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Influence of Cobalt and Mycorrhizae Mediated Phosphorus on Some Higher Plants Growth and Yield

Nadia Gad; M.R. Abdel-Moez and Hala Kandil

Plant Nutrition Dep., National Research Centre Dokki, Egypt

ABSTRACT

Two pot experiments were conducted to assess the effect of cobalt and mycorrhizae *(Gigaspora gigantean)* mediated phosphorus on the growth and yield of corn as monocots and soybean as dicots. Experiments were carried out at Wire house in National Research Centre, Egypt. Plastic pots (40 cm diameter) filled with silty clay soil and inoculated with mycorrhizae fungi before seeds sowing and fertilized by calcium mono phosphate at 50, 100 and 200 mg P/Kg soil. The seedlings (at the third truly leaf) were irrigated with cobalt sulphate once, with 0, 4, 8, 10, 12, 16 and 20 ppm cobalt.

The obtained results can be summarized as follows:-

- The growth of both corn and soybean plants, inoculated with low phosphorus level were significantly increased compared other levels.
- The mycorrhizae colonies decreased as P increased while cobalt is not significant.
- Cobalt at 10 ppm with mycorhizae had a significant promotive effect on growth, yield minerals composition and chemical content of corn compared with mycorrhizae alone.
- Cobalt at 12 ppm with mycorrhizae gave a similar effect of soybean.
- Phosphorus content of plants was nearly doubled in mycorrhizae and cobalt compared with mycorrhizae alone.

It can be concluded that the cobalt with mycorrhizae inoculation under low phosphorus level enhanced the growth, yield quantity and quality in both corn and soybean, but this positive impact was more significant in the dicot plants compared to monocot.

KEYWORDS: Cobalt, Mycorrhizae, Phosphorus, Soybean, Corn.

INTRODUCTION

Most of cultivated soils in Egypt are characterized by high efficiency for phosphorus fixation which leads to accumulation of this element in an unavailable form **(Hilal *et al.*, 1973).** Also these soils are characterized with low available trace elements contents namely Fe, Mn, Zn and Cu **(Lambert *et al.*, 1989).**

Phosphorus is one the most essential elements for plant growth after nitrogen. However, the availability of this nutrient for plants is limited by different chemical lreactions especially in arid and semi-arid soils. Phosphorus plays a significant role in several physiological and biochemical plant activities like photosynthesis, transformation of sugar to starch, and transporting of the genetic traits. **Sharma (2002)** reported that one of the advantages of feeding the plants with phosphorus is to create deeper and more abundant roots. Phosphorus causes early ripening in pants, decreasing grain moisture, improving crop quality and is the most sensitive nutrient to soil pH **(Malakooti, 2000).**

Cobalt is an essential element for the synthesis of vitamin B_{12} which is required for human and animal nutrition **(Young, 1983 and Smith, 1991).** Unlike other heavy metals, Co^{2+} is more safe for human consumption and it can be consumed up to 8 ppm on a daily bases without health hazard **(Young, 1983).**

In higher plants, moreover, cobalt is an essential element for legumes due to its fixing atmospheric nitrogen **Basu *et al.*, (2003) and Nadia Gad *et al.*, (2011).**

During the recent era, the ecophysiology of Vesicular-Arbuscular Mycorrhizae (VAM) association has been subjected to increasing intensive study. Emphasis has been imposed on relationship with nutrient uptake by VAM fungal hypha symbiont and reflections on the growth of the host plant, such phenomenon being frequently utilized in economical agriculture **(Abbott and Robson, 1982).**

The Vesicular-Arbuscular Mycorrhizae association, considered to be one of the most common forms of symbiosis is frequently favorable for growth of many host plant species including soybean; such responses were attributed to an enhanced nutrient uptake by the host plant **(Daft and Nicolson,**

***Corresponding Author:** Hala Kandil, Plant Nutrition Dep., National Research Centre Dokki, Egypt.

1966). Also **Saad (1982)** found that inoculation with VAM increased the dry weight of both maize and tomato plants grown under Egyptian conditions, calcareous soils being different to alluvial clay ones.

Barea and Azcon-Aguilar (1983) reported that VAM improved growth and nodulation in legume-Rhizobium systems. **El-Deepah (1985)** added that favorable effect of mycorrhizal inoculation on the total dry weight of shoot was obtained 60 days from planting.

Barea *et al*., (1989) demonstrated that regardless of the cropping system and the P concentration in soil, VAM improved the dry matter production of the legumes, dry weight and P- uptake being also affected **(Eranna and Parama, 1994).**

(Saif, 1987) added that, VAM not only increase plant biomass but also influence the partitioning of this material between shoot and root of mycorrhizal legume plants, usually giving a lower root: shoot ratio than non-mycorrhizae ones**.**

The mycorrhizae symbiosis is influenced by several factors including soil fertility; depression of plant growth due to mycorrhizae infection at higher phosphorus level has been observed by several investigators.

Moss (1973) found that mycorrhizal plants grew much better than non-mycorrhizal controls when no phosphate was added to the soil; 1.5 g added phosphate $Ca(H_2PO_4)_2.H_2O$/Kg soil caused a decrease in growth of control plants; no arbuscules were formed at rate of 1 gm added phosphate/Kg soil with many attenuated hyphae being ramified through the cortex and finally the host seemed to loose control over fungal development. **Bethlenfalvay *et al*., (1982)** added that increasing P availability encouraged plant growth as well as nodule activity for both mycorrhizal and non- mycorrhizal plants, responses of the formers being however significantly lower possibly due to intersymbiont competition for P. **Hayman (1984)** showed that percentage of legume root infection decreased from 54 to 37% by addition of super phosphate at 90 kg ha^{-1}.

Medina *et al*., (1990) found that fungal inoculation gave at least a 30% saving (40 kg ha^{-1}) in the amount of P fertilizer required for the maximum yield of forage legumes. The plants inoculated with VAM fungi, compared to control ones, had a better status of both N and P at both low and intermediate levels of applied P. **Peng *et al*., (1993)** added that at 52 days from transplanting, mycorrhizae and non-mycorrhizae plants receiving high P rate were almost identical in plant growth; VAM-plants had, however, 19% higher root dry weight with 10% higher daily rates of growth. In spite of that, negative responses for growth of VAM plants were obtained at 92 days from transplanting.

Tavassoli *et al*., (2000) reported increased thousand kernel weight with increasing phosphorus and applying mycorrhiza.

(Zaidi *et al*., 2003) stated that mycorrhizal fungi have been reported in roots of chickpea plants, improving the growth and yield of these plants, especially in phosphorus deficient soils

Arbuscular mycorrhizal fungi have been shown to differentially colonize plant roots, causing a variety of effects on plant growth, biomass allocation and photosynthesis **(Fidelibus *et al*., 2000; Miransari *et al*., 2007).**

Irshad Ahmed Khan *et al*., (2007) found that the maximum shoot dry weight with dual inoculation was 12.57 g at 0 kg P_2O_5 ha^{-1} and 12.01 at 25 kg P_2O_5 ha^{-1} while root dry weight was 3.68 g at 0 kg P_2O_5 ha^{-1} and 3.52 at 25 kg P_2O_5 ha^{-1}.

Mehrvarz *et al*., (2008) reported that the research on Mycorrhiza fungus and its role in soil and plant has been an interesting scientific subject since 1800. The presence of this fungus in rhizosphere provides with an advantageous and interactive symbiosis relationship between a higher plant root and a nonpathogenic fungus. Through receiving energetic carbon resources from plant, fungus facilitates the uptake of many inorganic nutrients such as phosphorus, zinc, molybdenum, copper and iron for it. The symbiotic relationship between Mycorrhiza and plants is one of the most abundant symbiotic activities in plant kingdom which exists in most of the ecosystems.

Recently, **Ali Faramarzi *et al*., (2012)** pointed that applying phosphorus at 50, 100 and 150 kg ha^{-1} levels increased yield up to 62, 101 and 124% in corn (cv. KSC 647) in comparison to the control. Mycorrhizae inoculation with 150 kg ha^{-1} phosphorus resulted in the highest seed yield, while no application mycorrhizae and phosphorus caused the least seed yield.

MATERIAL AND METHODS

Soil analysis:-

Physical and chemical properties of Nubaria Soil were determined and particle size distributions along with soil moisture were determined as described by **Blackmore *et al*., (1972).** Soil pH, EC, cations and anions, organic matter, $CaCO_3$, total nitrogen and available P, K, Fe, Mn, Zn, Cu were run according to **Black *et al*., (1982).** Determination of soluble, available and total cobalt was determined according to method described by **Cottenie *et al*., (1982).** Some physical and chemical properties of Nubaria soil are shown in Table (1)

Table (1): Some physical and chemical properties of Nubaria soil

Physical properties							
Particle size distribution (%)				**Soil moisture constant (%)**			
Sand	**Silt**	**Clay**	**Soil texture**	**Saturation**	**FC**	**WP**	**AW**
13.93	47.64	30.07	Silty clay	32.0	19.2	6.1	13.1

Chemical properties											
pH 1:2.5	EC (dS m^{-1})	CaCO3 %	OM %	Soluble cations ($meq^{1}L$)				Soluble anions ($meq^{-1}L$)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	HCO_3^{-}	CO_3	Cl^{-}	$SO_4^{=}$
8.2	1.9	1.91	0.72	4.20	3.4	0.2	8.3	3.0	-	7.0	6.10

CEC meq/ 100 g soil	ESP	Total	Available		Available micronutriments				
		(mg 100 g^{-1} soil)			(ppm)				
15.2	6.15	N	P	K	Fe	Mn	Zn	Cu	Co
		10.3	3.1	10.3	4.46	11.9	9.3	3.23	4.8

FC (Field capacity), WP (Welting point), AW (Available water)

Experimental works:-

Two pot experiments were conducted to study the effect of cobalt and mycorrhizae mediated phosphorus on the growth, yield and mineral composition of corn as monocot and soybean as dicots. Plastic pots (40 Cm diameter) filled with silty clay soil. Physical and chemical properties of the soil used are given in Table (1). The pots were inoculated with mycorrhizae fungi before seeds sowing according to the technique described by **Mego and Timmer (1982).** Seeds of corn (pa 70 * pa 94 hybrid) and soybean (chippewa 64) are sowing. Both plants were fertilized with calcium monophosphate at four rates namely 0, 50, 100 and 200 mg/Kg soil. Seedlings (at the third truly leaf) were irrigated with cobalt sulphate form once with 0, 4, 8, 12, 16 and 20 ppm cobalt.

Mycorrhizae colonization:-

After 40 day from sowing plants were harvested. Roots were separated for determining the density of mycorrhizae colonization according to **Phillips and Hayman (1990).**

Measurement of vegetative growth:-

After 75 days from sowing, all growth parameters as shoot and root biomass were recorded according to **FAO (1980).**

Measurement of yield characteristics:-

After 120 days from sowing all yield characteristics such as seed weight per plant, seed yield Kg/Fadden and oil yield per Fadden were determined according to **Gabal *et al.*, (1984).**

Measurement of oil percentage:-

Oil percentage in both soybean seeds and corn grains sampled was determined according to **A.O.A.C. (1995)** and calculated oil yield per fadden.

Nutritional status:-

Both soybean seeds and corn grains sampled either the intact plant for each treatment was oven dried at70°C for 48 hr ground and kept to minerals determinations. For extraction a weight of 0.2 g finally podered dry sample and digested using a mixture of sulphoric acid (H_2SO_4) with hydrogen peroxide (H_2O_2). Macronutrients (N, P and K) as well as micronutrients such as Fe, Mn, Zn and Cu were determined according to the method described by **Cottenie *et al.*, (1982).**

Statistical analysis:-

All data were subjected to statistical analysis according to procedure outlined by **SAS (1996).** Computer program and means were compared by LSD method according to **Snedecor and Cochran (1980).**

RESULTS AND DISCUSSION

Mycorrhizal coloniation:-

Fig. (1) indicates that colonization percentage is a quantitative indicator of mycorrhizal activity. Colonization figures are included to demonstrate the adverse effect of P on fungal growth in both soybean and corn roots. Figure (1) clearly indicates that the mycorrhizal colonization decreased as P rates increased in both two plants. The increasing was higher in soybean (dicotes) than corn (monocots). These results go hand in hand with those of **Viebrock and Jungk (1986)** and **Chandrashekara *et al.*, (1995).** Figure (1) also indicates that cobalt is no significant effect on mycorrhizae colonization.

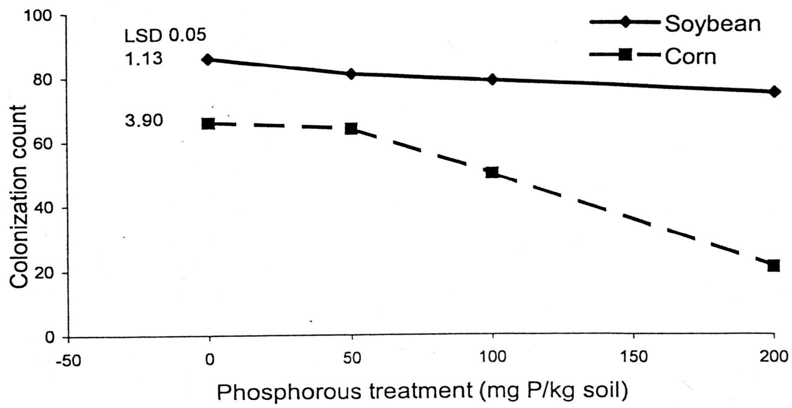

Fig. (1): Mycorrhizal colonization of soybean and corn plants at different levels of phosphorus.

Growth and yield characteristics:-

The effects of cobalt and mycorrhizae on corn and soybean under different phosphorus levels were given in Tables (2 and 3). Data show that dry weight of both corn and soybean shoot and root significantly increased by phosphorus addition. The increase of dry weight was more obvious in corn than in the soybean. Treating the soil with mycorrhizal fungi under the different doses of phosphorous significantly increased both plants the shoot and root biomass. However, the rate of increase of dry weight due to mycorrhizae infection was higher in soybean plants (dicots) than corn plants (monocots). It worth to be mentioned that the role of mycorrhiza in increasing was more clear and low phosphorus level (50 mg P/Kg soil). These results are in harmony with those obtained by **Barea *et al.*, (1989) and Hamed (1998)** who stated that lower applied P rate more effective on shoot and root dry matter contents with results.

Table (2): Growth and yield parameters of soybean as affected by cobalt and mycorrhizae mediated phosphorus.

Treatments	Added P (mg/kg soil)	Biomass (g /plant)		Seeds (weight/plant)	Seeds (yield/ fed)	Oil (yield/ fed)
		Shoots	Roots	(g)	(Kg)	(Kg)
NMR	Control	3.89	1.60	14.7	1590	183
	50	4.11	1.66	15.5	1620	189
	100	4.02	1.63	15.0	1601	186
	200	3.96	1.59	14.8	1593	185
Mean		3.99	1.62	15.0	1236.5	185.8
NMR + Co (12 ppm)	Control	4.52	1.79	17.6	1660	189
	50	4.63	1.89	18.2	1669	200
	100	4.59	1.85	18.0	1665	197
	200	4.56	1.82	17.8	1660	192
Mean		4.58	1.84	17.9	1663.5	194.5
MR	Control	5.34	2.01	18.6	1651	185
	50	5.42	2.21	19.3	1658	198
	100	5.39	2.18	19.0	1653	195
	200	5.36	2.12	18.8	1649	190
Mean		5.38	2.13	18.9	1652.8	192.0
MR + Co (12 ppm)	Control	5.76	2.35	21.7	1686	199
	50	5.87	2.45	22.6	1696	210
	100	5.82	2.41	22.2	1694	206
	200	5.79	2.38	21.8	1689	201
Mean		5.81	2.39	22.08	1691.3	204.0
LSD at 5%		0.002	0.003	0.009	1.21	2.15

MR= Mycorrhizae
NMR = Non Mycorrhizae

Table (3): Growth and yield parameters of corn as affected by cobalt and mycorrhizae mediated phosphorus.

Treatments	Added P (mg/kg soil)	Biomass (g /plant)		Grains (weight/plant)	Grains (yield/ fed)	Oil (yield/ fed)
		Shoots	Roots	(g)	(Kg)	(Kg)
NMR	Control	236	21.8	183	1747	48.20
	50	249	27.5	200	1759	55.06
	100	243	24.0	195	1753	52.15
	200	239	22.9	189	1749	49.41
Mean		241.8	24.1	191.8	1752.0	51.2
NMR + Co (12 ppm)	Control	257	24.2	224	2001	57.06
	50	273	32.1	234	2024	63.51
	100	269	29.3	230	2019	60.12
	200	261	25.0	227	2012	58.23
Mean		265.0	27.7	228.8	2014.0	59.73
MR	Control	297	28.6	235	2168	66.10
	50	314	38.5	246	2180	67.70
	100	309	34.2	242	2176	67.00
	200	302	30.4	239	2161	66.20
Mean		305.5	32.9	240.5	2171.3	66.8
MR + Co (12 ppm)	Control	334	46.5	259	2293	60.06
	50	345	43.2	269	2312	70.51
	100	341	41.0	263	2305	67.24
	200	337	38.1	260	2298	62.15
Mean		339.3	42.2	262.8	2302.0	64.99
LSD at 5%		2.43	0.9	1.06	3.41	0.5

MR= Mycorrhizae
NMR = Non Mycorrhizae

Depression of plant growth due to mycorrhizal infection at higher phosphorus level has been observed. Mycorrhizal inoculation was not significantly favorable during all growth stages. These results are agreed with those obtained by **Saif (1987)** who reported that the competition for photosynthesis between the fungus and roots is the main factor responsible for the typical larger shoot: root dry weight ratio. Higher applied rate of phosphorus also seemed to be not significantly growth parameters.

Data in Tables (2 and 3) clearly indicate that cobalt had a significantly promotive effect on both shoot and root biomass of corn and soybean plants with non-mycorrhizal (NMR) as well as mycorrhizal (MR) treatments especially under low phosphorus level (50 mg/ Kg soil). These results are agrees with those obtained by **Nadia Gad *et al.*, (2011)** who found that cobalt had a significantly increased faba bean shoot and root dry weights.

The obtained data in Tables (2 and 3) demonstrated that yield parameters of both corn and soybean such as grains or seeds weight per plant, grains or seeds yield per feddan and oil yield per Fadden. All yield parameters of two studied plants significantly increased by phosphorus addition compared with control treatment. Phosphorus at 50 mg/Kg soil gave the highest yield parameters compared with other P levels under non-mycorrhizal (NMR). Under mycorrhizal fungi inoculation (MR) all yield parameters are enhance of both plants compared with non- mycorrhizae (NMR). Mycorrhizae inoculation produced higher yield quality, such trend being also obtained with low rate of phosphorous. These results are good agreement with those obtained by **Mengel and Krikby (1979)** who suggested that positive effect micronutrients are well known to help plants to grow well and improve the transference for the phosphsynthetic substances from leaves to seeds mainly through enzymatic activity and hormonal reactions. **Nelson and Safir (1982)** stated that mycorrhizal fungi can stimulate growth and yield of legumes. **El-Deepah (1985)** showed that soybean plants produced more pod when inoculated with mycorrihzal fungi. Similar results were obtained by **Lynch *et al.*, (1991)** who found that mycorrhizal inoculation significantly improved the seed yield of common bean under limited P regimes by increasing both seed weight, the number of pods/ plant and the number of seed/pod. **Saad (1982)** added that inoculation with mycorrhizal fungi increased the dry weight and yield of both maize and tomato plants grown under Egyptian conditions, calcareous soils being different to alluvial clay ones. Confirm, **Moss (1973),** mycorrhizal plants grew much better than non-mycorrhizal controls when no phosphate was added to the soil.

The present data in Tables (2 and 3) clearly indicate that cobalt gave the maximum yield parameters with both mycorrhizal and non-mycorrhizal fungi. According to, **Abdul Jaleel *et al.*, (2009 a&b),** cobalt addition in soil increased all growth and yield parameters such as seedling vigour number and weight of pods and seeds yield/ plant in green gram *(vigno radiat L.)* and increased grains yield/plant in maize *(zea maiz L.)* plants. **Nadia Gad *et al*., (2011)** added that cobalt improved all growth and yield parameters of faba bean compared with untreated plants.

Nutritional status:-

Data in Tables (4 and 5) are representing the micronutrients and phosphorus content of both corn and soybean as affected by cobalt and mycorrhizal infection under different phosphorus levels.

Table (4): Phosphorus and micronutrients status of soybean seeds as affected by cobalt and mycorrhizae mediated phosphorus.

Treatments	Added P (mg/kg)	P	Micronutrients (ppm)				Co
		(%)	Zn	Fe	Mn	Cu	(ppm)
NMR	Control	0.091	32.7	75.9	71.3	4.77	2.86
	50	0.122	33.5	78.5	72.5	4.86	3.44
	100	0.118	30.8	81.4	68.3	4.24	2.69
	200	0.113	27.9	83.6	65.6	4.03	2.40
Mean		0.111	31.2	79.82	69.43	4.48	2.85
NMR + Co (12 ppm)	Control	0.096	35.2	82.7	73.6	7.25	7.82
	50	0.125	37.5	86.0	74.2	8.88	8.34
	100	0.130	33.2	88.9	69.5	6.77	7.24
	200	0.211	30.8	91.8	66.3	6.01	7.88
Mean		0.140	34.2	87.4	70.9	7.22	7.82
MR	Control	0.193	58.3	78.7	83.5	8.87	4.06
	50	0.255	59.8	81.8	85.6	9.74	6.69
	100	0.262	57.1	86.0	83.2	7.77	6.00
	200	0.424	55.0	89.4	80.0	6.92	5.59
Mean		0.276	57.6	63.9	83.1	8.33	5.59
MR + Co (12 ppm)	Control	0.388	60.8	85.5	85.3	10.2	9.24
	50	0.513	62.2	87.6	88.5	10.7	11.52
	100	0.524	60.7	89.5	86.0	9.80	10.90
	200	0.849	58.6	92.2	82.7	7.36	10.32
Mean		0.569		88.7	85.6	9.52	10.50
LSD at 5%		0.004	0.01	0.22	0.19	0.13	0.11

MR= Mycorrhizae
NMR = Non Mycorrhizae

Table (5): Phosphorus and micronutrients status of corn grains as affected by cobalt and mycorrhizae mediated phosphorus.

Treatments	Added P (mg/kg)	P	Micronutrients (ppm)				Co
		(%)	Zn	Fe	Mn	Cu	(ppm)
NMR	Control	0.085	21.4	55.3	62.6	5.84	3.77
	50	0.093	24.6	59.8	66.2	6.96	4.19
	100	0.135	19.2	64.6	63.0	6.04	3.95
	200	0.252	16.5	69.5	61.3	5.79	3.81
Mean		0.141	20.4	62.3	63.3	6.16	3.93
NMR + Co (12 ppm)	Control	0.089	23.5	56.6	64.0	7.82	8.69
	50	0.096	24.6	62.1	68.4	9.56	9.71
	100	0.139	21.8	66.5	66.2	8.94	8.92
	200	0.258	20.2	72.3	63.0	8.28	8.80
Mean		0.146	22.5	64.4	65.4	8.65	9.03
MR	Control	0.166	39.7	67.7	73.9	7.91	10.10
	50	0.187	42.5	73.4	74.2	8.44	12.30
	100	0.244	38.9	78.8	72.4	9.79	11.50
	200	0.387	36.7	83.5	70.2	10.4	11.00
Mean		0.246	39.5	75.9	72.7	9.14	11.23
MR + Co (12 ppm)	Control	0.335	41.8	69.0	75.8	9.88	14.60
	50	0.378	45.6	75.9	77.2	10.50	16.70
	100	0.491	43.9	81.4	74.2	11.60	15. 00
	200	0. 776	40.6	85.6	71.6	12.00	13.90
Mean		0.495	42.9	77.9	74.7	10.99	15.05
LSD at 5%		0.005	0.07	0.11	0.09	0.02	0.04

MR= Mycorrhizae
NMR = Non Mycorrhizae

Phosphorus status:-

Data in Tables (4 and 5) indicate that phosphorus content in both corn and soybean significantly increased as phosphorus addition increased. As it was expected the rate of increase in dicots (soybean) is higher than monocots (corn). Treated both studied plants with mycorrhizae has resulted an increase in p content. However, the role of mycorrhizae in increasing p absorption was clear in the dicots than in the monocots ones. Phosphorus content in soybean plants was nearly doubled by mycorrhizae treatment compared with non- mycorrhizal plants. However, the effect of mycorrhizae diminishes as P application increased. These results reflects clearly the role of mycorrhizae in P nutrition and goes hand in hand with those of **Lynch *et al.*, (1991)** who found that mycorrhizal inoculation increased P content and uptake. Also **Saad (1982)** added that the mycorrhizal plant explore more P through solubilization of the unavailable P- form. Relatively, little is known about the processes by which P is transferred from fungus to host plants. Several physiological mechanisms have been suggested to justify the increased P uptake by mycorrhizal inoculation **(Bolan *et al.*, 1984).** Confirm, **Moss (1973)**, mycorrhizae are able to lower the threshold concentration for effective phosphate acquisition from soil and or mycorrhizae take up P from solution faster than non-mycorrhizae plants.

Data in Table (4 and 5) show that, cobalt significantly promotive effect on P content of both soybean and corn with non-mycorrhizal and mycorrhizal inoculation. Phosphorus content of soybean and corn plants was nearly doubled in mycorrhizae and cobalt compared with mycorrhizae alone.

Cobalt significantly increased P content with both non-mycorrhizae and mycorrhizae inoculation plants. These results are in harmony with those obtained by **Nadia Gad *et al.*, (2011)** who stated that cobalt significantly increased N, P and K content in faba bean compared with control.

Manganese, Zinc and cobber status:-

Data in Tables (4 and 5) represent Mn, Zn and Cu content in both soybean and corn plants as affected by cobalt and mycorrhizae under different phosphorus levels. The figures show that Mn, Zn and Cu contents in both plants significantly increased with low phosphorus level (50 mg/ Kg soil) under non- mycorrhizae and mycorrhizal inoculation. Increasing P rates gave the adverse effect. Data also indicate that mycorrhizal fungi are known to improve the nutrition status of two plants. Increasing phosphorus supply significantly decreases mycorrhizal infection to a level not sufficient to enhance the content of the nutrients in the growth medium. These results are harmony with those obtained by **Mclaughlin *et al.*, (1990)** who found that mycorrhizae stimulated N-fixation in legumes, independently of improve P- supply to nodules. Plants inoculated with mycorrhizal significantly had higher minerals nutrient (Mn, Zn and Cu) concentrations than non-mycorrhizal plants. Data in Table (4 and 5) also indicate that, Mn, Zn and Cu contents of leaves increased progressively with increasing the rate of P-fertilizer, the stimulative effect being attributed to the high amount of available P and/or the increase in absorbing efficiency of plant roots. These results are good agreement with those obtained by **Barea and Gonzalez (1986)** who stated that mycorrhizal inoculation helped plants uptake of the nutrients which diffuse slowly in the soil solution to the rhizosphere, such effect being especially crucial in the case of phosphate and therefore, mycorrhizae contributed to a better exploitation of soil P and to a more efficient use of added P- fertilizers. This is true in spite of results introduced by **Gildon and Tinker (1982)** indicate an adverse effect for certain micronutrients, including Mn, Zn and Cu as well as Ni and Cd on the onion root mycorrhizal infection with high P rates.

Data in Tables (4 and 5) clearly indicate that cobalt had a significant promotive effect on the contents of Mn, Zn and Cu in both soybean and corn with non-mycorrhizae and mycorrhizal plants. With mycorrhizal inoculation plants, cobalt enhanced the contents of Mn, Zn and Cu in both soybean and corn plants, but this positive impact was more significant in the dicots plants compared to monocot ones. Values of Mn, Zn and Cu significantly increased in two plants as affected by cobalt increased and mycorrhizal infection. The observed reduction in the Mn, Zn and Cu concentrations of two studied plants in response to high phosphorus levels. These results are good agree with those obtained by **Wallace *et al.*, (1974)** who found that, the high P- fertilizers gave the adverse effect on Mn, Zn and Cu contents in sour orange. The adverse reduction may be attributed to the negative influence of excessive phosphorus on the availability, absorption, translocation and/or utilization of micronutrients. According, **Nadia Gad *et al.*, (2011)** cobalt significantly increased the contents of Mn, Zn and Cu in faba bean shoots and seeds compared with control plants.

Iron status:-

The results concerning Fe content in soybean and corn plants as affected by cobalt and mycorrhizae under different phosphorus levels are given in Tables (4 and 5). The results clearly indicate that Fe content in two plants gradually increases on higher phosphorus levels. Introducing mycorrhizae in plants media slightly increased the content of Fe in the low phosphorus levels (50 mg/Kg soil). These results are agree with findings of **Daft *et al.*, (1985) and Saad (1990)** who pointed that values of Fe in clover plants increased as affected by mycorrhizae inoculation and increasing phosphorus fertilization rate.

Data in Tables (4 and 5) also indicate that cobalt, as unexpected increased Fe content with both non-mycorrhizae and mycorrhizal infection soybean and corn plants. Cobalt alone decreased Fe content in higher plants such as corn, faba bean, pea, groundnut, cowpea, tomatoes and cucumber plants. **Bisht, (1991)** reported that the antagonistic relationships between Co and Fe elements.

Cobalt status:-

Data in Tables (4 and 5) show that cobalt content significantly increased with low phosphorus level (50 mg/Kg soil) under non-mycorrhizae and mycorrhizal infection soybean and corn plants. Increasing cobalt in plant media, cobalt content in two plants significantly increased. These results are harmony with those obtained by **Lambert *et al*., (1989)** who found that cobalt uptake was obtained in case of low phosphorus level by mycorrhizal fungi. **Nadia Gad *et al*., (2011)** reported that cobalt status in wheat seeds significantly increased with the increasing cobalt rate in plant media.

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