Effect of vesicular-arbuscular mycorrhizal fungus and humic acid application on the growth of *Parkinsonia aculeata* L. seedlings

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BSTRACT

The study is aimed at investigating the influence of mycorrhizal fungus and humic acid (HA) on the growth of *Parkinsonia aculeata* L. seedlings**.** The experiments were carried out during the period from July, 1st, 2017 to March, 1st 2018. The inoculation with mycorrhiza was applied to the seedlings at age of 2 months. Two types of soils were used in this study as follows: a) a mixture of sand, peat and perlite at the ratio of 1:1:1, by volume, and b) clayey soil. Humic acid (HA) was applied just after seed sowing at the rate of 1g/L (200 ml\ pots). The obtained results showed that there were significant differences between the two soil types tested. However, the seedlings grown in clayey soil displayed the highest shoot height (SH) (47.44cm), the highest shoot dry weight (SDW) (2.40g), the highest total dry weight (TDW) (3.59g) and the highest shoot/ root ratio (SRR) (2.26). The inoculation with VAM has brought about the highest SH (34.66cm), SDW (1.76g), TDW (1.76g), P% (1.81) and N% (2.73) in the leaves. However, the highest TDW was obtained in the inoculated seedlings treated with HA acid and grown on clayey soil (4.498g). The highest P% was obtained in the inoculated seedlings of *P. aculeata* grown on clayey soil and untreated with HA (3.94 P%). Therefore, it is recommended to inoculate the seedlings with VAM to achieve the highest growth and performance as an important nursery practice in afforestation and windbreaks program and in poor soils as well.

Keywords: Mycorrhiza, VAM, Humic acid, Parkinsonia.

INTRODUCTION

Palo verde (*Parkinsonia aculeata*), is spiny shrub or a small tree, which grows 2 to 8 m (6.6 to 26.2 ft) height, up to 10 m (33 ft). It has a single or multiple stems and many branches with pendulous leaves. The leaves and stems are hairless. The leaves are alternate and pinnate (15 to 20 cm long). The flattened petiole is edged by two rows of 25–30 tiny oval leaflets; the leaflets are soon deciduous in dry weather (and during the winter in some areas) leaving the green petioles and branches as a main photosynthesizer part of the tree (**Sandro, 1982).**

The branches are of double or triple sharp strong spines, 7–12 mm (0.28–0.47 in) long at the axils of the leaves. The flowers are yellow- orange and fragrant, 20 mm (0.79 in) in diameter, growing from a long cylender stalk in groups of eight to ten. They have five sepals and five petals, four of them clearer and rhomboid ovate, the fifth elongated, with a warmer yellow and purple spots at the base. The tree is flowering in midspring or autumn. The flowers are usually pollinated by the bees. The fruit is a seedpod, leathery in appearance, light brown when mature **(Greenway, 2000)**.

Parkinsonia aculeata is high tolerant to drought, simply attaining shorter stature. In moist and humus-rich environment, it becomes taller, spreading shade. This plant prefers a full sun exposure and can grow on a wide range of dry soils (sand dunes, clayey, alkaline and chalky soils,etc.), at an altitude of 0–1,500 metres (0–4,921 ft) above sea level (**Sandro, 1982)**.

Parkinsonia aculeata is used for firewood, charcoal, medicine, fodder (pods and leaves), shade, mulch and as a live fence. It is useful in soil stabilization as windbreaks **(Henderson, 2001)**.

Humic acids are the main components or fractions of HA substances (HS) and the most active components of soil and compost organic matter. HA can enhance nutrient availability and improve chemical, biological, and physical soil properties **(Nardi, *et al.*, 2002 , Selim and Mosa 2012).** There are direct and indirect beneficial effects of HA on plant growth and development, notably, on cell membranes which lead to the enhanced transport of minerals, improved protein synthesis, plant hormone-like activity, promoted photosynthesis, modified enzyme activities, solubility of micro-elements and macro-elements, reduction of active levels of toxic minerals and increased to extant beneficial microbial populations **(Hamideh, *et al.*, 2013.)**

Arbuscular mycorrhizae (AM) are characterized by the formation of unique structures, arbuscules and vesicles by fungi of the Phylum: Glomeromycota. AM fungi help plants to capture nutrients such as phosphate, sulfur, nitrogen and micronutrients from the soil **(Smith and Smith 2010a).** It is believed that the development of the arbuscular mycorrhizal symbiosis played a crucial role in the initial colonization of land by plants and in the evolution of the vascular plants **(Brundrett, 2002 , Sally *et al.,* 2011 and smith and smith 2011).**

It has been said that it is quicker to list the plants that do not form mycorrhizae than those that do. This symbiosis is a highly evolved mutualistic relationship found between fungi and plants, the most prevalent plant symbiosis known (**Simon, *et al.*, 1993)** . Moreover, AM is found in 80% of vascular plant families in existence today (**Schüßler *et al.*, 2001).**

The objectives of this study were:

1- Studying the effect of mycorrhiza inoculation and HA on growth characteristics of *Parkinsonia aculeata L.* seedlings.
2- Investigating the effect of soil types on the growth of *Parkinsonia aculeata*, to pinpoint the best recommended treatment for getting best germination level and growth performance of the plant *in situ.*

Materials and Methods

This study was conducted at the nursery of Forestry and Wood Technology Dept. of the Experimental Station of Faculty of Agriculture, University of Alexandria, Abies region, Alexandria. The study aimed at investigating the **influence of mycorrhizal fungus and HA acid on growth of *Parkinsonia aculeata L.* seedlings.** The experiments were carried out during the period from July 1st, 2017 to March, 1st 2018.

2.1. The plant material

The seeds of ***Parkinsonia aculeata L.*** were collected from 20 years old trees grown at the Experimental Station of Faculty of Agriculture, University of Alexandria, Abies region, Alexandria.

2.2. Soil

The soils used in this study were: a) A mixture of sand, peat and perlite at the ratio of 1:1:1, by volume, and b) Clayey soil.

The soils were treated with 20% formaldehyde solution and left for 10 days for aeration.

2.3. Symbiotic agents

2.3.1. Vesicular arbuscular mycorrhizal fungus (VAM)

Inocula implied clamydospores of *Glomus fasciculatum* and infected root debris with the fungus were obtained originally from the Experimental Station of Philipps University, Botany, Dept. Marburg/ Lahn, Germany.

2.4. Experimental procedure

On August, 8th2017, seeds of ***Parkinsonia aculeata L.*** were sown in plastic bags, filled with 2.0kg of 1:1:1 sand, peat and perlite (v:v:v) and ca 3.5kg of clayey soil, except for the upper 3 cm from the rim. Surface sterilized seeds (4 seeds per pot) with 10% NaHCl were sown then HA was applied using 1g/L (200 ml\ pots). After germination of seeds, the mycorrhiza inoculum was applied to the seedlings at the age of 2 months. The amount used was 3.0g/ plant, containing 50 chlamydospores of VAM.

2.5. Medium analysis

The chemical and physical properties of the medium were determined as follows:

The electrical conductivity (EC) of the saturated medium paste extract by using conductimeter GLP 31 and the pH of the medium was measured for the saturated medium-water suspension using pH-meter GLP 21. Water soluble ions were determined in the saturated medium paste extract. Calcium and magnesium were determined by versenate method, while sodium and potassium were determined by a flame photometer. Bicarbonate and carbonate were determined by titration with dilute hydrochloric acid and chloride by silver nitrate method **(Richard, 1954)** and total carbonate in the medium was measured by calcimeter method **(Page *et al*., 1982)**. The organic matter content of the medium was determined according to Wakely and Black method **(Page *et al.*, 1982)**.

Available nitrogen was determined or assayed by the extraction with 0.1 M potassium chloride and then determined by Kjeldahle method **(Page *et al*., 1982)**. Available phosphorus was extracted with sodium bicarbonate method and the concentration of phosphorus was determined colorimetrically by a spectrophotometer **(Olsen and Sommers, 1982)**. Available potassium was extracted with neutral normal ammonium acetate and the concentration of potassium was determined using a flame photometer **(Chapman and Pratt, 1961)**. Available copper (Cu), manganese (Mn), zinc (Zn), nickel (Ni), cadmium (Cd) and lead (Pb) were determined by extraction by DTPA-reagent and the concentrations of metals were measured by an atomic absorption spectrophotometer **(Page *et al*., 1982)**.The particle size distribution (sand, silt and clayey) was determined by the hydrometer method **(Black, 1965)**.

2.6. Growth parameters

Growth parameters, i.e., seedlings height (cm), dry weight of the seedling (g), shoot/ root ratio, shoot growth rate (cm/ month), and root length (cm) were determined. At the end of the experiment, seedlings were extraced carefully from the polyethylene bags, then the roots were washed gently with a tap water. Each seedling was cut into root and shoot (leaves and stem) and their fresh weights were determined then oven-dried at 70°C for 48 hours to a constant weight, to determine the dry weight of each plant part.

2.7. Determination of the VAM –infection level.

2.7.1. Ultrastructural examination of infected feeder roots with VAM

Feeder -root samples were collected, washed free from debris, cut into small pecies (3 mm length) then soaked in chain of ethanol solutions, 50, 70, 90 and 100% (absolute alkohol) then in mixture of alcohol and xylene (1:1,V:V) eventually in pure xylene solution. The specimens were soaked in each concentration for 1.0 hour, dried and fixed for scanning electron microscope (SEM) examination, according the method described by **Hayat, (1991).**

2.8. Determination of mineral concentration of the plants

Samples of the leaves, stems and roots of the seedlings were dried, ground in Wiley mill to a fine powder and stored in plastic bags for analysis.

A half gram of the oven-dried plant material powder was digested by 2.5 ml concentrated sulphuric acid (H_2SO_4) and poured in a hot plate at approximately 270°C. Few drops of 30% hydrogen peroxide were repeatedly added until a clear digest was obtained. The solution was left to cool, filtered and diluted to 50 ml with distilled water **(Cottenie, 1980)**. The digested samples were prepared for measuring total nitrogen, phosphorus and potassium.

Nitrogen was determined by Kjeldahle method and phosphorus was determined by the colorimetric method **(Olsen and Sommers, 1982)**. Potassium was determined by a flame photometer according to the method described by **Chapman and Pratt, (1961)**. The cocentaration of N, P and K in plant samples were calculated as a percentage on dry weight basis.

2.9. The experimental design

A complete randomized design (CRD) was used in this experiment. The split plot technique was used in analyzing the obtained data, where the main plot was for soil type, the sub plot for a HA acid treatment and the sub-sub plot was for the impact of the inoculation with symbiotic agent according to **Snedecor (1956)** using **SAS ver. 9.1.3 (2007)**.

Four replications were used for each treatment. The outline of source of variance is set out in Table (1).

Table1: Outline of the source of variation and its degree of freedom (d.f) of the experiment used.

source of variance	d.f
Replicates	3
A	1
Error a	3
B	1
AB	1
C	1
AC	1
BC	1
ABC	1
Experimental error	18
Total	31

Results

3.1. Mycorrhization

The scanning electron microscope examination has revealed the presence of appressorium and extrametrical hyphae as shown in (Fig.1).

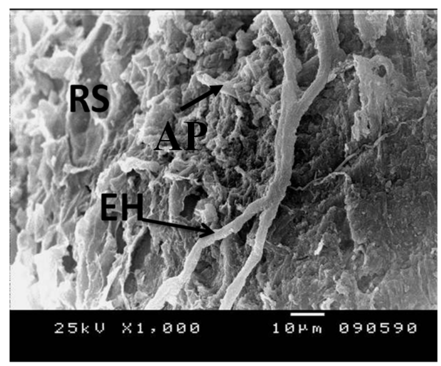

Fig. 1: Scanning electron micrograph indicates root surface (RS) penetrated by extrametrical hyphae of VAM fungus (EH) and AP is a appressorium of the fungus.

3.2. Growth parameters

3.2.1. Shoot height SH (cm)

There were significant differences between soil types, the highest SH was obtained in the seedlings grown on clayey soil (47.44cm), whilst the lowest value was found in those grown on sandy peat mixture soil (16.85cm) (Table 2).

As for the effect of inoculation with the symbiotic agents, it was found that the inoculated seedlings with VAM exhibited the highest SH (34.66cm) (Table, 2). Furthermore, the statistical analysis has also revealed significant interaction between HA application and VAM inoculation and the triple interaction among soil type, HA application and VAM inoculation.

Table2: Shoot height (cm) of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM)grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	50.38	44.25	47.32		
	H-	38.88	56.25	47.57	47.44	
C×VAM		44.63	50.25			
Clayey S:P:P	H+	13.25	15.13	14.19		
1:1:1	H-	16.00	23.00	19.50		
Sp×VAM		14.63	19.07		16.85	
H×VAM	H+	63.63	59.38			61.51
	H-	54.88	79.25			67.07
VAM		29.63	34.66			

LSD S =2.0284 LSD H =------- LSD VAM=2.0406
LSD S*H=---- LSD S*VAM=------- LSD H*VAM=1.557
LSD S*H*VAM= 3.113

3.2.2. Shoot dry weight (SDW) (g)

It was found that the seedlings grown on clayey soil displayed the highest SDW (2.40g) which averaged as much 3.5 fold as that in sand-peat mixture (0.68g). The inoculation with VAM has also brought about the highest SDW (1.76g), while uninoculated seedlings displayed the lowest value of SDW, since it was 1.33 g (Table, 3). Furthermore, the significant interaction between soil type and VAM inoculation has manifested that the seedlings grown on clayey soil and inoculated with VAM fungus displayed the highest SDW (2.82g), followed by uninoculated seedlings with VAM which grown on the same soil type (1.98g) (Table, 3).

As for the significant triple interaction of the factors studied, it was found that the seedlings inoculated with VAM which grown in calcareous soil and amended with HA acid displayed the highest SDW, since it was 3.18g, which considered as much 5 fold as that of the control (0.61g).

3.2.3. Total dry weight (TDW) (g)

Seedlings grown on clayey soil displayed the highest TDW (3.59g), while the seedlings grown on sand – peat mixture recorded 1.2 g (Table 4).

As for the effect of inoculation with symbiotic agent, there were significant differences among uninoculated seedlings (control) and inoculated ones with symbiotic agent under study. It was found that the inoculated seedlings had the highest TDW (2.602g) (Table 4).

Finally, there was a significant interaction among the three factors studied. However, the highest TDW was obtained in the inoculated seedlings which applied with HA and grown on clayey soil (4.498g), followed by VAM inoculated ones grown on sand peat mixture (0.915g) (2.18g) (Table 4).

3.2.4. Shoot/ root ratio (SRR)

As for, soil type the seedlings grown on clayey soil indicated that the highest SRR (2.26).

The significant interaction between soil type and HA application indicated that the seedlings grown on clayey soil and untrated with HA acid displayed the highest SRR (2.76), yet the seedlings grown on the same soil and treated with HA acid displayed the lowest SRR (1.85) (Table, 5).

Finally, the significant triple interaction among soil type, HA application and symbiosis type manifested that the uninoculated seedlings grown on clayey soil and untreated with HA displayed the highest SRR (3.32), whilst the lowest value (1.06) was obtained for those uninoculated ones grown on the same soil and treated with HA (Table, 5).

3.2.5. Root dry weight (RDW) (g)

There were significant effects of the soil type. However, seedlings grown on clayey soil displayed the highest RDW (1.19g) (Table, 6).

As for, the effect of inoculation mycorrhizal fungus, there were significant differences among uninoculated seedlings (control) and inoculated ones with VAM, the inoculated seedlings displayed the highest value of RDW (1.68g) (Table, 6).

3.3. Mineral concentration in the flattered mid-rib (leaves)

3.3.1. Nitrogen (N%)

Regardless HA application and symbiosis type, seedlings grown on clayey soil displayed the highest N% in their leaves (2.76%) as compared with those grown on sand-peat perlite mixture (1.50 %) (Table 7).

However, the inoculated seedlings with VAM contained the highest N% (2.73 N%) as compared with the uninoculated ones, since it was 1.53% (Table,7).

Table3: Shoot dry weight (g) of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM)grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	2.7825	2.4575	2.62		
	H-	1.1825	3.1825	2.1825		
C×VAM		1.9825	2.82		2.401	
Clayey S:P:P 1:1:1	H+	0.6125	0.715	0.66375		
	H-	0.735	0.6825	0.70875		
Sp×VAM		0.67375	0.69875		0.686	
H×VAM	H+	1.6975	1.58625			1.641875
	H-	0.95875	1.9325			1.445625
VAM		1.328125b	1.759375a			

LSD S= 0.3528 LSD H =--------- LSD VAM=01359
LSD S*H=-------- LSD S*VAM=0.1517 LSD H*VAM=0.1517
LSD S*H*VAM= 1.213

Table4: Total dry weight (g) of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM)grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	3.62	3.77	3.70		
	H-	2.505	4.498	3.50		
C×VAM		3.063	4.134		3.598	
Clayey S:P:P 1:1:1	H+	0.915	1.098	1.01		
	H-	1.105	1.035	1.07		
Sp×VAM		1.01	1.07		1.038	
H×VAM	H+	2.268	2.434			2.350
	H-	1.805	2.767			2.286
VAM		2.036	2.602			

LSD S= 0.6764 LSD H =---------- LSD VAM=0.2862
LSD S*H=0.3365 LSD S*VAM=-------- LSD H*VAM=0.1011
LSD S*H*VAM=0.2022

Table5: Shoot root ratio of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM)grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	3.32	2.0175	2.67		
	H-	1.06	2.6475	1.85		
C×VAM		2.19	2.3325		2.2612a	
Clayey S:P:P 1:1:1	H+	2.0125	1.8675	1.94		
	H-	1.985	1.9375	1.96		
Sp×VAM		1.99875	1.9025		1.9506b	
H×VAM	H+	2.66625	1.9425			2.304375
	H-	1.5225	2.2925			1.9075
VAM		2.094375	2.1175			

LSD S= 0.3364 LSD H =--------- LSD VAM=--------
LSD S*H=0.1654 LSD S*VAM=-------- LSD H*VAM=0.1188
LSD S*H*VAM=0.2377

Table6: Root dry weight (g) of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM)grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	0.838	1.313	1.076		
	H-	1.323	1.315	1.319		
C×VAM		1.080	1.314		1.197	
Clayey S:P:P 1:1:1	H+	0.303	0.383	0.343		
	H-	0.370	0.353	0.362		
Sp×VAM		0.337	0.368		0.352	
H×VAM	H+	1.141	1.696			1.419
	H-	1.693	1.668			1.680
VAM		1.417	1.682			

LSD S= 0.2357 LSD H =-------- LSD VAM=0.0301
LSD S*H=-------- LSD S*VAM=--------- LSD H*VAM= ----
LSD S*H*VAM= --------

Table7:Nitrogen (%) in the leaves of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM)grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	1.64	3.24	2.44		
	H-	2.20	3.94	3.07		
C×VAM		1.92	3.59		2.76	
Clayey S:P:P 1:1:1	H+	0.58	1.72	1.15		
	H-	1.71	1.99	1.85		
Sp×VAM		1.14	1.86		1.50	
H×VAM	H+	1.10	2.48			1.79
	H-	1.96	2.97			2.47
VAM		1.53	2.73			

LSD S= 0.2405 LSD H =-------- LSD VAM=0.5701
LSD S*H= 0.0782 LSD S*VAM=--------- LSD H*VAM=----
LSD S*H*VAM= 0.6322

Considering the significant interaction between soil type and HA application, leaves of *Parkinsonian aculeata* seedlings grown on clayey soil and untreated with HA acid displayed the highest N% (3.07%) (Table, 7).

The triple interaction among all studied factors indicated that the inoculated seedlings with VAM and untreated with HA acid, which grown on clayey soil as well as those uninoculated displayed the highest N%, since it was 3.94%. On the other hand, the uninoculated seedlings and treated with HA and grown on sand- peat- perlite displayed the lowest N% (0.58 N%) (Table 7).

3.3.2. Phosphorus (P %)

As for, soil type the seedlings grown on clayey soil displayed the highest P% (1.81%) as compared with the other soil, since it was (0.93%) (Table, 8).

Regardless mycorrhizal inoculation, there was found significant interaction between soil type and HA application. It is clear that the untreated seedlings with HA grown on clayey soil displayed the highest value of P %, since it was 2.03% (Table, 8).

Concerning the effect of inoculation with symbiotic agents, there were significant differences among uninoculated seedlings (control) and inoculated ones with VAM since the inoculated seedlings with VAM exhibited the highest P% (2.37 P%), but uninoculated ones displayed the lowest P% value (0.37 P% (Table, 8).

The significant triple interaction among all studied factors showed that the highest P% was obtained in the inoculated seedlings of *P. aculeata* grown on clayey soil and untreated with HA acid (3.94 P%), followed by inoculated ones grown on the same soil and treated with HA (2.40 P%). (Table,8).

Table8: Phosphorus (%) in the leaves of uninoculated (C) and inoculated seedlings of *Parkinsonia aculeata* with vesicular-arbuscular mycorrhizal fungi (VAM) grown on two types of soil

Soil type (S)	HA (H)	Inoculation with VAM C	VAM	S×H	S	H
Clayey	H+	0.786	2.40	1.59		
	H-	0.117	3.94	2.03		
C×VAM		0.45	3.17		1.81	
Clayey S:P:P 1:1:1	H+	0.118	1.54	0.83		
	H-	0.453	1.61	1.03		
Sp×VAM		0.29	1.58		0.93	
H×VAM	H+	0.452	1.97			1.211
	H-	0.285	2.775			1.53
VAM		0.37	2.37			

LSD S= 0.2405 LSD H =-------- LSD VAM=1.5703
LSD S*H= 0.0082 LSD S*VAM=--------- LSD H*VAM=-----
LSD S*H*VAM= 1.4368

Discussion

The obtained results showed that the inoculation with VAM led to enhance the growth significantly, in terms of SH, SRR, RDW, SDW and minerals of the leaves of *P. aculeata* (N% and P%) compared with the uninoculated ones, owing to the ability of mycorrhiza to increase root surface area to uptake mineral contents and make phosphorus more available to be absorbed by plant roots. Growth would be enhanced both by increasing the pH and by inoculating with the VAM fungi, with plant responses greater with inoculation (**Smith *et al.,* 2004).**

The high degree of mycorrhizal colonization in the roots of soil pH ranging from 5.5 to 7.5 **(Soti *et al.* 2014).** Also, differs between inter the genera of mycorrhiza. Furthermore, mycorrhizal fungi can modify the soil pH in the rhizosphere **(Jones *et al.* 2004),** and in most cases, it induced the decrease in soil pH **(McNear 2013),** which bring about the solubility of minerals of the soil, notably phosphorus and some heavy metals**.**

In this study, there was an evidence for the negative effect of HA on the mycorrhization and seedlings biomass. **Francois (1993)** manifested that respiration of the two fungi (*Cenococcum gratiforme and Laccaria laccata*) was inhibited by the four phenolic acids from HA solutions which have biological activity at extremely low concentrations. The understanding of the ecological control by dissolved HA substances is still fragmentary and needs to be studied in more details (**Christian, *et al.,* 2008).**

Dry weight yields and mineral concentration of plants inoculated with *Glomus fascieculatum,* which grown on clayey soil was significantly higher than those of Mycorrhhizal ones grown on the sand-peat mixure, that may be ascribed to the increasing EC in the clayey soil (2.81dS $m^{-1)}$ which accounted for 2 fold of that in the soil mixture (1.36 dS m^{-1}) .

However, few studies have demonstrated that the ability of different species of mycorrhizal fungi to increase plant growth also differs with soil pH. The effects of soil pH on the growth of uninoculated and inoculated *Eucalyptus globulus* highlights the importance of determining the mycorrhizal status of plants when examining the effects of soil factors such as pH on plant growth (**Thomson *et al.*, 1996)**.

Until recently the functioning of AM at low pH was generally studied by growing plants with and without inoculation in acid soils differing naturally in pH **(Clark and Zeto, 1996)** or acid soils limed to achieve different pH **(Raju *et al.,* 1988 and Nurlaeny *et al.*, 1996).** Using these methods, some interesting data on the effects of low pH on the functions of AM symbiosis have been obtained, but it is hardly ever possible to identify factors responsible for measured outcomes, due to the variability of soil components used in these studies **(Sunita, *et al.,* 2011).**

Inoculation of *Eucalyptus globulus* with the ectomycorrhizal isolates tested increased the uptake of P and growth of plants under different levels of soil pH (**Thomson *et al.,* 1996)**.

The ability of VAM fungi to colonize plant roots differed and was affected differently by pH. Percentages of root length colonized by *Glomus etunicatum* were significantly lower than those colonised by *Gigaspora margarita*. Decreasing the initial pH from 5.2 to 4.7 significantly depressed the ability of *G. etunicatum* to colonize plant roots, but did not affect *Gi. margarita*. No AM colonization was observed in roots of non mycorrhizal plant and as it expected, there was no nodulation on roots of any plants **(Smith *et al.,* 2004).**

Conclusion and Recommendations

The inoculation with VAM significantly enhanced the growth (in terms of shoot height, shoot root ratio, shoot dry weight and total dry weight) of *Parkinsonia aculeata* seedlings. The mycorrhization and growth of seedlings on clayey soil was rather better or distinct as compared to that in the mixture of sand: peat: perlite. The negative impacts of the *Parkinsonia aculeata* to application with HA, were noticed in terms of all growth parameters, P and K (%).

It is recommended; however, to inoculate the seedlings with VAM to enhance its growth and performance as an important nursery practice in windbreaks programs, even though in poor soils.

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الملخص العربي

تأثير فطر الميكوريزا الحويصلية الشجرية وإضافة حمض الهيوميك علي نمو شتلات الباركينسونيا أكيولاتا

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تهدف هذه الدراسة إلى بحث تأثير فطر الميكوريزا وإضافه حمض الهيوميك على نمو شتلات الباركنسونيا وقد أجريت التجارب فى الفترة من ١ يوليو ٢٠١٧ حتي ١ مارس ٢٠١٨. أضيفت الميكوريزا للبادرات عند عمر شهرين واستخدم نوعان من الأراضى فى هذه الدراسة هما: أ– خليط من الرمل والبيتموس والبيرليت بنسبة ١:١:١ تبعا للحجم ، ب– التربة الطينية . أضيف حمض الهيوميك بعد بذر البذور بمعدل ١جم/لتر (٢٠٠مل / أصيص). أظهرت النتائج أن هناك فروقاً معنوية بين نوعى التربة المختبرتين حيث كان أعلى طول للمجموع الخضرى SH فى التربة الطينية ٤٧,٤٤سم وأعلى وزن جاف للمجموع الخضرى SDW ٢,٢٤جم وأعلى وزن كلي جاف TD (٣,٥٩جم) وأعلى نسبة بين المجموع الخضرى والمجموع الجذرى SRR (٢,٢٦) وذلك فى حالة النباتات النامية فى التربة الطينية، كما أدى تلقيح التربة حول منطقة جذور النباتات بالـ VAM إلى الحصول على أعلى SH (34.66cm) وTDW (1.76g) وأعلى نسبة فوسفور (1.81%) ونسبة نيتروجين فى الأوراق (2.73%)، إلا أنه ظهر تأثير الهيوميك على الوزن الكلي الجاف وكان أعلى ما يمكن فى حالة البادرات النامية فى التربة الطينية 4.49 جم وأعلى نسبة مئوية للفوسفور كانت فى البادرات الملقحة بالميكوريزا النامية فى التربة الطينية وغير المعاملة بحامض الهيوميك (3.94%). ولذا ننصح بتلقيح البادرات بالـ VAM للحصول على أعلى نمو كإجراء هام يتم فى العمل بالمشاتل وفى عمليات التشجير وبرامج مصدات الرياح وكذلك فى الأراضى الفقيرة.