004. 'Yield and quality of essential oils of *Mentha arvensisin* response to inoculation with arbuscular mycorrhizal fungi'. *Pesquisa Agropecuaria Brasileira*, 9: 887-894.

Guissou, T., A.M. Ba,S. Guinko,R. Duponnois and **C. Plenchette**. 1999. 'Rock phosphate and vesicular–arbuscular mycorrhiza effects on growth and mineral nutrition of *Zizyphus mauritianalam* in an alkaline soil'. *Ann. For.Sci*, 55:925–931.

Gupta,V.V.S.R. and **G.W. Yeates**.1997.'Soil micro fauna as bio-indicators of soil health'. P 201-233. In: Pankhurst C.E., B.M. Doube (eds) Biological Indicators of Soil Health. CAB International, Walling ford. UK.

Gupta, M.L., A. Prasad, M. Ram and **S. Kumar**.2002. 'Effect of the vesicular-arbuscular mycorrhizal (VAM) fungus *Glomus fasciculatum* on the essential oil yield related characters and nutrient acquisition in the crops of different cultivars of menthol mint (*Mentha arvensis*) under field conditions. *BioresTechnol*, 81:77–79.

Morone-Fortunato,I. and **P. Avato**. 2008.'Plant development and synthesis of essential oils in micro propagated and mycorrhiza inoculated plants of *Origanum vulgare* L. ssp. hirtum (Link) Ietswaart '.*Plant Cell Tiss Organ Cult,* 93:139–149.

Kapoor, R., B. Giri and **K.G. Mukerji.** 2002a.'Mycorrhization of coriander (*Coriandrum sativum*) to enhance the concentration and quality of essential oil'. *Journal of the Science of Food and Agriculture*, 82 (4): 339- 342.

Kapoor,R., B. Giri and **K.G. Mukerji**.2002b.*'Glomus macrocarpum*: a potential bio inoculant to improve essential oil quality and concentration in Dill (*Anethum graveolens* L.) and Carum (*Trachyspermum ammi* (Linn.) Sprague'. *World Journal of Microbiology and biotechnology*, 18(5):459-463.

Kapoor, R., B. Giri and **K.G. Mukerji**. 2004. 'Improved growth and essential oil yield and quality in *Foeniculum vulgare* Mill on

mycorrhizal inoculation supplemented with P-fertilizer'. *Bioresource Technology*, 93: 307-311.

Karimi, M.M. and **K.H.M. Siddique**.1991. 'Crop growth and relative growth rates of old and modern Wheat cultivars'. *Australian. Journal of Agriculture Research*,8: 45-47.

Khaosaad, T., H. Vierheilig, M. Nell, Zitterl-Eglseer and **J. Novak**. 2006. 'Arbuscular mycorrhiza alters the concentration of essential oils in oregano (*Origanum* sp., Lamiaceae)'.*Mycorrhiza*, 16:443–446.

Khorramdel, S., A. Koocheki,M. NassiriMahallati and **R. Ghorbani**. 2008. 'Application effects of bio fertilizers on the growth indices of black cumin (*Nigella sativa* L.)'. *Journal of Iranian Field Crops Research*, 6(2): 285-294.

Kolata, E. and **K. Adamezewska- Soinska**. 1995. 'The effect of seedling raising and planting methods in early production of leeks'. *Folia Horticulturae*, 7(1): 3-13.

Kuzuya, H., L. Tamai,H. Beppu, K. Shimpo and **T. Chihara**. 2001. 'Determination of aloenin, barbaloin and isobarbalion in Aloe species by micellar electrokinetic chromatography . J. Chromatogr. B. Biomed. Sci.Appl,5; 752(1):91-7.

Mandal,A., A.K. Patra, D. Singh, A. Swarup and **R. Ebhin Masto**.2007.'Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages'. *Bioresource technology*, 98:3585-3592.

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

Matinez-Romero, D., N. Alburquerque and **J.M. Valverde**. 2006. 'Postharvest sweet cherry quality and safety maintenance by *Aloe vera* treatment: A new edible coating'. *Post-Harvest Biology and Technology*, 39: 93–100.

Omidbaigi, R. 1997.'Approaches to Production and Processing Of Medicinal Plants'. Volume II,TarahanNasherpress, Iran.424p.

Omidbaigi, R. 1989.'Production and process medicinal plants'. Volume 1, Tarahan Nasher press,Iran.350 p.

Sarmadnia, G.H. and **A. Koochaki**. 1984. 'Physiology of agronomy plants'. Jahad daneshgahi mashad press, Iran. 450 p.

Tavasolee, A., N. Aliasgharzad, G. salehijouzani, M. mardi and **A. Asgharzadeh**. 2011. 'Interactive effects of arbuscular mycorrhizal fungi and rhizobial strains on chickpea growth and nutrient content in plant'. *African journal of Biotechnology*, 10(39):7585-7591.

Wu, Q.S. and **R.X. Xia**. 2006. 'Arbuscular mycorrhizal fungi influence growth, osmotic adjustment and photosynthesis citrus under well-watered and water stress conditions'. *Journal of Plant Physiology*, 163: 417-425.

Yaseen, T., T. Burni and **F. Hussain**. 2012. 'Effect of arbuscular mycorrhizal inoculation on nutrient uptake, growth and productivity of chickpea varieties'. *International journal of agronomy and plant production*, 3(9): 334-345.