EFFECT OF MYCORRHIZA AND *RHYZOBIUM* ON MICRONUTRIENT UPTAKE BY SOYBEAN AT DIFFERENT PHOSPHORUS LEVELS IN LIMED SOIL

OMAR ALI FATTAH* AND ADEL KAMAL KHDHER**
* Dept. Soil and Water Science, Faculty of Agricultural Science, University of Sulaimani, Kurdistan Region-Iraq.
** Dept. of Biology, College of Education Science, University of Salahaddin, Kurdistan Region- Iraq.
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ABSTRACT

A greenhouse pot experiment was conducted to study the effect of inoculation with arbuscular mycorrhiza fungi (AMF) and *Bradyrhizobium japonicum* at different P levels on mycorrhiza effectiveness Zn, Mn, Cu and Fe contents in soybean plants in limed soil. When the acidic soil was limed, the best phosphorus level for mycorrhizal effectiveness was a medium level 0.02 mg p L^{-1}. The AMF inoculation significantly increased the effectiveness of mycorrhiza as a function of time between 21 to 45 days after planting .The maximum P value found in plants was 5.55 µg p leaf $disk^{-1}$ at 33 days after planting, while the lowest value (2.94 µg p $leafdisk^{-1}$ was recorded at 15 days after planting.

Co-inoculation soils with AMF and *R. japonicum* significantly affected the shoot Zn, Mn, Cu and Fe contents with increasing applied phosphorus. The maximum values recorded for shoot Zn, Mn, Cu and Fe was 38.33, 56.0, 9.33 and 175.0 µg g^{-1} respectively and for AMF inoculation was 77.50 , 46.00 , 12.17 and 151.00 µg g^{-1} while for *Rhizobium* inoculation was 46.33, 59.83, 8.67 and 183.83 µg g^{-1} and for non inoculated 73.83, 42.67, 10.83 and 81.50 µg g^{-1}.

INTRODUCTION

The symbiotic association between certain plants and micro-organisms plays an important role in soil fertilization, and improves their growth and mineral nutrition. Microorganisms implicated in this symbiotic interaction are bacteria and fungi. The bacterial group is implicated on nitrogen fixation, while the fungi group is involved in the uptake of low mobility micronutrients such as Zn, Cu, Mn, Cu and B (Gianinazzi-Pearson, 1996). Among the bacteria which can establish symbioses association with dicotyledonous plants are *rhizobium*. Nitrogen fixation is exclusively carryout by *rhizobia*; the root nodule which fixed atmospheric nitrogen is reduced to ammonium.

The two symbiotic associations between the root of the legume crop and soil microorganism play an extremely important role in soil fertilization and improve their growth, yield, mineral nutrition and reducing ecological pollution. Soybean *(Glycine max* L.*)* is an important crop either for oil and protein, or yield for human and animal consumption of the world, it is a good source of unsaturated fatty acid, minerals like calcium and phosphorus and vitamins (Rahman, 1982).

Soybean is a plant which can form a tripartite symbiosis with two distinct groups of mutualistic microorganisms *Bradyrhizobium japonicum* which forms nodules and fixes atmospheric-N_2 (Poeples and Craswell, 1992). Arbuscular mycorrhizal fungi can enhance nutrient uptake, crop productivity and disease tolerance (Smith and Read, 2008). The objectives of study is to determine the effects of arbuscular mycorrhiza fungi inoculation and N_2-fixing bacteria at different levels of phosphorus concentration on mycorrhiza activity and some micronutrient uptake by soybean plants

MATERIALS AND METHODS

This research has taken place in the department of Tropical Plant and Soil Science (TPSS), College of Tropical Agriculture and Human Resources (CTAHR), University of Hawaii at Monoa, USA during 2007 to 2008.

The soil used in this study belongs to the Wahiawa series and are classified in the Tropical, Clayey, Kaolinitic, Isothermice family, Tropetic Euteustox (USDA 1992). The soil was collected from Pomoha Farm Research Station, University of Hawaii at the depth of 40-60 cm simply because the soils are low in phosphorus content. The soil samples were sieved to pass through a 4mm a aperture size and stored in the trashcan.

The moisture content and the initial pH were determined in soil-water (1:2). 2.25 kg of soil was transferred into desterilized plastic pots 16 cm diameter by 17 cm deep, and the soil of each pots was mixed with 7.2 g liming material dolomite CaMg $(CO_3)_2$, inorder to increase the pH from 5.7 to 7.0.Water was added for all pots up to field capacity. The pots were covered and equilibrate with lime for 15 days. The chemical properties was determined on air-dried limed soil samples in the Lab of Agriculture and Diagnostic Service Center, College of Tropical Agriculture Human Recourses (CTAHR), University of Hawaii and the results were shown in Table (1).

Table (1): Some chemical properties of Wahiawa soil

Sample	pH	P	Fe	Mn	Cu	Zn
		$\mu g\ g^{-1}$				
Limed soil	7.03	9.36	30.60	3.10	6.46	2.10

The concentration of adsorptive p in soil solution at an equilibrium depending of phosphours sorption isotherm (Fox and Kamprath, 1970) was used to establish three target levels of P added KH_2PO_4 g pot^{-1} Seeds of soybean Kahla nematode resistance were obtained from UH seed Lab College of Tropical Agriculture and Human Resources (CTAHR), University of Hawaii., The Arabuscular Mycorrhiza Fungi inoculum *(Glomus aggregatum)* and bacteria *Bradyrhizobium japonicum* strain W006SR were obtained from the Department of Tropical Plant and Soil Science (TPSS),

The Availability of Fe, Mn, Cu, Zn and B were determined in DTPA extractable as described by Lindsay and Norvell, (1978) using ICP (Inductively Coupled Plasma).

Interaction effect of arbuscular mycorrhiza fungi *(Glomus aggregatam), Bradyrhizobium japonicum* and phosphorus concentration (0. 0.02 and 0.2) mg L^{-1} on some micronutrient uptake in soybean plant. Greenhouse pot experiment was conducted to determind the effect of AMF G aggregatum and three levels of P (0 ,0.02and 0.2 mg L^{-1}) in mycorrhiza activity and micronutrient uptake.

The inoculated pots with arbuscular mycorrhiza fungi*(G. aggregatmu)* were achieved by mixing througly a 50 g inoculum *G. aggregatam* (consisting of sand, spores, hyphal, fragments and pieces of *mycorrhiza* roots), with the soil of each pots. Non-inoculated soil pots were only mixed with same quantity of sterilized (mansand + tarface). The three target levels of phosphorus (0, 0.02 and 0.2) mg L^{-1} in the form of KH_2PO_4 were added. Soil pots were either inoculated or non-inoculated with 10 ml of a suspension of bacteria *Bradyrhizobium japonicun* strains W006 SR contain 10^8cells ml^{-1} which added directly in to the planting holes in each pot (2cm diameter-2cm depth). Three seeds of soybean were planted in each pot and the pots were arranged in greenhouse benches in a completed randomized design (C.R.B.D.) in six replicates per treatment. After germination, the seedlings were thinned to two per pot. The plants were grown under natural light in the greenhouse (21N° and 157°W). The pots were watered to maintain at field capacity. After 10 days of germination, 100 ml of five strength Hogland nutrients solution and 20 kg N ha^{-1} as a starter were added for each pot in the form of KNO_3. During the experiment the (AMF) effectiveness was determined as described by (Habte and Osario, 2001).

Plant leaf disk samples were taken from youngest fully opened soybean leaves using a crok borer of 0.8 cm diameter the samples were taken every 6 days starting from 15 days after planting, until harvesting. Plant leaves disks were dried at 70 °C for 2 hours and transferred to 18×150 mm Pyrex test tube and ashed in a muffle furnace at 500 °C for 3 hours (Habte and Osario, 2001). The ash will be dissolved and the P concentration was determined by the molybdate – blue method (Murphy and Riley, 1962).

After 8 weeks of growth, the plants were harvested, and the shoots were removed from the roots and dried at 70 °C for 72 hours until constant weight and ground. The micronutrients contentes were determined using ICP. (Inductively Coupled Plasma).

The data were statistically analyzed according to CRD using the SAS software (SAS, 1991). Analysis of variance was performed as a general test, while Duncan multiple range test were used for the mean comparisons, under 5% level of significant

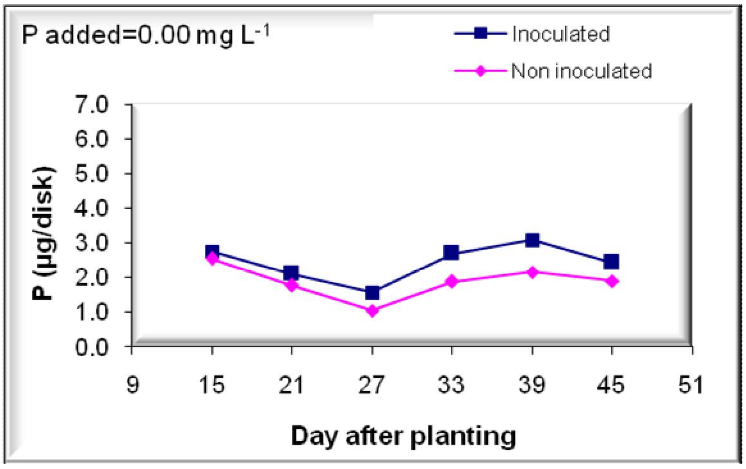
Results and Discussion

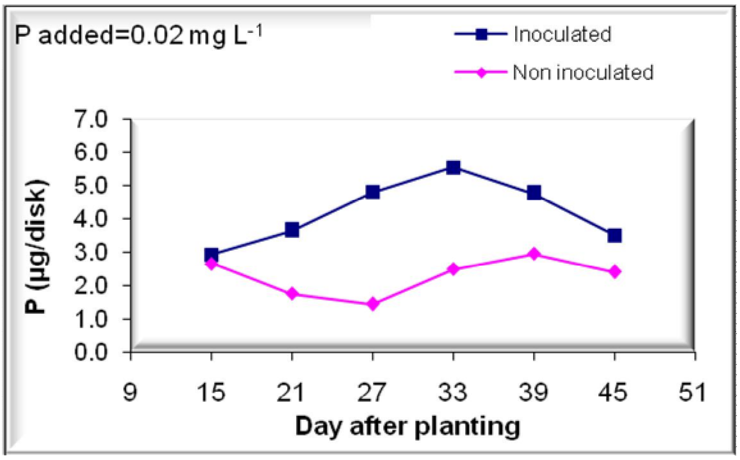
Mycorrhiza effectiveness

The effect of AMF inoculation and non-inoculation on the development of mycorrhizal effectiveness in soybean plants grown at different P levels were shown in Fig (1)

The effectiveness of AMF indicated by soybean leaf disk P content as a function of time up to 42 days of planting at three levels 0, 0.02 and 0.2 mg L^{-1} of phosphorus in the soil. When no P added to the soil; the plant leaf disk P content decreased during the initial establishment phase of AMF 15 to 27 days after planting then rapidly significantly increased up to 39 day from planting, then gradually decreased. The maximum peak value recorded of leaf disk P content 3.09 and 2.55 µg p disk^{-1} for inoculated and non-inoculated treatments respectively. The results show that there are not significantly differences between inoculated and non-inoculated plants at lowest P level Zero mg p L^{-1}.

The increasing of applied soil P to 0.02 mg p L^{-1} mycorrhizal activity was affected in inoculated treatments, and the amount of P content increased gradually as a function of time. The highest peak P value was5.55 µg p disk^{-1} found after 33 day after planting. Then the amount of P content in the plants decreased up to the end of the experiment 45 day after planting. While for non-inoculated treatments behave as zero P applied to the soil and the amount of P content decreased at 27 day from planting then increased to 39 days then decreased up to the end of the experiment fig (1)in spite of P add 0.02 mg p L^{-1}





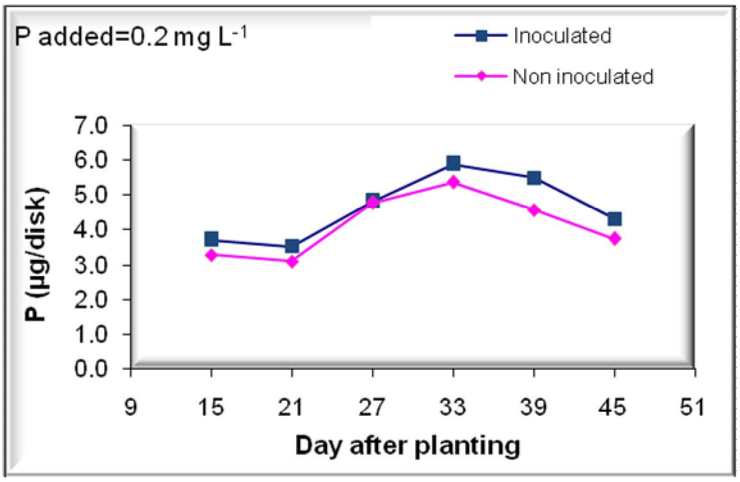


Fig (1): The effect of AMF inoculation and non-inoculation on the development of mycorrhizal effectiveness in soybean grown at different phosphorus levels.

On the other hand, increasing of applied P to the highest level 0.2 mg p L^{-1}, the P content in the leaf disk approximately was the same during the experiment for the both inoculated and non-inoculated. The maximum peak value 3.36 µg p $disk^{-1}$ was recorded at 33 days from planting, then decreased gradually without significant differences between inoculated and non-inoculated treatments.

The AMF effectiveness as indicated by leaf disk P content at different periods of time, was more effective when medium P applied to the soil 0.02 mg p L^{-1} with non- inoculated ,This may be due to high root colonization of medium soil P content, and decreasing effectiveness at high P soil content may be due to depression of AMF colonization by high P concentration (Powell *et al*., 2007).

Declining the P leaves content with time for plants and sufficient P available after 33 or 39 day after planting, may indicate the high tolerance limit of fungus to elevated P levels or low colonization rate of inoculated plants from the beginning of the experiments at high soil P content results lower dependency of the plant on AMF, and root capable to take up P from the soil to satisfy a portion of the plant P demand. Habte and Byappanhall, (1994) found a positive correlation between root colonization and AMF effectiveness in *leucaena* plant during the first 35 days after planting of 0.02 mg P L^{-1}, and they found that the optimum P levels was 0.02 mg p L^{-1}. This result is in agreement with (Aziz and Habte, 1987) than plant exhibiting response with AMF and plants more exhibited AMF dependency patterns because the medium level of P 0.02 mg p L^{-1} is available tool for predicting the response of host plants to AMF inoculation (Aziz and Hate, 1987).

However the positive effect of liming soil for AMF effectiveness may be related to the favorable effect of high Ca^{+2} and Mg^{+2} ions on AMF effectiveness (Soedarjo and Habte, 1993).

Shoot zinc content

The effect of inoculation with AMF,*Bradyrhizobium japonicum* and AMF with *Bradyrhizobium japonicum* on soybean shoot Zn content under different applied P were shown in Fig (2). The result indicated that when the soil inoculated with AMF and *R. Japonicum* the concentration of Zn in soybean shoots content was and the value often lower than in AMF, Rhizobium and non-inoculated plants at different P levels. The maximum value for Zn soybean shoot content 46.54 µg g^{-1} was recorded at highest P level 0.2 mg p L^{-1}, while the lowest value 30.82 µg g^{-1} was recorded at medium P level 0.02 mg p L^{-1},

The decrease of Zn in soybean shoot content may be due to the increasing plant production through application P and N by co-inoculation with AMF and Rhizobium bacteria which can dilute Zn concentration in plants. There is the well-known dilution effect, increased macronutrients availability (N and P) improve plant growth and there by spreads other available nutrients throughout much issue more specific interaction between the macronutrients N, P and the micronutrients Zn bioavailability (Cardose and Kuyper, 2006) or may be due to the formation and precipitation Zn3 (PO4)2 on the root surface So when the soil inoculated with AMF the concentration of zinc in soybean shoots of mycorihzal plant is higher than all treatments in non-mycorrhizal plants this result agrees with Lambert et al., (1979), and decreased at 0.2 mg p L-1.comparrd with non inoculated. The result showed increasing shoot Zn content soybean plants by mycorrhiza This result is in line with the result found by Manjunath and Habte, (1988) and there were no significant differences recorded between shoot Zn concentration and different P levels. The maximum value 77.41 µg g-1 was recorded at 0.02 mg pL-1, while the lowest 70.37 µg g-1 was recorded at highest P level (0.2 mg L-1). Increasing the concentration of Zn by mycorrhizal plants may be due to increasing the uptake of immobile nutrients such Zn by AMF (AL-Karaki, 2000). The important ability and enhancement of root surface area by hyphal growth lead to increase Zn uptake and translocation to plants (Gao et al., 2007).

The AMF pathway was independent on the P nutrition, but depends on the distribution and length density of hyphae in the soil (Liu, et al 2000). On the other hand, it may be due to the mycorrhiza take up Zn from the soil more efficiently than non colonized root systems due to the extra radical hyphae play an essential part in effectively increasing the volume of the soil available for acquition of Zn. This by the symbiosis on many aspect of the physiology of the plant (Koide, 1991) or may be due to the important of AMF for health or root activity which influence nutrient uptake (Simth and Read, 2008).

Fig (3) shows The relation between P levels and shoot Zn content with the linear correlation (R^2=0.92) for inoculated with AMF.

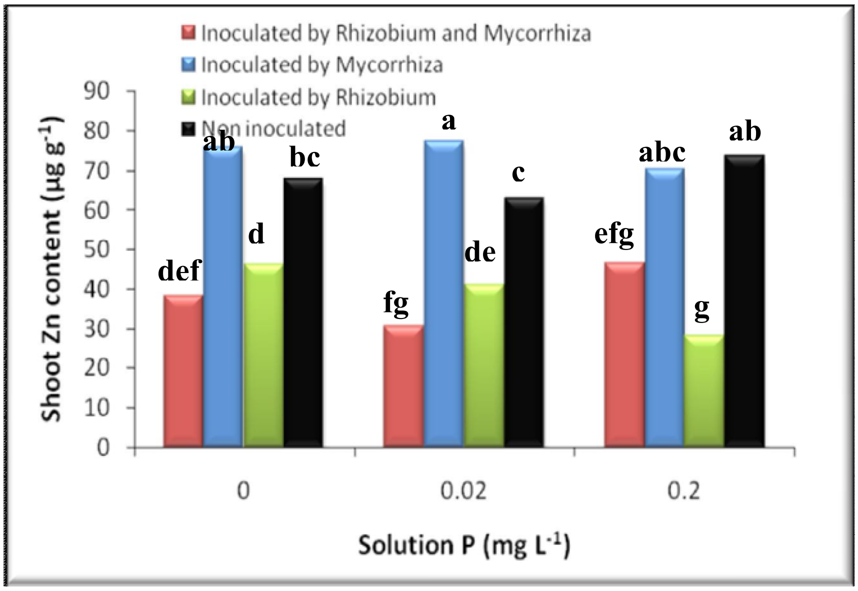


Fig (2): The effect of inoculation with AMF and *R. japonicum* and interaction between them on shoot zinc content at different phosphorus levels.

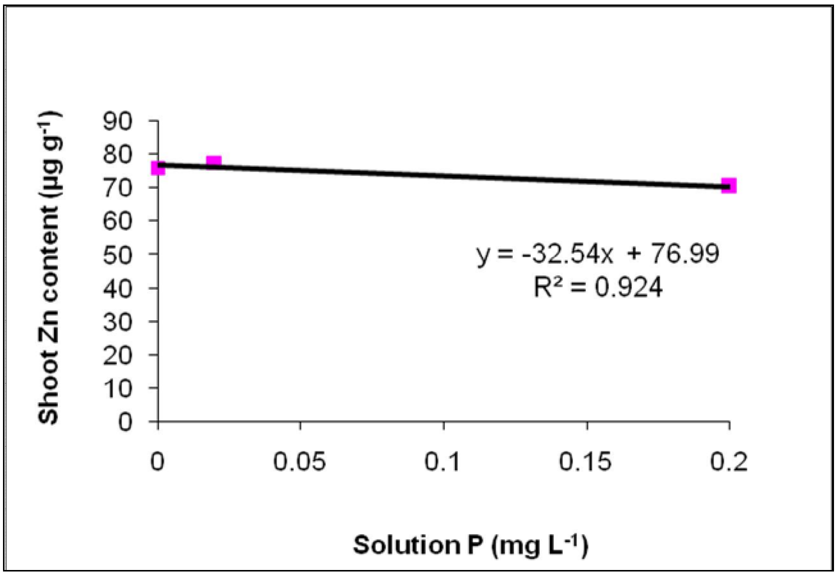


Fig (3): The relation between shoot Zinc content and phosphorus levels for inoculated with AMF.

Shoot manganese content

The effect of inoculation with AMF, *B japonicum* and AMF with *B japonicum* on soybean shoot Mn content under different applied P was shown in Fig (4). It is clear that amount of Mn increased with. *B japonicum* only, approximately was more than other treatments. Mn values were58.67 µg g^{-1}, 48.33 µg g^{-1} and 59.83 µg g^{-1}, for three applied P levels respectively,compert with non-inoculated plants 40.50,42.67 and 40.00 µg g^{-1} respectively at different P levels. So generally the soil co–inoculated the concentration of Mn content were higher than non-inoculated plants at different P levels the Mn value were 41.5 µg g^{-1}, 56.0 µg g^{-1} and 54.17 µg g^{-1} for applied P levels respectively This may due to the rhizobium which enhances plant by supply nitrogen which is important for AMF activity and plant growth. High Mn in rhizobium treatment may be due to the important of Mn in physiological rule in regulating the nitrogen fixation process by bacteria and Mn important for nitrogen fixation (Sinclair *et al.,* 2003). On the other hand the result in Fig (4) show that when the soil inoculated with AMF, the shoot Mn concentration of soybean was not significantly influenced when the P level increased from zero to 0.02 mg p L^{-1} and decreased with increasing P level from 0.02 to 0.2 mg L^{-1} .This result agree with Habte and Soedarjo, (1995). The highest value for shoot Mn content 46 µg g^{-1} was recorded at0.02 mg p L^{-1} while the lowest shoot Mn content 37.5 µg g^{-1} was recorded at highest P level 0.2 mg p L^{-1}. So when the soil non-inoculated the maximum value of shoot Mn content 42.67 µg g^{-1} was recorded at medium P level 0.02 mg p L^{-1}, and the lowest value 40 µg g^{-1} was recorded at highest P levels 0.2 mg p L^{-1}. The result showed that there was not significant differences recorded in shoot Mn content between inoculation with AMF and control at different P levels.

Plants tissue Mn concentration decrease in both inoculated with AMF and non-inoculated plants at different P levels compared with co-inoculation. This result agree with Soedarjo and Habte, (1995). This may be due to the precipitates of Mn as Mn $(OH)_2$ (Ritche, 1989), when the soil was limed the soil pH may be increased from 5.7 to 7.0 (Table 1). Increasing in soil pH cause Mn concentration to decrease under different P concentration. This result agrees with the result reported by Soedarjo and Habte (1995).

The relation between p levels and shoot Mn content which fit the quadratic polynomial correlation with (R^2=1) for inoculated with AMF was shown Fig (5)

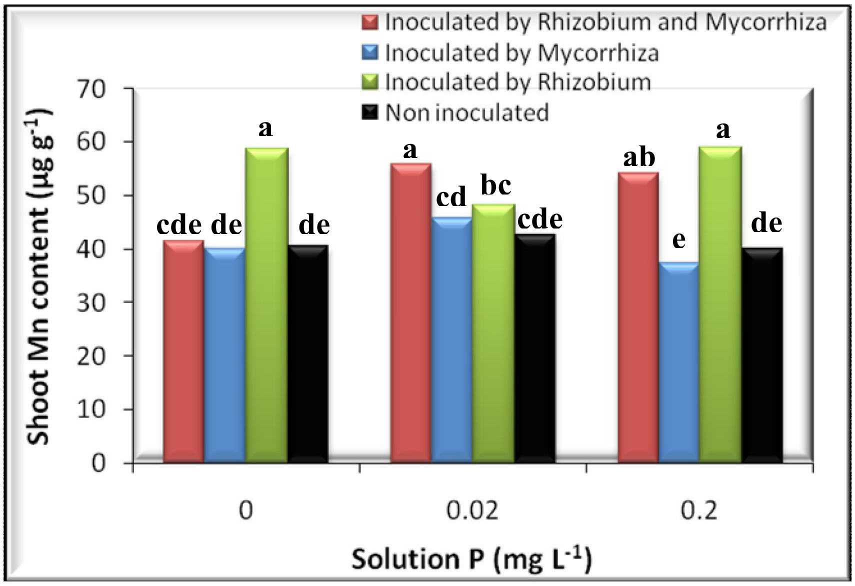


Fig (4): The effect of inoculation with AMF and *R. japonicum* and interaction between them on shoot manganese content at different phosphorus levels.

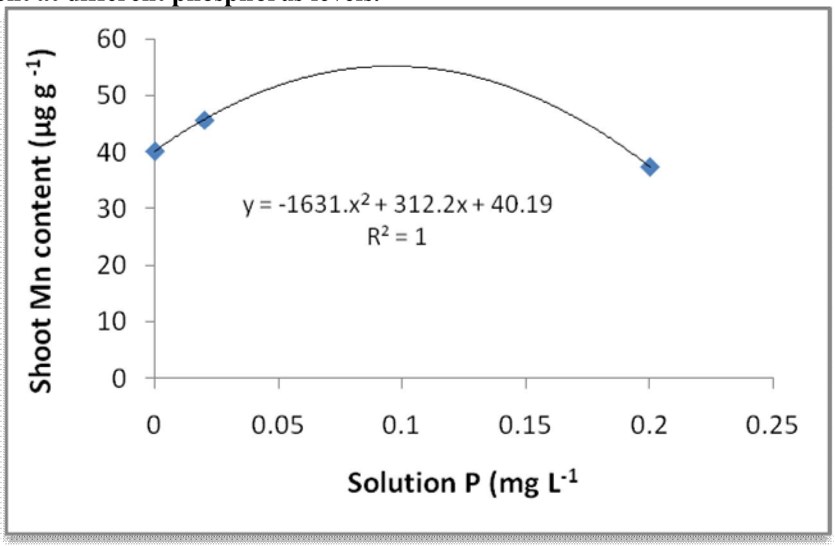


Fig (5): The relation between shoot manganese content and phosphorus levels for inoculated with AMF

Shoot copper content

The effect of inoculation with AMF, Rhizobium and AMF with *B japonicum* on soybean plants shoot Cu content at different P levels were shown in Fig (6). It was clear that when the soil co-inoculation increased Cu content for all applied P levels and shoot Cu contents were 7.50, 7.83 and 9.33 µg g^{-1} for 0 , 0.02 and 0.2 mg P L^{-1} respectively compared with no inoculated . This result agrees with the results found by Manjunath and Habte (1988).
Inoculation plant with Rhizobium the concentration of Cu increased with increasing P levels. The highest Cu value 8.67 µg g^{-1} was recorded at highest applied P 0.2 mg P L^{-1}. While the lowest value 5.33 µg $g^{-1}$was recorded at lowest P level. There were no significant differences recorded between inoculated plants with rhizobium and Cu uptake at different P concentration. This result is in agreement with Gildon and Tinker (1983). On the other hand
When the soil inoculated with AMF the shoot Cu content in soybean plants increased at different P levels in compares with no inoculatin with AMF. This result agree with Munir and Malkawi ., (2004) The highest Cu value 12.17 µg g^{-1} was recorded at medium P level while the lowest value 8.67 µg g^{-1} was recorded at lowest P level. The increasing Cu contend in AMF plant may be to improve plant vigor and soil quantity by using the grater surface area and the hyphae of these fungi extend out into the soil and secrete extracellular

enzymes and efficiently absorb the Cu transport to the root (Munir and Malkawi 2004)

In the non-inoculated soil the shoot Cu content in soybean plants

increased by increasing the rate of phosphorus application, .., The highest Cu value recorded at 0.2 mg P L^{-1} was 10.83 µg g^{-1}, while the lowest value 5.67 µg g^{-1} was recorded at lowest P zero mg L^{-1}. There was significant differences recorded on shoot Cu content at different P levels. The accumulation of Cu in non inoculated shoot plants increased by increasing the rate of phosphorus application, This may be due to the important of indigenous AMF at different level of phosphorus concentration to uptake Cu in the soil and transferred to the plant while the plant was dependent on indigenous mycorrhizal to uptake of immobile nutrients such , Zn and Cu (Manjunath and Habte, 1988), The effect of indigenous AMF on the accumulation of Cu by hyper accumulators (Chen *et al*., 2006).

Fig (7) shows the relation between P levels and shoot Cu content which fit the quadratic polynomial correlation with (R^2=1) for inoculated with AMF.

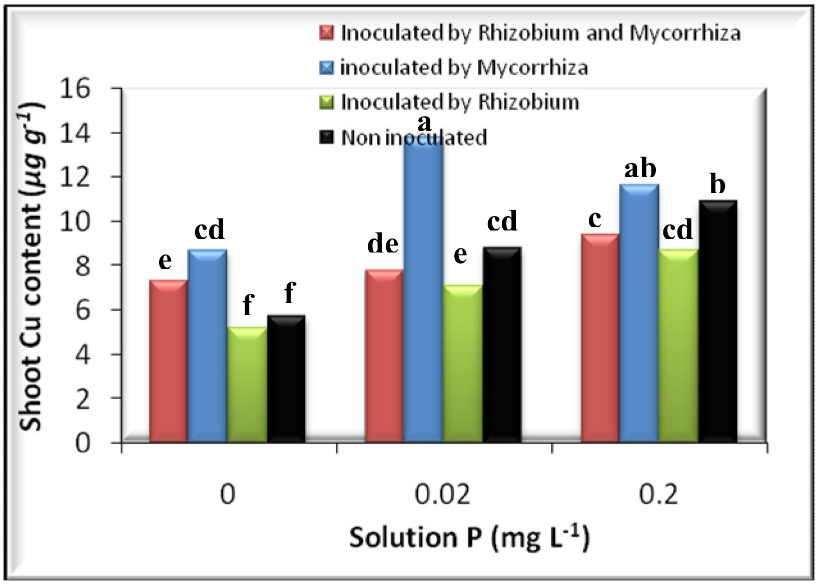


Fig (6): The effect of inoculation with AMF and *R. japonicum* and interaction between them on shoot copper content at different phosphorus levels.

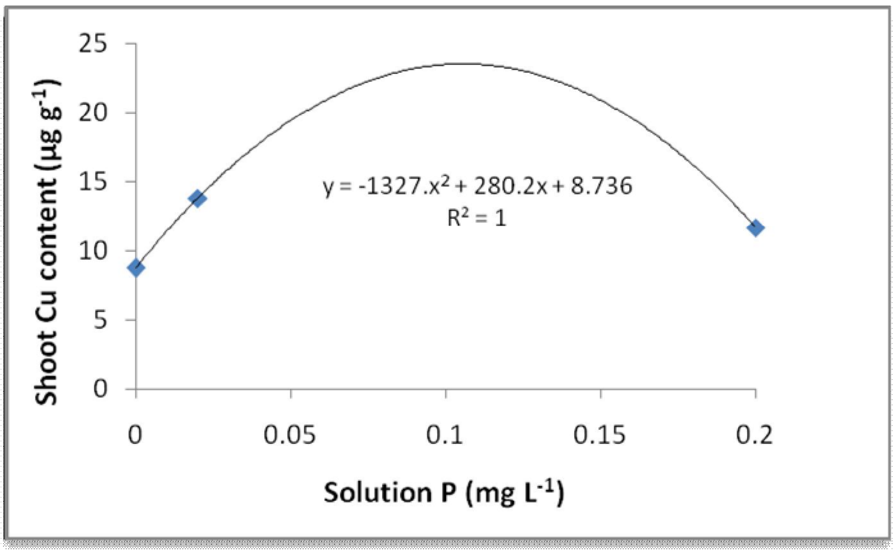


Fig (7) shows the effect of inoculation with AMF, *R. japonicum* and AMF with *R. japonicum* on soybean plants shoot Cu content at

Shoot Iron content

The effect of inoculation with AMF, Rhizobium and AMF with *B japonicum* on soybean plants shoot Cu content at different P levels were shown in Fig (8). It is clear that all, inoculated treatments either by AMF or Rhyzobium or co-inoculation, the amount of shoot Fe content were higher than non-inoculated treatments. When the soil co-inoculated the shoot Fe content increased with increasing P levels and the maximum value was 148.67 µg g^{-1} recorded at lowest P level 0.0 mg p L^{-1}.There was no significant differences recorded between shoot Fe content and co-inoculation at different P levels. The high Fe content for co-inoculated may be due to AMF and rhizobium for more Fe uptake because Fe is important for structure of nitrogen's enzymes (Sylvia *et al*., 2005), which is necessary for nitrogen fixation. When soil inoculated with rhizobium the shoot Fe content higher than non inoculated at different P levels. The maximum value was 183.83 µg g^{-1}recorded at higher P levels 0.02 mg p L^{-1} while the lowest value was 137.83 µg g^{-1} recorded at medium P levels 0.02 mg p L^{-1} , High shoot Fe content for rhizobium inoculated may be due to rhizobium for more Fe uptake because Fe is important for structure of nitrogen's enzymes (Sylvia *et al*., 2005), which is necessary for nitrogen fixation.

When soil inoculated with AMF the shoot Fe content in inoculated plant was higher, than non-inoculated plants. This result agree with Wu .et al (2011) and Munir and Malkawi (2004) The maximum value was 151.00 µg g^{-1}.recorded at medium P levels 0.02 mg p L^{-1} while the lowest value was 78.33 µg g^{-1} recorded at higher P level, There was a significant deferens's recorded between shoot Fe content and AMF inoculation at 0.02 and 0.2 mg P L^{-1} . The. Increasing Fe content in inoculated plant shoot with AMF may be due to excretion of different organic acids to the soil which increase availability of iron, hence increasing its uptake, moreover AMF has the ability to take-up iron from the rhizosphere and the ability of hyphae to uptake and transport it to the host plant (Gao et al., 2007)

Fig (9) shows the relation between P levels and shoot Fe content which fit the liner correlation with (R^2=0.99) for inoculated with AMF.

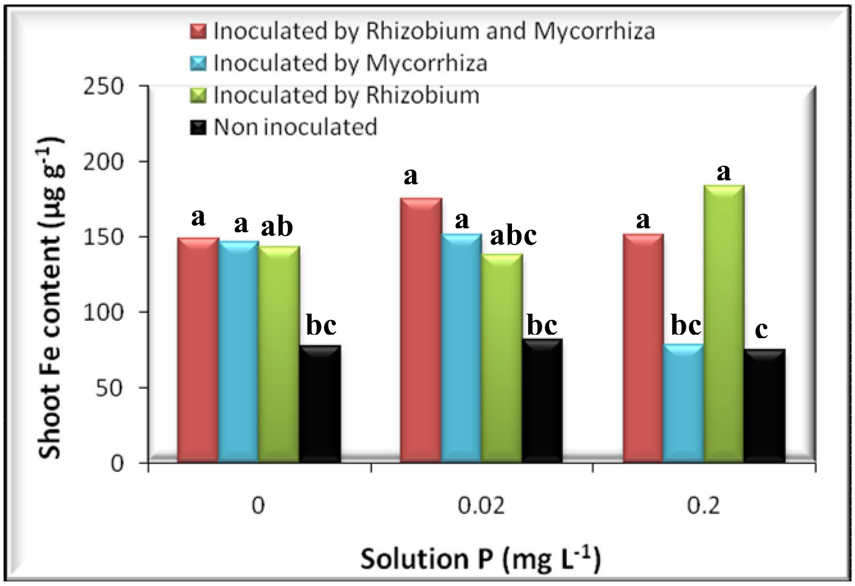


Fig (8): The effect of inoculation of AMF and *R. japonicum* and interaction between them on shoot iron content at different phosphorus levels.

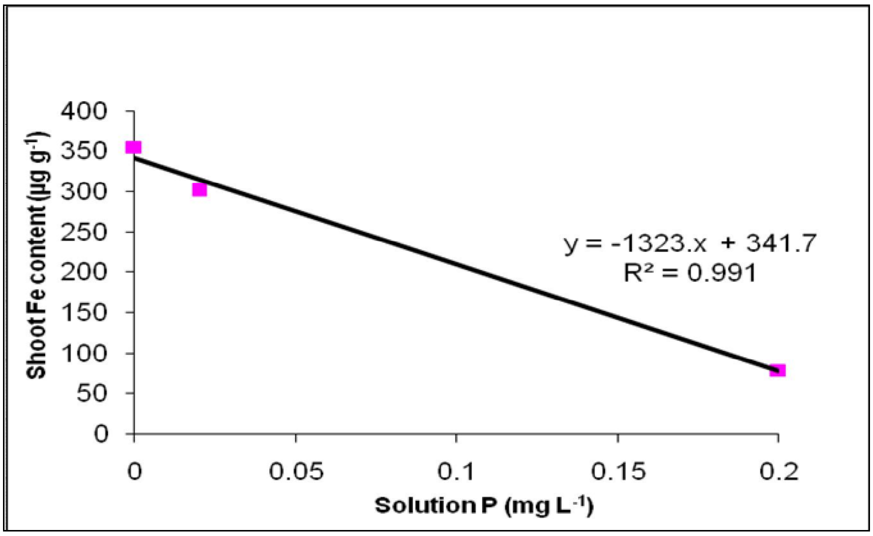


Fig (9): The relation between shoot iron content and phosphorus levels for inoculated with AMF

Table (2) Effect of AMF and *R japonicum* inoculation and non-inoculation and interaction between them on soybean shoot Mn, Zn, Cu and Fe content at different phosphorus levels.

		Mn	Zn	Cu	Fe
			(µg g^{-1})		
		Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.
P _ Level (mg L^{-1})	**Trait**				
0	**Rh**	**A** **58.67 ± 5.01**	**d** **46.33 ± 5.20**	**f** **5.33 ± 0.52**	**ab** **142.67 ± 31.82**
	Ctr	**De** **40.50 ± 3.39**	**bc** **67.50 ± 10.82**	**f** **5.67 ± 0.52**	**bc** **77.33 ± 40.13**
	Rh-My	**Cde** **41.50 ± 5.89**	**def** **38.33 ± 3.67**	**e** **7.50 ± 0.55**	**a** **148.67 ± 16.52**
	My	**De** **40.17 ± 5.19**	**ab** **75.83 ± 7.57**	**cd** **8.67 ± 0.82**	**a** **146.50 ± 73.19**
0.02	**Rh**	**Bc** **48.33 ± 2.07**	**de** **41.00 ± 8.92**	**e** **7.33 ± 0.82**	**abc** **137.83 ± 40.41**
	Ctr	**Cde** **42.67 ± 6.74**	**c** **63.33 ± 5.16**	**cd** **8.83 ± 0.75**	**bc** **81.50 ± 27.89**
	Rh-My	**A** **56.00 ± 6.51**	**fg** **30.83 ± 5.91**	**de** **7.83 ± 0.75**	**a** **175.00 ± 62.36**
	My	**Cd** **46.00 ± 8.69**	**a** **77.50 ± 5.24**	**a** **12.17 ± 1.72**	**a** **151.00 ±14.70**
0.2	**Rh**	**A** **59.83 ± 7.57**	**g** **28.17 ± 2.04**	**cd** **8.67 ± 0.52**	**a** **183.83 ± 56.02**
	Ctr	**De** **40.00 ± 6.03**	**ab** **73.83 ± 9.26**	**b** **10.83 ± 1.17**	**c** **74.83 ± 35.83**

	Rh-My	Ab 54.17 ± 4.45	efg 34.83 ± 9.00	c 9.33 ± 0.52	a 151.00 ± 44.36
	My	E 37.50 ± 6.86	abc 70.33 ± 12.79	ab 11.67 ± 0.52	Bc 78.33 ± 16.72
Overall Mean		**47.11 ± 2.43**	**53.99 ± 3.16**	**8.65 ± 0.34**	**129.04 ± 21.14**

Means with the same letter are not significantly different

Table (3): Effects of AMF and *R japonicum* inoculation and interaction between them on mycorrhiza effectiveness, of the soybean grown under different phosphorus levels.

		Day 15	**Day 21**	**Day 27**	**Day 33**	**Day 39**	**Day 45**
		Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.
P _ Level (mg L^{-1})	**Trait**						
0	**Rh**	e 2.36 ± 0.24	e 1.44 ± 0.37	c 1.17 ± 0.34	e 1.78 ± 0.19	d 2.07 ± 0.13	d 1.86 ± 0.17
	Ctr	de 2.55 ± 0.22	de 1.78 ± 0.23	c 1.07 ± 0.19	e 1.89 ± 0.19	cd 2.16 ± 0.28	d 1.90 ± 0.23
	Rh-My	abcd 3.21 ± 1.32	de 1.72 ± 0.27	c 2.12 ± 0.69	d 2.98 ± 0.58	cd 2.89 ± 0.59	d 2.25 ± 0.25
	My	cde 2.75 ± 0.32	d 2.10 ± 0.28	c 1.58 ± 0.45	de 2.70 ± 0.70	cd 3.09 ± 0.65	d 2.43 ± 0.33
0.02	**Rh**	de 2.55 ± 0.16	e 1.59 ± 0.27	c 1.89 ± 0.21	de 2.26 ± 0.73	c 3.17 ± 0.96	d 2.34 ± 0.50
	Ctr	de 2.66 ± 0.42	de 1.77 ± 0.27	c 1.45 ± 0.53	de 2.50 ± 0.64	cd 2.97 ± 0.75	d 2.41 ± 0.65
	Rh-My	abcde 3.06 ± 0.70	a 3.96 ± 0.37	b 3.34 ± 1.17	a 6.28 ± 1.22	a 5.80 ± 1.10	ab 3.88 ± 0.65
	My	bcde 2.94 ± 0.55	a 3.64 ± 0.59	a 4.81 ± 1.88	abc 5.55 ± 0.81	b 4.77 ± 1.59	bc 3.52 ± 0.49
0.2	**Rh**	abc 3.44 ± 0.20	bc 3.13 ± 0.21	a 4.75 ± 1.32	c 4.93 ± 0.57	b 4.68 ± 0.65	c 3.19 ± 0.67
	Ctr	abcd 3.29 ± 0.36	c 3.10 ± 0.34	a 4.77 ± 0.82	bc 5.36 ± 0.59	b 4.57 ± 0.59	abc 3.75 ± 0.71
	Rh-My	ab 3.60 ± 0.65	ab 3.59 ± 0.16	a 4.86 ± 1.31	ab 5.89 ± 1.01	ab 5.60 ± 0.84	ab 4.11 ± 0.66
	My	a 3.70 ± 0.69	abc 3.53 ± 0.79	a 4.81 ± 1.20	ab 5.87 ± 0.71	ab 5.49 ± 0.56	a 4.31 ± 0.51
Overall Mean		**3.01± 0.24**	**2.61 ± 0.16**	**3.05 ± 0.40**	**4.00 ± 0.29**	**3.94 ± 0.33**	**2.99 ± 0.21**

Means with the same letter are not significantly different

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تأثير المايكورايزا و الرايزوبيم على محتوى فول الصويا من العناصر الصغرى عند مستويات مختلفة من الفسفور في الترب المعاملة بالكلس

الخلاصة

اجريت تجربة في البيت الزجاجية في سنادين لدراسة ثأير اللقاح المايكورايزا**Mycorrhiza** واللقاح البكتيري**Rhizobium** والتداخل بينهما عند مستويات مختلفة من عنصر الفسفور على محتوى نباتات فول صويا من العناصرالصغرى (الخارصين، المنغنيز،النحاس و الحديد) ونشاط المايكوريزا . وجد عند اضافة الكلس للترب الحامضية فأن أنسب مستوى مؤثر للفسفور على نشاط المايكوريزا كانت عند المستوى المتوسط ($0.02\ \mu g\ P\ L^{-1}$) وكانت الزيادة معنوية في نشاط المايكوريزا مع الوقت بين 21 الى 45 يوم بعد الزراعة عند تلقيح النباتات بالمايكوريزا. بلغت اعلى قيمة **5.5 µg** ($P\ disk^{-1}$ للفسفور في نباتات فول الصويا في القرص المؤخوذة من الورقة بعد 33 يوم من الزراعة .بينما كانت اقل قيمة) ($2.94\ \mu g\ P\ disk^{-1}$ في الورقة بعد 15 يوم من الزراعة .ان تأثير اللقاحين المايكوريزا والرايزوبيوم معا يؤثران تأثرا معنويا على محتوى العناصر الخارصين ، المنغنيز النحاس و الحديد في الجزء الخضري مع زيادة الفسفور المضاف ، وبلغت اعلى قيمة للعناصر 38.33، 56.0، 9.33 و 175.0 مايكروغرام لكل غرام على التوالي . بينما كانت القيم للعناصر77.5 . 46.0 ، 12.17 و 151.0 مايكروغرام لكل غرام للقاح المايكورايزي فقط ، بينما النباتات التي لقحت باللقاح الراريزوبيوم كانت القيم العناصر46.33 ، 59.83 ، 8.67 و 183.83 مايكروغرام لكل غرام على التوالي ولكن قيم العناصر في النباتات الغير ملقحة بلغت 73.83 ، 42.67 ، 10.83 و 81.5 مايكروغرام لكل غرام.

كاريگەري مايكۆڕايزاو ڕايزوبيەم لە سەر وەرگرتني توخمە دەگمەنەكان لە لايەن فول سۆيا لە ئاستي فسفوري جياواز لە خاكێكي مامەڵە كراو بە كلس

پوختە

تاقي كردنەوەيەكي ئينجانەيي لە ژورێكي شووشەدا ئەنجام درابە مەبەستي لێكۆلینەوە لە كاريگەري پيتاندن بە كەڕووي مايكۆرايزا لە گەڵ بكتريايي ڕايزۆبيەم وەچەند ئاستێكي جياواز لە فسفۆر لە سەر چالاكی مايكۆرايزا ، وەرگرتني ئەم توخمە دەگمەنانە (زنك،مەنگەنيز ،مس ،وە ئاسن) لە پێكهاتەي ڕووەكي فول سويا لە خاكێكي مامەڵە كراو بە كلس . كاتێك كە خاكێكي ترش مامەڵە دەكرێت بە كلس باشترين ئاستی فسفۆر بۆ چالاكيي مايكۆرايزا بريتی يە لە ئاستی مامناوەند 0,02 ملغرام p/لتر . كە ڕووي مايكۆرايزا بە شيۆەيەكي بە هادار ئەبێتە هۆي زياد بووني چالاكي مايكۆرايزا بە هۆكاري كات لە نێوان 12–45 ڕۆژ دواي تۆوكردني . بەرزترين نرخی فسفۆر لە ڕووەكەكە بريتی بوو لە 5,55 مايكرۆ گرام p /دسك لە 33 ڕۆژ دواى ڕواندن.بەلأم نزمترين نرخ بريتی بوو لە 2,94 مايكرۆغرام p /دسك تۆماركرا لە دواى 15 ڕۆژ لە چاندن و پيتاندني هاوبەش كاري كردەسەر بەشەسەوزي ڕووەكەكە لە پێكهاتەي هەريەك لە زنك ، مەنگەنيز، مس، وە ئاسن لە گەڵ پێداني فسفۆر بەرزترين نرخي تۆمار كراو لە پێكهاتەي بە شە سەوزي ڕووەكەكەبريتی بوو 38.33 ، 56.0 ،9.33 و 175مايكروگرام p /گرام وەبۆ پيتاندن بە مايكوڕايزا هەريەك لە زنك ، مەنگەنيز ،مس، وە ئاسن كە نرخەكانيان بريتي بوو لە 77.5 ، 46 ، 12.7 وە 151 مايگرو گرام p/گرام بەلآم بۆ بكترياي ڕايزۆبيەم نرخەكاني بريتي بوون لە 46,33 ، 59.83 ، 8.67 وە 183.83 مايكرۆگرام p/گرام بەلآم بۆ نەپيتێنراو بريتي بوو لە 73,83 ، 42.67 ,83 .10و 81,5 مايكروگرام p/گرام .