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IMPROVING GROWTH, YIELD AND NUTRIENT UPTAKE OF FABA BEAN (*Viciafaba* L.) BY INOCULATION WITH MYCORRHIZAY AND FOLIAR APPLICTION OF COBALT UNDER SALINE IRRIGATION WATER ON A CALCAREOUS SOIL.

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ABSTRACT

A field experiment was conducted during 2012/2013 and 2013/2014 winter growing seasons to evaluate the effect of mycorrhiza inoculation and foliar application of cobalt on growth, yield and nutrient uptake and quality of faba bean (variety Giza 643). The experiment was carried out under drip irrigation system on calcareous soil at the experimental farm El-Arish Agricultural Research Station, ARC, Egypt. The adopted treatments were arranged in a split plot design with four replicates, in which mycorrhiza treatments were allocated in the main plots, while five levels of cobalt e.g. 0, 5, 10, 15 and 20 ppm were foliar - sprayed on faba bean seedlings in the form of cobalt sulfate($CoSO_4$, $7H_2O$) were arranged in the sub plots.

The results showed that mycorrhiza inoculation significantly affected chlorophyll contents, growth characters i.e. plant height and branches Nºplant^{-1} and yield attributes e. g, pods Nº plant^{-1}and seed weight plant^{-1} and seed yield as well as macronutrients (N, P and K) and micronutrients (Co and Fe) contents in straw and seeds. The highest figures of the abovementioned traits were attained due to inoculation the faba bean seeds with mycorrhiza fungi in 1st and 2nd seasons.

Spraying the plant with cobalt at 10-ppm exhibited the highest figures of the abovementioned traits in 1st and 2nd seasons, comparable with the other tested concentrations.

Cobalt at 10 ppm as interacted with mycorrhiza inoculation enhanced chlorophyll, growth parameters, yield, status of N, P, K and Fe in shoots and seeds except iron, which was decreased particularly without mycorrhiza inoculation. Generally, the obtained results showed that increasing cobalt concentration above 10 ppm had an adverse effect on all parameters recorded.
keywords: *Faba bean growth, seed yield, mycorrhiza inoculation, nutrient uptake, cobalt foliar application*

INTRODUCTION

Faba bean (*Vicia faba* L.) is considered the main leguminous crop grown in winter season in Egypt where the seeds are used for human and animal's consumption. The Egyptian Government is pressing hard to increase the crop productivity, however, the production did not match the consumption.The new reclaimed areas are brought into faba bean cultivation for increasing the production horizontally and poor soil fertility is still the principle production constraints, especially micronutrients deficiency. In addition, salt stress has become an ever-increasing threat to food production, via reducing water potential, causing ion imbalance or disturbance in ion homeostasis and toxicity (Rabie and Almadini, 2005).Salt stress affects all the major processes such as growth, photosynthesis, protein synthesis and energy and lipid metabolism (Ramoliya *et al*., 2004; Parida and Das, 2005). Therefore, different scientific manners were paid and still ongoing aiming for improving the crop productivity under such soil conditions. Many studies have demonstrated that inoculation mycorrhiza play an important role in increasing nutrient uptake, improving osmotic regulation, as well as enhancing water use efficiency, chlorophyll content, photosynthetic rate and enhancing plant growthparticularly under salinity stress conditions and soil with low phosphorous level (Diallo *et al*., 2001; Burke *et al*., 2003; Tain *et al*., 2004). Recently, investigations revealed that inoculation of mycorrhiza fungi significantly increased chlorophyll a, b and total chlorophyll of soybean leaves in saline soil. In this concern, (Rahmawat *et al*., 2014). More or Khalil *et al*., (2014) found out that inoculating with mycorrhiza fungi had significant effects on chlorophyll a, b and total chlorophyll (a + b) and carotenoids contents compared to non-mycorrhiza-inoculated garden grass plants when the amount of phosphorus in soil is low Mycorrhiza colonize the cortical tissue of plants roots of most plant species and thus increase the root surface area and minerals uptake such as N, P, K, Ca, S, Cu ,Zn and other microelements from the soil. (Meyer, 2007). Furthermore, Miransari *et al*., (2007); Monther and Kamaruzaman (2012) and Vafadar *et al*. (2014) suggested that mycorrhiza fungi significantly increased root and shoot biomass as well as chlorophyll, and NPK content in plants.

Cobalt is a natural element found in rocks, soil, water, plants, and animals and has diverse industrial importance (Gál *et al*., 2007). Cobalt is an essential element for the synthesis of vitamin B12, which is required for human and animal nutrition (Young, 1983 and Smith, 1991). It is essential in trace amounts for humans and other mammals as it is an integral component of the vitamin B12 complex (Smith and Carson, 1981). Unlike other heavy metals, cobalt is safe for human consumption and up to 8 mg can be consumed on a daily basis without health hazard (Young, 1983). Cobalt is unequivocally essential for leguminous crops as it is required for nitrogen fixation by bacteria in root nodules and it even has beneficial effects on some non-leguminous crops (Kandil, 2007).

Moreover, cobalt reduces the peroxidase activity which is known to affect the breakdown of indole acetic acid (IAA), Plant hormones, especially abscisic acid (ABA) which play an important role in plant water relations through their effect on stomata and abscisic acid reduces opening of stomata (Gad, 2005). Cobalt, as transition element, is an essential component of several enzymes and co-enzymes. It has a role in affecting growth and metabolism of plants in different stages, depending on the concentration and status of cobalt in rhizosphere and soil (Palit and Sharma, 1994).The beneficial effects of cobalt include retardation of senescence of leaf, increase in drought resistance, regulation of alkaloid accumulation in medicinal plants, and inhibition of ethylene biosynthesis (Palit and Sharma, 1994). Due *et al.* (1999) Showed that cobalt at 8 ppm had a greatest growth parameters, pods and seeds yield in cowpea. Kandil (2007) found that addition of 20-ppm cobalt fertilization, improved all the growth and yield parameters as well as macro and micronutrients content of faba bean plants. Abdel Moez and Gad (2002); Kandil (2007); Gad and Kandil (2008); Gad *et al.* (2013); Gad *et al.* (2014) stated that addition of cobalt at 12 ppm increased the nodules formation of root and atmospheric N fixation by microorganisms which increased growth and yield parameters as well as macro and micronutrients content without human health hazard. The authors added that cobalt addition had a promotive effect for better status N, P and K, Co and Mn contents. However, cobalt and iron seemed to be competitive elements in the nutrition of cowpea, groundnut, soybean tomatoes, sweet potato and faba bean plants.

The present study was conducted to evaluate the efficacy of inoculating faba bean seeds with mycorrhiza fungi as combined with foliar spray of different cobalt levels on growth, yield and nutrients status of the crop under the conditions of El–Arish area, which are mainly representing in salinity stress and poor nutrients availability.

MATERIALS AND METHODS

A field experiments was carried out at the experimental farm of El–Arish Agricultural Research Station, Agricultural Research Center, Egypt. The experimental site is located at 31.12^o N latitude and 33.78° E longitude, Governorate of North Sinai. The present study is aiming at determining the effect of mycorrhiza inoculation and cobalt as foliar spray on yield, yield components and chemical contents of faba bean (Variety Giza 643) under Al-Arish soil conditions during 2012/2013 and 2013/2014 winter growing seasons. Representative surface soil samples (0-30 cm) were collected from the experimental field to determine particle size distribution and some physical and chemical properties of the soil according to Ryan *et al.* (1996) and the results are shown in Table 1.

The experimental unit consists of five ridges, 4 meter in length and 70 cm width (14 m^2) and drip irrigation system was adapted at the experimental field. The adopted treatments were arranged in a split-plot design with four replications, in which mycorrhiza treatments were allocated in the main plots, while the sub ones were designated for the assessed cobalt levels e.g. 0, 5, 10, 15 and 20 ppm in cobalt sulphate form ($CoSo_4$, $7H_2O$). Before sowing, faba bean seeds (Giza 643) were washed with water, air-dried and soaked in the suspension of rhizobium leguminosarum for 2 hours and inoculated with mycorrhiza. The mycorrhiza fungi and rhizobium leguminosarum used in this study were provided by Microbiology Research Dept., Soils, Water and Environment Research Institute, Agricultural Research Center (ARC), Egypt. Planting was took place on 28th and 20th October in 1st and 2nd seasons, respectively. The plants were thinned to leave two plants per hill three weeks later. The tested cobalt levels were foliar- sprayed 40 days post planting. Calcium superphosphate and potassium sulphate were applied during seed- bed preparation at 30 kg P_2O_5 and 24 kg K_2Ofed^{-1}, rates respectively. Nitrogen fertilizer was applied in three equal portions at 25, 40 and 55 days from sowing as ammonium nitrate (33.5%N) at the rate of 20 kg /fed. The N fertilizer dose was completely dissolved in the appropriate water quantity and the supernatant was injected into the drip irrigation system. Irrigation water was pumped from a well located at the farm and chemical analysis of the irrigation water was performed according to Richards (1954), Table 2.

Table 1: Particle size distribution and some physiochemical soil properties of the experimental site in 2012/2013 and 2013/2014 seasons.

Properties		2012/2013	2013/2014
Particle size distribution (%)			
Coarse sand		13.4	11.8
Fine sand		54.5	52.6
Silt		31.4	34.8
Clay		0.7	0.7
Textural class		Sandy loam	Sandy loam
EC_e (dSm^{-1})		2.92	3.42
pH (1:2.5)		7.55	8.36
$CaCO_3$ (%)		18.20	16.80
Soluble cations($meqL^{-1}$)	Ca^{+2}	5.2	5.7
	Mg^{+2}	7.1	7.9
	Na^+	16.2	19.5
	K^+	1.6	1.9
Soluble ions ($meqL^{-1}$)	HCO^-_3	8.5	10.8
	Cl^-	12.8	14.5
	SO_4^{--}	8.8	9.7
Available nutrients (ppm)	N	11.1	12.3
	P	3.55	4.65
	K	26.6	29.3
Cobalt (ppm)	Soluble	Available	Total
	0.18	1.55	4.82

Table 2: Some chemical analysis of the irrigation water

Season	Parameters									
	EC_e		pH	Soluble cations (mqL^{-1})				Soluble cations (mqL^{-1})		
	(dSm^{-1})	ppm		Na^+	Mg^{++}	Ca^{++}	K^+	Cl^-	HCO_3^-	$SO_4^=$
2012/2013	5.33	3411	7.5	38.4	6.2	9.2	0.1	42.3	4.7	6.9
2013/2014	5.46	3493	7.2	39.9	6.5	8.9	0.1	43.9	4.1	7.4

Fifty days after planting, four leaf from plant tip was taken to extract and determine photosynthetic pigments (chlorophyll a, b and total chlorophyll) according to Moran (1982). At harvest, ten guarded plants were hand pulled randomly from each sub-plot to determine, growth parameters e.g.plant height and number of branches plant^{-1} and yield attributes e.g. pod N^{o}plant^{-1}, 100 - seed weight (g) and seed weight (g plant^{-1}). Plants of the three inner ridges were harvested and biological, seed and straw yields were determined and expressed as kgfed^{-1}. Representative seed and straw samples were taken to determine total nitrogen by wet oxidation using Kjeldahl digestion and distillation procedures, Parkinson and Allen (1975), while phosphorous was determined calorimetrically using ammonium molybdate and ammonium metavanadate according to Ryan *et al.* (1996). Potassium was determined flame spectrophotometrically as described by Black (1982). Cobalt and iron were determined according to the method out lined by A.O.A.C. (1990). Protein content % was estimated by multiplying the N content% with the conversion factor of 6.25. Obtained results were statistically analyzed using M stat computer package to calculate F ratio according to Snedecor and Cochran (1980). Least Significant Differences (LSD) was used to differentiate means at the 0.05 level (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

Chlorophyll pigments content:

The results in Table 3 show that inoculating faba bean seeds with mycorrhiza fungi significantly increased leaves chlorophyll a, b and chlorophyll (a + b) contents in 1st and 2nd seasons of study, comparable with the un-inoculated seeds (control). The increases in chlorophyll a, b and a + b, due to mycorrhiza inoculation, amounted to 14.36, 14.18 and 14.31% in 1st season and to 17.99, 9.35 and 14.98%in 2nd season, respectively, comparing to withoutinoculation.These results are in harmony with those obtained by Diallo *et al.* 2001; Burke *et al.* 2003 and Tain *et al.* 2004 who reported that mycorrhiza fungi inoculation lead to increase chlorophyll content and photosynthetic rate and enhancing plant growth particularly under salinity stress conditions. In connection, Khalil *et al.* (2014) stated that mycorrhiza fungi symbiosis could increase chlorophyll concentration as well as carotenoids and enhancing the photosynthetic ability under the stress conditions.

Table 3: chlorophyllous pigments in faba bean leaves as affected by mycorrhiza inoculation, different cobalt levels and their interaction at 50 days from sowing under saline irrigation water in 2012/2013 and 2013/2014 seasons.

Mycorrhiza inoculation Treatment	Cobalt level	2012/2013 Season ($mg\ dm^{-2}$)			2013/2014 Season ($mg\ dm^{-2}$)		
		Chlorophyll A	Chlorophyll B	Chlorophyll A + B	Chlorophyll A	Chlorophyll B	Chlorophyll A + B
without Mycorrhiza inoculation	without	1.630	0.780	2.410	1.760	0.890	2.650
	5 ppm	1.940	0.910	2.850	2.130	1.070	3.200
	10 ppm	2.390	1.260	3.650	2.580	1.670	4.250
	15 ppm	1.760	0.840	2.600	1.910	0.980	2.890
	20 ppm	1.470	0.580	2.050	1.570	0.740	2.310
with Mycorrhiza inoculation	without	1.890	0.890	2.780	2.090	1.030	3.120
	5 ppm	2.280	1.060	3.340	2.540	1.240	3.780
	10 ppm	2.790	1.340	4.130	2.970	1.560	4.530
	15 ppm	1.970	0.980	2.950	2.230	1.130	3.360
	20 ppm	1.580	0.720	2.300	1.910	0.890	2.800
LSD 0.0 5%		0.215	0.100	0.166	0.180	0.110	0.356
Mycorrhiza Treatments mean							
Mycorrhiza inoculation	Without	1.838	0.874	2.712	1.990	1.070	3.060
	inoculated	2.102	0.998	3.100	2.348	1.170	3.518
F Test		44.791*	38.443*	67.770*	38.606*	19.962*	18.177*
Cobalt levels mean							
Cobalt levels	Without	1.760	0.835	2.595	1.925	0.960	2.885
	5 ppm	2.110	0.985	3.095	2.335	1.155	3.490
	10 ppm	2.590	1.300	3.890	2.775	1.615	4.390
	15 ppm	1.865	0.910	2.775	2.070	1.055	3.125
	20 ppm	1.525	0.650	2.175	1.740	0.815	2.555
LSD 0.05%		0.094	0.082	0.151	0.125	0.078	0.214

The adopted cobalt concentrations exerted significant influence to alter chlorophyllous pigments content in 1st and 2nd seasons. The highest figures of a, b and a + b chlorophyll contents were recorded with 10 ppm of cobalt concentration, and that trend was similar in 1st and 2nd seasons. Furthermore, the other tested cobalt concentrations revealed lower values of the investigated chlorophyllous pigments in1st and 2nd seasons of study. The 2- seasons reduction mean in a, b and a + b chlorophyll contents reached to (45.66, 20.80, 36.47 and 64.66%), (61.96, 35.91, 47.97 and 99.8%) and (51.04, 25.74, 40.33 and 75.34%), respectively, under without, 5, 15 and 20 ppm of cobalt concentrations comparable with 10 ppm one. These results could be enhanced with those obtained by El-Sheekh *et al*. (2003) who found that the lower cobalt concentrations led to significant increases in chlorophyll and carotenoids of the algae (Monoraphidiumminutum and Nitzchiaperminuta). On contrast, higher cobalt concentrations were associated with progressive reductions in chlorophyll pigments content. De Filippis *et al*. (1981) pointed that reduction of chlorophyll a content is a common symptom of heavy metals toxicity, which could be attributed to inhibition of reduction steps in the biosynthetic pathways of the pigments. In connection, Csatorday *et al*. (1984) stated that the proposed mechanism for this inhibition is replacing of magnesium in the chlorophyll molecule and consequently cells accumulate protoporphyrin and synthesis of chlorophyll is blocked.

The interaction effect of mycorrhiza treatments and cobalt levels on chlorophyllous pigments content was significant, and the highest value of the chlorophyllous contents were obtained due to mycorrhiza inoculation as combined with cobalt foliar application at 10 ppm level in 1st and 2nd seasons.

Growth and seed yield attributes:

Data in Table 4 illustrate that inoculating faba seeds with mycorrhiza fungi exerted significant effects to alter growth parameters and seed yield attributes under investigation in 1st and 2nd seasons. The increases in plant height and branches N° plant^{-1}growth parameters, with mycorrhiza inoculation, were (10.38 and 11.32%) and (12.90 and 11.27%) higher than those attained under without inoculation, respectively, in 1st and 2nd seasons. Furthermore, the studied seed yield attributes e.g. pods N° plant^{-1}, seed weight plant^{-1} and 100- seed weight exhibited similar trends, where the increase values reached to (7.74 and 9.94%), (13.44 and 18.43%) and (7.79 and 6.68%) due to mycorrhiza inoculation, respectively, in 1st and 2nd seasons higher than those under without mycorrhiza inoculation. In connection, Ghorbanian et al. (2011) mentioned that Mycorrhiza fungi extending their root absorbing area through their mycelium network and changing unavailable phosphorus into available form and translate to root system causing increases in plant height and growth parameters.The positive response of yield attributes to mycorrhiza fungi inoculation is in harmony with those of Liu et al. (2000), Bianciotto and Bonfante (2002), Abdul-Wasea and Elhindi (2010).

In addition, Ibrahim *et al*. 2010 and Abdel-Rahman *et al*. 2011 stated that mycorrhiza inoculated plants may be due to the ability of mycorrhiza to produce hyphae, which are microscopic tubes colonize plant roots and grown out the soil further than hairy roots. Nutrients were taken up by the hyphae to the plant, which lead to a very efficient mobilization and uptake of phosphate, nitrogen, potassium, magnesium, copper, zinc, boron, Sulphur and other elements that were transported to the plant.

Data Table 4 reveal that cobalt foliar spray at the adopted concentrations exhibited significant influence on the studied growth characters and seed yield attributesin 1st and 2nd seasons. The highest values of growth characters e.g. plant height and branches N° plant^{-1} resulted from the application of 10 ppm of cobalt. The other tested concentrations resulted in lower plant height values reached to (21.30 and19.04 %), (10.02 and 10.38%), (19.75 and17.63%) and (31.84 and 27.88%) in 1st and 2nd seasons, respectively, under without, 5, 15 and 20 ppm of cobalt concentrations comparing to 10 ppm one. Branches N° plant^{-1}parameter exhibited the same trend, where the reduction values were (47.82 and 40.74 %), (21.43 and 18.75%), (21.43 and 26.67%) and (78.95 and 65.22%), respectively, in 1st and 2nd seasons in the same order of the investigated cobalt levels. In this respect, Gad (2005) reported that low cobalt levels being with positive effect due to inducing several effects in hormonal synthesis and metabolic activity, while the higher cobalt levels were found to increase the activity of some enzymes such as peroxidase and catalase in plant and hence increasing the catabolism rather than the anabolism.

The interaction data showed that the growth parameters and seed yield components of faba been plants were significantly affected due to mycorrhiza fungi inoculation treatments as combined with the adopted cobalt levels. The highest figures of growth parameter and seed yield components resulted from mycorrhiza inoculation as interacted with foliar spray of cobalt at 10-ppm level in 1st and 2ndseasons.

Table 4: Growth and seed yield attributes for faba bean as affected by mycorrhiza inoculation, cobalt levels and their interactions under saline irrigation water in 2012/2013 and 2013/2014 seasons.

Mycorrhiza Inoculation Treatment	Cobalt level	Plant height (cm)	Branches Nº plant^{-1}	Pods Nº plant^{-1}	Seed weight (gplant^{-1})	100-seed weight (g)
				2012/2013 season		
Without mycorrhiza inoculation	without	53.63	2.20	3.20	18.28	55.58
	5 ppm	58.42	2.60	3.80	21.55	59.73
	10 ppm	62.94	3.20	4.20	27.87	67.96
	15 ppm	54.87	2.60	3.20	18.97	56.23
	20 ppm	48.43	1.80	2.40	14.12	48.76
Mycorrhiza inoculation	without	57.92	2.40	3.40	20.93	59.22
	5 ppm	64.58	3.00	4.10	23.22	65.92
	10 ppm	72.37	3.60	4.40	31.42	74.14
	15 ppm	58.12	3.00	3.60	21.56	60.17
	20 ppm	54.21	2.00	2.60	17.21	51.23
LSD 0.05%		3.91	0.36	0.52	2.71	3.91
Mycorrhiza treatments mean						
Without Inoculation		55.66	2.48	3.36	20.16	57.65
Inoculation		61.44	2.80	3.62	22.87	62.14
F Test		19.53*	26.53*	67.43*	61.12*	20.32*
Cobalt levels mean						
without		55.78	2.30	3.30	19.61	57.40
5 ppm		61.50	2.80	3.95	22.39	62.83
10 ppm		67.66	3.40	4.30	29.65	71.05
15 ppm		56.50	2.80	3.40	20.27	58.20
20 ppm		51.32	1.90	2.50	15.67	50.00
LSD 0.05%		3.27	0.48	0.31	0.86	3.11
				2013/2014 season		
Without mycorrhiza inoculation	without	57.14	2.60	3.30	20.42	59.86
	5 ppm	60.96	3.00	4.20	24.67	62.93
	10 ppm	66.78	3.60	4.60	30.12	72.68
	15 ppm	57.87	2.80	3.30	20.55	60.10
	20 ppm	54.13	2.20	2.70	17.40	54.33
Mycorrhiza inoculation	without	63.23	2.80	3.70	23.25	64.57
	5 ppm	68.85	3.40	4.40	28.57	70.88
	10 ppm	76.52	4.00	5.00	35.28	76.10
	15 ppm	63.96	3.20	3.80	24.31	65.03
	20 ppm	57.92	2.40	3.00	22.60	60.24
LSD 0.05%		4.18	0.35	0.38	2.62	4.82
Mycorrhiza treatments mean						
Without Inoculation		59.38	2.84	3.62	22.63	61.98
Inoculation		66.10	3.16	3.98	26.80	67.36
F Test		22.33*	31.41*	84.50*	67.43*	24.45*
Cobalt levels mean						
Without		60.19	2.70	3.50	21.84	62.22
5 ppm		64.91	3.20	4.30	26.62	66.91
10 ppm		71.65	3.80	4.80	32.70	74.39
15 ppm		60.91	3.00	3.55	22.43	62.57
20 ppm		56.03	2.30	2.85	20.00	57.29
LSD 0.05%		3.76	0.33	0.41	1.86	3.40

Seed, straw and biological yields:

Data in Table 5 show that mycorrhiza fungi treatments had significant effects on seed, straw and biological yields in 1st and 2nd seasons. Inoculating faba bean seeds with mycorrhiza fungi resulted in the highest figures of seed, straw and biological yields amounted to (10.60 and 13.62%), (8.37and 9.85%) and (9.13 and11.18 %), respectively, in 1st and 2nd seasons more than those under without mycorrhiza inoculation. The current results are in accordance with those reported by Ahmed *et al*. (2000) and Al-Karaki *et al*. (2007) who stated that the increase in faba bean yield could be attributed to the role of mycorrhiza fungi in enhancing nutrient uptake, water relations and plant growth and protecting the plants against abiotic stresses such as drought and salinity.

The adopted cobalt levels induced significant effects to influence seed, straw and biological yields of faba bean in 1st and 2nd seasons. The highest seed, straw and biological yields figures (925.96 and1051.89 kgfed^{-1}), (1810.88 and 1965.56kgfed^{-1}) and (2736.84 and3017.45 kgfed^{-1}), respectively, in 1st and 2nd seasons were recorded with 10 ppm concentration. The other tested cobalt concentrations seemed to reduce the values of seed, straw and biological yields in 1st and 2nd seasons. The 2nd season mean of reductions in seed yield reached to 48.80, 18.21, 43.24 and 62.72% due to without, 5, 15 and 20 ppm of cobalt concentrations, comparable with 10-ppm concentration. The corresponding 2-season mean of reductions in straw and biological yields were (57.04, 20.30, 47.67 and 70.03%) and (54.11, 19.61, 46.10 and 67.45%), respectively, in the same order of cobalt concentrations. These results are in agreement with those obtained by Atta-Aly et al. (1991); Anter and Gad (2001) and Kandil, (2007) who stated that positive responses associated with low cobalt level may be attributed to catalase and peroxidase enzymes activities which were found to decrease with low levels of cobalt. On contrary, higher cobalt ones. While, these enzymes are known to induce plant respiration possibly resulting in successive consumption for products of photosynthesis and subsequently reduction in plant growth (Flanagam and Owens, 1985).

The interaction between the assessed mycorrhiza inoculation treatments and cobalt levels was significantly affected seed, straw and biological yields, Table 5.The highest figures of seed, straw and biological yields were attained due to mycorrhiza inoculation as interacted with 10 ppm of cobalt concentration, and such trend was true in1st and 2nd seasons.

Table 5: Seed, straw and biological yields of faba bean (Kg Fed^{-1}) as affected by mycorrhiza inoculation, cobalt levels and interaction under saline irrigation water in 2012/2013 and 2013/2014 seasons.

Mycorrhiza treatment	Cobalt level	2012/2013 season Seed Yield (Kgfed^{-1})	2012/2013 season Straw yield (Kgfed^{-1})	2012/2013 season Biological yield (Kgfed^{-1})	2013/2014 season Seed Yield (Kgfed^{-1})	2013/2014 season Straw yield (Kgfed^{-1})	2013/2014 season Biological yield (Kgfed^{-1})
Without mycorrhiza inoculation	Without	600.23	1134.76	1734.99	668.45	1212.22	1880.67
	5 ppm	726.45	1402.43	2128.88	805.12	1493.86	2298.98
	10 ppm	883.26	1757.43	2640.69	981.33	1873.71	2855.04
	15 ppm	618.92	1197.58	1816.50	695.62	1292.28	1987.90
	20 ppm	543.15	1020.44	1563.59	618.32	1096.93	1715.25
Mycorrhiza inoculation	without	653.76	1178.57	1832.33	734.85	1283.57	2018.42
	5 ppm	843.31	1644.18	2487.49	971.10	1736.10	2707.20
	10 ppm	968.67	1864.32	2832.99	1122.44	2057.41	3179.85
	15 ppm	661.43	1268.27	1929.70	787.58	1355.61	2143.19
	20 ppm	602.27	1102.66	1704.93	666.32	1222.97	1889.29
LSD 0.05%		49.72	41.81	82.54	58.08	53.53	102.71
Mycorrhiza treatments means							
Without inoculation		674.40	1302.53	1976.93	753.77	1393.80	2147.57
Mycorrhiza inoculation		745.89	1411.60	2157.49	856.46	1531.13	2387.59
F Test		69.50*	36.21*	98.93*	57.32*	41.83*	107.51*
Cobalt levels means							
Cobalt levels	Without	627.00	1156.67	1783.66	701.65	1247.90	1949.55
	5 ppm	784.88	1523.31	2308.19	888.11	1614.98	2503.09
	10 ppm	925.96	1810.88	2736.84	1051.89	1965.56	3017.45
	15 ppm	640.18	1232.93	1873.10	741.60	1323.95	2065.55
	20 ppm	572.71	1061.55	1634.26	642.32	1159.95	1802.27
LSD 0.05%		37.11	34.99	66.64	49.26	43.68	84.00

Macronutrients content:

The adopted mycorrhiza fungi Inoculation treatments significantly affected N, P and K contents in seeds and straw of faba bean in 1st and 2nd seasons, Table 6. The increases in seed N, P and K contents, due to mycorrhiza inoculation, amounted to (14.36 and 14.24%), (33.62 and 37.19%) and (17.25 and 22.72%) higher than those under without inoculation, respectively, in 1st and 2nd seasons. Similar trends for straw N, P and K contents, where the increases with mycorrhiza inoculation reached to (22.45 and 27.34%), (26.24 and 22.79%) and (18.50 and 21.40%), respectively, in 1st and 2nd seasons comparable with under without mycorrhiza inoculation. These results are agree with findings of Rabie and Almadini (2005) who pointed that inoculation of mycorrhiza fungi increased number of nodulation, efficacy of N-fixation by Rhizobium and nutrient uptake under salinity stress. Moreover, Khalil *et al*. (2014) stated that mycorrhiza fungi inoculation clearly increased protein and mineral ions contents compared with non-inoculated plants under draught stress. In connection, Ghorbanian *et al*. (2011) mentioned that mycorrhiza fungi extending their root absorbing area through their mycelium network and changing unavailable phosphorus to available form and translate to root system cause increases in plant growth parameters.

With regard to interaction effects of the treatments under study, it was noticed that inoculating faba seeds with mycorrhiza fungi as combined with cobalt at 10-ppm concentration increased significantly seeds N, P and K contents of seeds and straw. This observation similar to that recorded by Gad et al. (2012) who stated that inoculation mycorrhiza fungi with addition of cobalt had a significant promotive effect on minerals composition and macro-elements content of corn plants.

Table 6: Seed and straw N, P and K contents (Kg Fed^{-1}) of faba bean as affected by mycorrhiza inoculation, cobalt levels and interaction under saline irrigation water in 2012/2013 and 2013/2014 seasons.

Mycorrhiza treatment	Cobalt Level (ppm)	2012/2013 season N ($Kgfed^{-1}$) seeds	N straw	P ($Kgfed^{-1}$) seeds	P straw	K ($Kgfed^{-1}$) seeds	K straw	2013/2014 season N ($Kgfed^{-1}$) seeds	N straw	P ($Kgfed^{-1}$) seeds	P straw	K ($Kgfed^{-1}$) seeds	K straw
Without Mycorrhiza inoculation	Without	16.68	22.01	1.92	1.70	11.40	18.72	18.98	24.73	2.41	2.18	13.23	20.97
	5	21.28	29.87	2.61	2.24	15.54	24.96	24.72	34.06	3.14	2.96	18.11	27.49
	10	29.06	41.82	3.62	3.86	21.02	34.62	33.46	48.53	4.22	4.50	25.22	38.60
	15	19.50	24.19	2.10	1.92	12.19	20.48	20.31	27.52	2.57	2.33	14.68	24.29
	20	14.07	17.04	1.52	1.33	8.85	15.51	16.26	19.52	1.92	1.65	11.07	17.66
Mycorrhiza inoculation	Without	19.35	25.57	2.28	2.12	13.20	21.33	22.93	29.89	3.23	2.57	15.65	24.90
	5	26.22	39.29	3.71	3.29	18.80	32.55	31.95	46.53	4.76	3.98	23.60	36.63
	10	33.03	50.15	4.94	4.47	23.44	39.52	30.74	60.28	5.29	5.35	31.20	46.91
	15	19.97	28.41	2.77	2.54	14.22	23.97	25.28	32.94	3.62	2.85	17.48	27.11
	20	16.50	21.83	1.98	1.54	11.26	18.08	19.06	24.34	2.67	1.96	13.05	21.04
LSD 0.05%		2.01	2.98	0.29	0.31	1.61	2.02	3.61	3.34	0.64	0.34	1.93	3.52
Mycorrhiza inoculation treatments mean													
Without inoculation		20.12	26.99	2.35	2.21	13.80	22.86	22.75	30.47	2.85	2.72	16.46	25.80
Mycorrhiza inoculation		23.01	33.05	3.14	2.79	16.18	27.09	25.99	38.80	3.91	3.34	20.20	31.32
F Test		85.5*	35.7*	23.4*	26.6*	58.6*	95.6*	73.2*	41.2*	28.3*	3.34*	19.7*	31.3*
Cobalt levels means													
Cobalt levels (ppm)	Without	18.02	23.79	2.10	1.91	12.30	20.03	20.96	27.31	2.82	2.38	14.44	22.94
	5	23.75	34.58	3.16	2.77	17.17	28.76	28.34	40.30	3.95	3.47	20.86	32.06
	10	31.05	45.99	4.28	4.17	22.23	37.07	32.10	54.41	4.76	4.93	28.21	42.76
	15	19.74	26.30	2.44	2.23	13.21	22.23	22.80	30.23	3.10	2.59	16.08	25.70
	20	15.29	19.44	1.75	1.44	10.06	16.80	17.66	21.93	2.30	1.81	12.06	19.35
LSD 0.05%		4.64	9.67	0.94	0.68	4.23	5.51	2.75		1.02		5.36	

Cobalt and iron contents:

Data in Table 7 reveal that cobalt content in seeds and straw were significantly influenced due to the adopted mycorrhiza inoculation treatments in 1st and 2nd seasons. Mycorrhiza inoculation resulted in higher seed cobalt and iron contents amounted to (31.25 and 44.36%) and (29.93 and 41.12%) in 1st and 2nd seasons, respectively, comparable to without mycorrhiza inoculation. Straw cobalt and iron contents exhibited similar trend, where higher values were recorded due to mycorrhiza inoculation and reached to (21.72 and 20.29 %) and (23.52 and 32.83%) higher than those of without mycorrhiza inoculation, respectively, in 1st and 2nd seasons.

Table 7: Cobalt and iron contents of faba bean seeds and straw as affected by mycorrhiza inoculation and cobalt levels and interaction under saline irrigation water in 2012/2013 and 2013/2014 seasons.

Mycorrhiza inoculation treatment	Cobalt Level (ppm)	2012/2013 Season Cobalt (ppm) seeds	Cobalt straw	Iron (ppm) seeds	Iron straw	2013/2014 Season Cobalt (ppm) seeds	Cobalt straw	Iron (ppm) seeds	Iron straw
Without mycorrhiza inoculation	Without	0.35	1.85	33.33	50.13	0.48	1.96	36.62	54.62
	5	0.58	3.16	38.56	61.88	0.77	3.33	41.15	60.15
	10	1.32	5.82	30.15	55.96	1.48	6.15	32.95	52.95
	15	1.71	8.13	26.46	45.21	1.93	8.61	26.95	46.10
	20	2.43	10.02	20.13	38.39	2.68	10.37	19.28	39.15
Mycorrhiza inoculation	Without	0.52	2.91	36.42	53.84	0.67	3.18	40.88	56.88
	5	0.86	4.42	42.14	58.93	1.09	4.77	42.33	60.33
	10	1.77	7.21	43.29	60.74	1.92	7.63	45.96	69.96
	15	2.24	9.56	45.34	63.42	2.48	10.15	47.00	73.78
	20	3.03	11.21	47.43	65.65	3.37	11.82	50.06	75.06
LSD		0.14	0.93	2.38	2.06	0.15	1.13	3.42	2.03
Mycorrhiza treatment mean									
Without Mycorrhiza inoculation		1.28	5.80	29.73	50.31	1.47	6.08	31.39	50.59
Mycorrhiza inoculation		1.68	7.06	42.92	60.52	1.91	7.51	45.24	67.20
F Test		0.26	0.08	8.44	8.65	0.34	0.53	10.43	11.81
Cobalt levels mean									
Cobalt levels	Without	0.44	2.38	34.88	51.99	0.58	2.57	38.75	55.75
	5 ppm	0.73	3.79	40.35	60.41	0.93	4.05	41.74	60.24
	10 ppm	1.55	6.52	36.72	58.35	1.70	6.89	39.46	61.46
	15 ppm	1.98	8.85	35.90	54.32	2.21	9.38	36.98	59.94
	20 ppm	2.73	10.62	33.78	52.02	3.03	11.10	34.67	57.11
LSD 0.05%		0.11	0.20	1.83	5.20	0.21	1.03	2.35	3.87

The assessed cobalt levels exerted significant influences to alter cobalt and iron contents in either seeds or straw of faba bean in 1st and 2nd seasons. Seed and straw cobalt contents were increased as the tested cobalt level increased, and straw exhibited highest contents. Such findings are coincided with Abdul Jaleel *et al*. (2009) who found that cobalt content in soybean increased with increasing cobalt addition in plant media. Data also reveal that higher values of iron contents either in seeds or straw of faba bean were recorded with the lower cobalt level e.g. 5ppm concentration in 1st and 2nd seasons. In connection, Bisht, (1991), Kandil (2007) and Gad *et al*. (2012) justified such trend that a certain antagonistic relationships between Co and Fe elements are occurred.

Interactions of the adopted treatments reveal significant effects to influence cobalt and iron contents in seeds and straw of faba bean in 1st and 2nd seasons. Fortunately, lower level of cobalt concentration was superior to attain acceptable figures of seed cobalt content and higher iron seed content as well. However, considerable attention should be paid concerning applying this element (Co) as a fertilizer, and further studies are needed to learn more about this element and its mechanisms in soil and plant.In connection, Young (1983) pointed that the daily cobalt requirement for human nutrition could reach 8 ppm without health hazard. Fortunately, data of seed cobalt concentrations under all treatments and interactions in the present trial were below this level.

On conclusion**,** mycorrhiza inoculation and cobalt as foliar spray were promising treatments in the newly reclaimed soils. It is used to reduce the harmful effect of high temperature, drought and salinity in these soils. From the study it could be suggested that Pre-treated faba bean seeds with soaking in suspension of mycorrhiza and foliar sprayed with cobalt at 10-ppm concentration, enhanced all the studied characteristics including chlorophyll contents, growth, seed, straw yields, and yield attributes as well. Data proved that faba bean seeds cobalt content was secure for the human consumption. The daily cobalt requirements for human nutrition could reach 8 ppm depending on cobalt levels in the local supply of drinking water without health hazard. Therefore, considerable attention should be paid concerning applying this element (Co) as a fertilizer, and further studies are needed to learn more about this element and its mechanisms in the soil and plant.

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تحسين نمو وإنتاجية الفول البلدي بالتلقيح بالميكروهيزا والاضافة الورقية للكوبلت تحت ظروف الري بمياه مالحة في الأراضي الجيرية

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أقيمت تجربة حقلية في المزرعة التجريبية بمحطة البحوث الزراعية بالعريش التابعة لمركز البحوث الزراعية – محافظة شمال سيناء في الموسمين الشتويين ٢٠١٣/٢٠١٢ و٢٠١٤/٢٠١٣ لدراسة تأثير تلقيح تقاوي الفول البلدي صنف جيزة ٦٤٣ بالميكروهيزا ورش البادرات النامية بمعدلات مختلفة من الكوبالت ٠,٥,١٠,١٥,٢٠ جزء مليون-١ على مكونات المحصول ومحصولي البذور والقش والتركيب الكيميائي.

وكانت أهم النتائج كما يلي: -

١ – تغليف البذور بالميكروهيزا قد أعطى زيادة في طول النبات وعدد الأفرع وعدد ووزن البذور لكل نبات ومحصولي البذور والقش وكذلك النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم بالإضافة إلى الحديد والكوبالت في البذور والقش وكذلك محتوى الأوراق من كلوروفيل أ، ب في كلا الموسمين مقارنة بالكنترول.

٢ – إضافة الكوبالت بتركيز ١٠ جزء مليون-١ أعطي زيادة معنوية في جميع الصفات المدروسة. وأدت الزيادة في تركيز الكوبالت المضاف حتى ١٥ جزء مليون-١ إلى إحداث نقص الزيادات في صفات النمو والمحصول بينما أدى التركيز العالي للكوبالت (٢٠ جزء مليون-١) إلى انخفاض المحصول وزيادة محتوى الأوراق، وكذلك البذور من الكوبالت ونقص محتواهما من الحديد في كلا الموسمين.

٣ – أدت إضافة الكوبالت بتركيز ١٠ جزء مليون-١ مع الميكروهيزا الى الحصول على أفضل مقايس النمو والصفات المحصولية وايضا زيادة محتوي البذور والقش من العناصر الكبرى والحديد وانخفاض محتواها من الكوبلت مقارنة بباقي المعاملات تحت الدراسة.