International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304, ISSN(Online): 2455-9563
Vol.9, No.9, pp 158-169, 2016

Physiological and chemical response of faba bean to water regime and cobalt supplement in sandy soils.

El-Metwally I.M.[1] and Aml E.A. El-Saidy [2]

[1]Botany Dept., National Research Centre, El-Bohooth St., Dokki, Cairo, Egypt
[2]Seed Technology Dept., Field Crops Research Institute, ARC, Egypt

Abstract : Two field experiments were carried out to study faba bean physiological and chemical response to water requirements and cobalt nutrition. Experiments were conducted at Research and production Station, National Research Centre, El-Nobaria, Beheara Governorate, during the two successive winter seasons 2012/2013 and 2013/2014. The results showed that irrigation with 100% of water requirement significantly increased plant height, shoot dry weight, root dry weight (gm), leaf area index, yield and nutrients status in shoot , root and seeds compared to addition of 50% of water requirement. Results appeared that no significant differences between 100 and 75% of water requirement. Results also indicated that cobalt concentrations up to 15 ppm had a promotive effect on aforementioned characters in faba bean. The interaction between water requirement and cobalt levels had significant effect on shoot dry weight, leaf area index, seed yield and protein percentage. Irrigation with 100% of water requirement integrated with cobalt at the rate of 15ppm gave the maximum values of shoot dry weight, leaf area index, seed yield and protein percentage. Moreover, it could be concluded that spraying faba bean plants with 15 ppm cobalt under 75 or 100% water requirements for improving growth, productivity and quality of faba bean seeds. Also, increase tolerance of the plants to water shortages under sandy soil conditions.
Keywords: Faba bean, Water requirements, Cobalt, Yield, nutrients status, Sandy soil.

Introduction

Highly graduate increase of food demand in the developed countries implies more production of carbohydrate and protein containing crops, (i.e., cereals and leguminous). Faba bean is an important crop in the crop rotation in Egypt, due to its fixation of atmospheric nitrogen, which enriches the soil with nitrogen and organic matter and improving water use efficiency of the cropping system (Ahmed *et al* [1]). On the other hand, sandy soils are highly considered in agriculture horizontal expansion plans in most of the third world countries. Overall, plant growth is a process of biomass accumulation (Hopkins [2]) and is a consequence of the interaction of the photosynthesis, long-distance transport, respiration, water relations and mineral nutrition processes. Growth is the most important process to understand in predicting plant responses to environment (Lambers *et al* [3]). Irradiance, temperature, soil water potential, nutrient supply and elevated concentrations of aatmospheric Co_2 are some external factors influencing crop growth and development.

Water is the most limiting natural resources for agricultural production in arid and semi-arid regions. Nowadays the total annual water resources of Egypt are about 67.27 billon m^3 (Abou Zied [4]). The agricultural sector consumes almost 80 - 90 % of the total water allocated to Egypt. The ever increasing of the Egyptian population and the limited water resources led to a steady decrease in per capita share of water. Therefore, decreasing plant water consumption through using more efficient irrigation methods (Tayel *et al* [5]). Plant breeding technology, longer irrigation intervals, higher moisture depletion, skipping irrigation during the early vegetative growth or during maturation stage, and timing the length of irrigation interval with the stage of plant growth, this will save irrigation through reducing number of irrigation but still attain similar economic yield. Ghassemi-Golezani [6] concluded that faba bean is a sensitive crop to water deficit and therefore sufficient water supply during vegetative and reproductive stages is required to ensure a satisfactory yield achievement. The faba bean is regarded as a drought-sensitive crop (Grashoff [7]). In faba bean, water stress decreases the final leaf area, net photosynthesis, light use efficiency, pod retention and filling by reducing the availability of assimilates and distorting hormonal balance (Cláudio *et al* [8]) .

Cobalt is important in the plant world. Bacteria on root nodules of legumes (beans, alfalfa and clover) require cobalt (and other trace elements) to synthesize B_{12} and fix nitrogen from air. In Co- deficient plants, nodulation process normally, but the nodules are inactive more numerous, their colour is yellow instead of the normal pink colour and they do not fix nitrogen. Co is involved in symbiotic N_2 fixation via vitamin B_{12} with leghaemoglobin production as a transfer agent in N_2 fixation process within the nodules. Cobalt is an essential element for the synthesis of vitamin B_{12}, which is required for human and animal nutrition. 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(Smith[9]). In higher plants cobalt is an essential element for legumes because of its use by microorganisms in fixing atmospheric nitrogen (Young [10]). Cobalt is also required in low levels for maintaining high yields of groundnut (Basu *et al* [11]), (Cottenie *et al* [12] and Allen *et al* [13]) on Faba bean. The aim of the present experiment is to evaluate the effect of water regime and cobalt levels on growth, yield and nutrients status of faba bean plants.

Material and Methods

Two field experiments were conducted during the two successive seasons (2012/13 and 2013/14) at the experimental research and production station of National Research Centre, Nubaria region, Egypt (latitude 30.8667 N, and longitude 31.1667 E, and mean altitude 21 m above sea level). The experimental area was classified as arid region with cool winters and hot dry summers prevailing in the experimental area. Table 1 illustrates the monthly mean weather data for the two growing seasons 2012/13 and 2013/14, for the experimental sites in Nubaria, as obtained from the Central Laboratory of Meteorology, Ministry of Agriculture and Land Reclamation. There was no rainfall that can be taken into consideration throughout the two growing seasons. The soil of experimental site is classified as sandy soil. Some physical and chemical properties of the experimental soil are shown in Tables (2a) and (2b). Irrigation water was obtained from an irrigation channel passing through the experimental area with pH 7.35, and electrical conductivity (EC) of 0.41 dS/m. The experiment was established with a split plot design having four replicates. The main plots included three irrigation water requirements (100%, 75% and 50% water requirement throughout the season). Sub-plots were assigned to seven cobalt concentrations (0.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 ppm). The water resource for irrigation came from an irrigation channel under rotational irrigation where water existed in the channel just for 3 days every week and the channel was empty for the remaining 4 days. The experimental field was deep ploughed before planting. First disc harrow, then duck food was used for further preparation of the field for planting. The experimental unit was 3.5 X 3.0 m. Faba bean seeds (Nubaria 1) were inoculated with the specific Rhizobium strain and immediately sown in hills 25 cm apart on both sides of the ridge (150 kg/ha). Faba bean seeds were sown in 8^{th} and 10^{th} November in the first and second seasons, respectively. During growth (at third truly leaf) spraying with cobalt sulfate was used as a source of cobalt with previous different concentrations under study

Table 1: Monthly and growing season climatic data of the experimental site

Months	**Growing season**	**Solar radiation** (W/m²)	**Precipitation** (mm)	**Wind speed** (m/sec)	**Air temperature (°C)**			**Relative humidity** (%)
				Average	**Average**	**Min.**	**Max.**	**Average**
December	2012/13	49.4	0.2	1.8	15.6	8.9	22.2	63.3
January		49.7	0.0	2.3	14.9	8.3	21.4	61.0
February		67.5	0.1	2.1	16.9	9.3	24.5	57.7
March		93.5	3.6	2.2	18.6	11.0	26.2	60.0
April		111.0	0.0	2.3	20.8	12.8	28.8	52.3
May		130.0	0.0	1.4	20.2	12.7	27.6	49.0
December	2013/14	49.5	0.0	2.0	15.8	9.1	22.6	63.4
January		50.0	1.2	2.5	15.7	7.3	24.1	66.0
February		68.0	2.6	2.3	16.8	7.2	26.4	56.0
March		95.0	0.0	2.5	18.2	8.2	28.3	56.0
April		113.0	0.0	2.4	20.7	10.9	30.6	50.0
May		135.0	0.0	1.6	24.0	14.3	33.8	47.0

Table 2a: Soil physical characteristics of experimental site

Soil depth (cm)	**Particle size distribution** (%)			**Texture class**	**Soil moisture constants**		
	Coarse sand	**Fine sand**	**Clay + Silt**		**SP** (%)	**FC** (%)	**WP** (%)
20	47.76	49.75	2.49	Sandy	21.0	10.1	4.7
40	56.72	39.56	3.72	Sandy	19.0	13.5	5.6
60	59.40	59.40	3.84	Sandy	22.0	12.5	4.6

SP = saturation percentage; FC = field capacity; WP = wilting point

Table 2b: Soil chemical properties of experimental site

Soil depth (cm)	**OM (%)**	**pH (1:2.5)**	**EC (dS/m)**	**$CaCO_3$ (%)**
20	0.65	8.7	0.35	7.02
40	0.40	8.8	0.32	2.34
60	0.25	9.3	0.44	4.68

OM= Organic matter; pH= acidity or alkalinity in soils; EC= electrical conductivity

All treatment plots received the same amount of total fertilizer. A compound fertilizer was applied as follow: Nitrogen fertilizer as ammonium nitrate (33.5 % N) at the rate of 50 kg N/ha was added after 20 days from sowing, phosphorus fertilizer was applied in the form of single super-phosphate (15.5% P_2O_5) during land preparation at the rate of 357 kg/ha and 150 kg/ha potassium sulphate (48 % K_2O) applied once after 35 days from sowing.

Measurements

After 50 and 80 days from sowing in both seasons samples of five random plants were taken from experimental plots to estimate the following characteristics:

1. Total number of nodules bacterial / plant.
2. Dry weight of nodules bacterial / plant (gm).
3. Plant height (cm)
4. Root dry weight (gm).
5. Shoot dry weight (gm).

6. Leaf area index (LAI).
7. Macronutrients (N, P and K) in shoot and root of faba bean were determined according to Cottenie *et al* [12].

At harvesting, the following data were recorded:

1. Number of pods / plant.
2. Pods dry weight / plant (gm).
3. Seeds weight / plant (gm).
4. Number of seeds / plant.
5. 100- seed weight (gm)
6. Seed yield (ton/ha) for the last traits the two central ridges of each experimental unit were devoted the determination.

Macronutrients (N, P and K) and micronutrients (Fe, Mn, Zn, Cu and Co) as well as total crude protein of faba bean seeds were determined according to Cottenie *et al* [12].

Weather data recorded from an adjacent weather station. The percentage of soil moisture content (θv) was measured by profile-probe apparatus in sandy soils.

For determination of the crop water requirements (CWR), crop evapotranspiration was calculated under standard conditions (ETc) as follows:

$ET_c = ET_o \times K_c$ (Equation 1)
where:
ET_c = Crop evapotranspiration (mm/day)
ET_o = Reference crop evapotranspiration (mm/day)
K_c = Crop coefficient

The values of ET_c and CWR are identical, whereby ET_c refers to the amount of water lost through evapotranspiration and CWR refers to the amount of water that is needed to compensate for the loss. ET_c calculated from climatic data by directly integrating the effect of crop characteristics into ET_o. The Food and Agriculture Organization of the United Nations (FAO) Penman-Monteith method is now the sole recommended as the sole standard method for calculating ET_o. The Penman-Monteith equation is given by the following equation (Allen *et al* [13]).

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma\left(1 + 0.34 u_2\right)} \quad \text{(Equation 2)}$$

Where:
ETo = Reference evapotranspiration (mm/day)
Rn = Net radiation at the crop surface [(MJ/m^2) per day]
G = Soil heat flux density [(MJ/m^2) per day]
T = Mean daily air temperature at 2 m height (°C)
u_2 = Wind speed at 2 m height (m/sec)
e_s = Saturation vapour pressure (kPa)
e_a = Actual vapour pressure (kPa)
e_s - e_a = Saturation vapour pressure deficit (kPa)
Δ = Slope of saturation vapour pressure curve at temperature T (kPa/°C)
γ = Psychrometric constant (kPa/°C)

The equation used the standard climatological records of solar radiation (sunshine), air temperature, humidity and wind speed for daily calculations. Amount of irrigation water was calculated according to the following equation for the sprinkler irrigation systems:

$$AW = \frac{ET_c}{E_a \times (1 - LR)} \qquad \text{(Equation 3)}$$

where:
AW = applied irrigation water depth (mm/day)
E_a = application efficiency equals 75% for sprinkler irrigation system
LR = leaching requirements equals 10% for sprinkler irrigation system.
Irrigation time (IT) for solid sprinkler system was calculated according to equation as follows:

$$\text{Irrigation time in hours (IT)} = \frac{\text{Applied irrigation water depth}}{\text{Application rate for sprinkler}} \qquad \text{(Equation 4)}$$

where:
AR = Application rate for sprinkler in (mm/hour)

$$AR = \frac{\text{Sprinkler discharge} \times 1000}{\text{Strip area}} \qquad \text{(Equation 5)}$$

where:
Sprinkler discharge in (m^3/hour)
Strip area in (m^2)

Irrigation Regimes:
Plants ware irrigated using the three following irrigation regimes:
IR1 =100% of ETc throughout the irrigation season
IR2 =75% of ETc treatment was applied after the beginning of flowering
IR3=50% of ETc treatment was applied after the beginning of flowering

The seasonal irrigation water applied(m^3/ha/season)for 2012/13 and 2013/14, respectively are shown in Table 3.

Table 3: The seasonal irrigation water applied (m^3/ha/season) for seasons 2012/13 and 2013/14

Treatments	Growing seasons	
	2012/13 (m^3/ha)	2013/14 (m^3/ha)
100%	4284	4382
75%	3213	3287
50%	2142	2191

Irrigation water use efficiency (kg m^{-3}).

Irrigation water use efficiency "WUE" is an indicator of effectiveness use of irrigation unit for increasing crop yield. Irrigation water use efficiency of wheat yield was calculated according to James [14] as follows:

IWUE wheat (kg m^{-3}) =Total yield (ton ha^{-1}) / Total applied irrigation water (m^3 ha^{-1}).

Statistical Analyses:

The combined analysis of variance for the data of the two seasons was performed after testing the error homogeneity and Fisher's Least Significant Difference(LSD) method at 0.05 level obtained data from each season were subjected to the proper statistical analysis of variance of significance was used for the comparison between means according to Gomez and Gomez[15].

Results and Discussion

Growth characters:

Effect of water requirement:

Results in Table 4 reveal the significant impacts of water requirement treatments on plant height, shoot and root dry weight (gm) as well as leaf area index (LAI) at 80 days from sowing. In this connection, irrigation with 100% of water requirement significantly increased aforementioned traits compared to addition of 75 or 50% of water requirement. Herein, no significant differences between 100 and 75% of water requirement were found. Accordingly, supplying wheat plants with adequate water requirement might help the plant to absorb greater amount of water and nutrients, enhancing internodes elongation since nutrients encourage cell division and enlargement and meristematic activity. Besides, the beneficial effect of water for improving pigments and photosynthetic process. These results are in harmony with those obtained by Ghassemi-Golezani *et al* [6] and Tayel and Sabreen [16]. Data also indicated that water requirement treatments had insignificant effect on plant height, shoot and root dry weight (gm) and leaf area index (LAI) as well as number and dry weight (gm) of nodules bacterial / plant at 50 days from sowing.

Table 4: Means of growth parameters of faba bean as affected by water requirements and cobalt concentrations at 50 and 80 days from sowing (combined analysis of two seasons)

Treatments	At 50 days from sowing						At 80 days from sowing			
	Plant height (cm)	Shoot dry weight (gm)	Root dry weight (gm)	LAI	Noodles No.	Noodles Weight (gm)	Plant height (cm)	Shoot dry weight (gm)	Root dry weight (gm)	LAI
Water requirements (%)										
100	68.7	12.74	3.46	2.67	65.00	2.13	105.00	24.84	5.60	5.02
75	66.6	12.22	3.16	2.72	63.61	2.08	103.00	22.77	5.21	4.75
50	65.4	11.91	2.91	2.66	60.43	1.97	88.15	17.94	4.80	3.30
LSD at 0.05	NS	NS	NS	NS	NS	NS	2.12	2.17	0.44	0.35
Cobalt concentration (ppm)										
0.0	60.6	9.81	1.31	2.19	47.33	1.49	84.67	16.50	3.95	3.71
7.5	62.0	10.42	2.51	2.45	51.33	1.66	90.33	17.47	4.70	4.16
10.0	65.0	11.98	2.92	2.76	62.67	2.03	98.00	20.81	5.06	4.39
12.5	69.6	13.23	3.67	2.92	70.00	2.29	105.33	23.55	5.63	4.56
15.0	72.0	13.91	4.27	2.98	73.00	2.41	109.33	25.81	5.95	4.73
17.5	70.3	13.54	3.97	2.86	68.67	2.30	102.67	24.69	5.60	4.61
20.0	68.3	13.00	3.63	2.81	66.33	2.24	99.33	24.11	5.43	4.37
LSD at 0.05	2.4	0.73	0.29	0.15	2.17	0.10	2.23	2.11	0.36	0.19

Effect of cobalt :

Data presented in Table 4 show significant increases of all the studied traits with increasing cobalt levels from 0 to 15 ppm. Application of 15 ppm led to the significantly increased maximum values of plant height, shoot and root dry weight (gm) and leaf area index (LAI) as well as number and dry weight (gm) of nodules bacterial / plant at 50 and 80 days from sowing. The positive effect of may be due to cobalt application promotion of many developmental processes such as stem and coleoptiles elongation, opening of hypostyle hooksand leaf disc expansion. Also, the proper doses of cobalt may help in better nodulation and consequently a better growth, but at high level cobalt reduced the bacterial population in the rhizosphere and as a result nodulation was hampered which led to a lower growth of crop (Jana *et al* [17] and Hala, Kandil [18]. In other words, cobalt addition increased the nodules formation of root and atmospheric nitrogen fixation by microorganisms which increase the nitrogen content in faba bean plants. This was confirmed by Hala, Kandil [18] and Nadia Gad *et al* [19]. Moreover, cobalt application increases the formation of loghaemoglobin required for nitrogen fixation, thereby improves the nodules activity. Das[20] stated that there are three specific cobalamine dependent enzyme systems in rhizobium which may account for influence of cobalt on nodulation ribonucleotide reductase and methylmalonyl coenzyme A mutase.

Interaction effect:

The interaction between water requirement and cobalt concentrations significantly affected by shoot dry weight and leaf area index (Table 5). Irrigation with 100% of water requirement produced the highest values of shoot dry weight and leaf area index when cobalt at 15 ppm treatments was used. Moreover, the minimal values of all obvious characters were obtained with irrigation of 50% water requirement and untreated plots with cobalt.

Table 5: Means of shoot dry weight (gm) and leaf area index as influenced by the interaction between water requirements and cobalt concentrations at 80 days from sowing (Combined data of 2012/2013 and 2013/2014 seasons)

Cobalt concentrations (ppm)	Water requirements (%)					
	100	**75**	**50**	**100**	**75**	**50**
	Shoot dry weight (gm)			Leaf area index		
0.0	18.90	17.11	13.49	3.56	3.21	2.91
7.5	19.70	18.70	14.00	3.89	3.75	3.17
10.0	23.50	21.90	17.03	4.17	3.95	3.39
12.5	27.30	24.18	19.16	4.55	4.13	3.65
15.0	29.17	27.16	21.11	5.11	4.22	3.85
17.5	28.17	25.33	20.64	4.89	4.18	3.73
20.0	27.17	25.00	20.15	4.75	4.06	3.67
LSD at 0.05	2.21			0.34		

Nutrients Status in shoot and root:

Effect of water requirement:

It is obvious from the data in Table 6 which reveal that water requirement treatments significant influence on N, P and K in shoots and roots of faba bean plants at 80 days from sowing. Regarding irrigation requirements, reducing of water requirements from 100 % to 50 % affected on N, P and K in shoots and roots of faba bean plants, where 100% irrigation requirements achieved the highest N, P and K in shoots and roots of faba bean plants followed by 75% and 50% irrigation requirements, respectively. These results may be due to the abundance of water helps the plant to absorb the largest amount of nutrients, leading to increase the amount of elements within shoot and root. These results are in coinciding with those detected by Mohamad Zabawi and Dennett [21].

Effect of cobalt :

Data presented in Table 6 show that addition of different levels of cobalt namely 7.5, 10.0, 12.5 and 15 ppm had a significant beneficial effect on the status of studied macro- elements (nitrogen, phosphorus and potassium) in both shoots and roots of faba bean plants. The highest content values of N, P and K in shoots and roots were obtained at the treatment of 15 ppm cobalt followed by 12.5, 10.0 and 7.5 ppm in decreasing order. These results may be due to the high numbers of nodules, higher nodule and root weight in faba bean probably resulted in higher aboveground plant growth of this treatment (cobalt rate increasing up to 15 ppm), as greater nodulation should have resulted in high rated of nitrogen fixation and better root growth can enable plants to absorb more nutrients and water for shoot growth may be reflected on N, P and K percentage in root and shoot. The same conclusion was mentioned by Hala, Kandil [18] and Nadia Gad et al [19].

Table 6: Means of macronutrients content in shoot and root of faba bean plants as affected by water requirements and cobalt concentrations at 80 days from sowing (combined analysis of two seasons)

Treatments	Shoot (%)			Root (%)		
	N	**P**	**K**	**N**	**P**	**K**
Water requirements (%)						
100	1.95	0.41	0.53	1.55	0.24	0.20
75	1.79	0.35	0.46	1.29	0.19	0.17
50	1.52	0.29	0.36	1.09	0.11	0.13
LSD at 0.05	0.18	0.11	0.09	0.17	0.07	0.06
Cobalt concentrations (ppm)						
0.0	0.92	0.21	0.29	0.43	0.11	0.08
7.5	1.22	0.27	0.35	0.76	0.14	0.13
10.0	1.63	0.33	0.43	1.13	0.18	0.16
12.5	2.11	0.40	0.56	1.63	0.22	0.21
15.0	2.20	0.42	0.54	1.81	0.24	0.23
17.5	2.13	0.37	0.51	1.75	0.21	0.20
20.0	2.07	0.35	0.49	1.62	0.19	0.17
LSD at 0.05	0.21	0.05	0.11	0.14	0.07	0.05

Yield, yield attributes and protein % :

Effect of water requirement:

All faba bean yield and its attributes as well as protein percentage were affected markedly by water requirement (Table7). The maximal increases of no. of pod/plant, pod dry weight, no. of seed/plant, seed weight /plant, 100- seed weight and protein percentage were produced from 100% water requirements. In contrast, the minimal values of obvious characters were recorded with 50 % water requirements. Herein, no significant differences between 100 and 75% of water requirement were found.

In this connection, addition of 100% of water requirement increased significantly seed yield ton/ha. There was no significant difference between addition of 100 and 75% watering regime on the most aforementioned traits. The decrease in yield and yield attributed due to wheat irrigation at 50% watering regime may be due to change in patterns of plant growth and development (Ouda[22]), disturbance of metabolites transportation to the seeds, reduction in the number of reproductive branches that limited their contribution to seed yield and caused pollen sterility (Tayel and Sabreen[16] and Mohamad Zabawi and Dennett[21]). So, sufficient watering regime of 100 or 75% of water requirement might help the plant to absorb greater amount of water and nutrients enhancing internodes elongation since nutrients encourage cell division and enlargement and meristematic activity Fageria et al [23]. Besides, the beneficial effect of water for improving pigments and photosynthetic process and accumulation of metabolites led to an increase in yield and its components. These findings confirmed previous results obtained by Tayel and Sabreen[16], Mohamad Zabawi *et al* [21], Hegaba *et al* [24] and Ouda *et al* [25]

Effect of cobalt :

Data presented in Table 7 show significant increases of all the studied traits with increasing cobalt levels from 7.5 to 15.0 ppm/l. Highest values of on. of pod/plant, pod dry weight, no. of seed/plant, seed weight /plant 100- seed weight and protein percentage were obtained from 15.0 ppm cobalt concentration. Whereas, the lowest values of the previous characters was obtained from the untreated treatments. Application of 7.5, 10.0, 12.5 and 15.0 ppm cobalt concentration gave higher values of seed yield ton/ha. They significantly increased seed yield ton/ha over the untreated by 14.2, 27.3, 35.7and 42.7%, respectively. These results may be due to cobalt is essential for growth rhizobia, the specific bacteria involved in legume nodulation and nitrogen fixation into amino acids and protein. In nitrogen-fixing bacteria, the nitrogenase enzyme drives the reaction of atmospheric dinitrogen fixation in presence of ATP (Balai and Majumdar [26]).

Table 7: Means of yield, yield attributes and protein percentage of faba bean as affected by water requirements and cobalt concentrations (combined analysis of two seasons)

Treatments	No. of pods /plant	Pod dry weight (gm)	No. of seeds / plant	Seed weight / plant (gm)	100- seed weight (gm)	Seed yield ton/ ha^{-1}	Protein %
Water requirements (%)							
100	27.36	123.29	75.03	36.71	53.86	3.43	24.77
75	24.76	120.43	71.75	34.57	51.00	3.25	23.25
50	18.56	90.71	47.77	24.57	46.86	2.61	19.68
LSD at 0.05	2.11	5.13	4.35	2.32	3.47	0.19	1.65
Cobalt concentrations (ppm)							
0.0	13.83	81.00	38.73	21.67	40.67	2.46	17.99
7.5	19.50	95.67	54.63	24.00	44.67	2.81	18.87
10.0	24.50	105.67	68.60	30.00	50.00	3.13	20.91
12.5	26.03	118.67	72.90	36.67	54.67	3.34	24.18
15.0	28.70	132.00	77.07	40.00	57.33	3.51	26.79
17.5	25.37	125.00	73.03	36.33	54.67	3.30	25.13
20.0	24.63	120.00	68.97	35.00	52.00	3.14	24.43
LSD at 0.05	1.89	6.41	4.71	2.53	3.11	0.13	1.12

Balai, C.M. and Majumdar[26] added cobalt at 0.21 kg/ha which increased number and dry weight of nodules per plant as well as leghemoglobin content in peanut roots especially with phosphobacterium than rhizobium treatment. Basu et al[27] demonstrated that cobalt significantly improvement total nodules number and dry weight, number and weight of effective nodules and root dry weight in both groundnut and cowpea. These data are in harmony with those obtained by Hala, Kandil [18], Nadia Gad et al [19] and Nadia Gad *et al* [29].

Interaction effect:

The results (Table 8) show that there were significant interactions between water requirements and cobalt levels on seed yield and protein percentage. The highest values were obtained from application of 100% water requirements and addition of cobalt at the rate of 15ppm. Vice- versa, the lowest values were recorded from the addition of 50% water requirements with spraying of water treatment.

Nutrients Status in seeds:

Effect of water requirement:

Table 9 shows the significant increase in macronutrients (N, P and K %), micronutrients (Mn, Zn, Cu and Fe ppm) and Co ppm with increasing level of water requirement treatment. In this respect, with each increase in irrigation requirements from 50% to 100% was a progressive increase in of macronutrients, micronutrients and Co content. On the other side, the lowest valued of aforementioned characters were recorded with 50% water requirement. Meanwhile, decreasing irrigation requirements from 100% to 75% show not significant differences in the most of studied characters, while decreasing irrigation requirements from 75 to 50% significantly decreased the most of studied characters. The increase in content of seeds on macronutrients (N, P and K %), micronutrients (Mn, Zn, Cu and Fe ppm) and Co ppm with increasing level of water requirement may be due to promote the growth can enable plants to absorb more nutrients and water for shoot growth and faba bean plants may be reflected on nutrients status in seeds of faba bean. The same conclusion was mentioned by Ghassemi-Golezani *et al* [6], Mohamad Zabawi and Dennett [21] and EL-Metwally *et al* [30].

Table 8: Means of seed yield (ton/ ha) and protein % as influenced by the interaction between water requirements and cobalt concentrations (Combined data of 2012/2013 and 2013/2014 seasons)

Cobalt concentrations (ppm)	Water requirements (%)					
	100	75	50	100	75	50
	Seed yield (ton/ ha)			Protein %		
0.0	2.75	2.51	2.11	19.13	18.00	16.85
7.5	3.12	2.95	2.35	20.14	19.23	17.23
10.0	3.52	3.23	2.65	23.18	21.42	18.14
12.5	3.67	3.49	2.87	28.17	25.17	19.19
15.0	3.89	3.68	2.95	29.85	27.17	22.81
17.5	3.65	3.51	2.75	27.17	26.11	22.11
20.0	3.42	3.38	2.63	26.75	25.13	21.42
LSD at 0.05	0.14			1.13		

Table 9: Means of macronutrients, micronutrients content in faba bean seeds and water use efficiency as affected by water requirements and cobalt concentrations (combined analysis of two seasons)

Treatments	Macronutrients %			Micronutrients ppm					Water Use Efficiency (WUE) kg/m^3
	N	P	K	Mn	Zn	Cu	Fe	Co	
Water requirements (%)									
100	2.36	0.27	0.70	34.1	23.4	32.7	35.9	1.38	0.79
75	2.17	0.23	0.62	28.3	21.0	29.4	33.4	1.23	0.98
50	1.84	0.13	0.48	19.4	13.1	22.3	30.1	0.90	1.20
LSD at 0.05	0.20	0.05	0.12	3.1	2.6	1.5	2.7	0.16	0.13
Cobalt concentrations (ppm)									
0.0	1.75	0.13	0.39	18.7	11.2	21.2	43.1	0.51	0.79
7.5	1.93	0.15	0.45	21.3	13.7	24.1	41.3	0.67	0.90
10.0	2.14	0.17	0.61	27.1	17.8	29.7	35.4	0.93	1.01
12.5	2.23	0.23	0.69	31.2	23.4	31.5	31.7	1.25	1.08
15.0	2.31	0.26	0.73	33.4	24.1	32.6	28.3	1.42	1.13
17.5	2.27	0.24	0.70	30.0	22.3	30.1	26.9	1.65	1.06
20.0	2.18	0.22	0.65	29.3	21.7	28.4	25.0	1.77	1.01
LSD at 0.05	0.12	0.04	0.09	1.3	1.2	1.1	1.4	0.14	0.10

Effect of cobalt :

Data presented in Table 9 show that addition of different levels of cobalt namely 7.5, 10.0,12.5, 15.0, 17.5 and 20.0 ppm had a significant beneficial effect on the status of studied macro (NPK) and micronutrients (Mn, Zn, Cu, Fe and Co) of faba bean seeds. The highest values of all the studied nutrients were found when cobalt treatment of 15.0 ppm was used and followed by 12.5, 10.0 and 7.5 ppm in decreasing order. Vice- versa the lowest values of in previous characters were recorded with untreated plants. Data also indicated that, increasing cobalt concentration in the plant media resulted in a progressive depression effect on iron content in the faba bean seeds. This may be explained on the basis of obtained results by[31] who showed certain antagonistic relationships between the two elements (Fe and Co).The beneficial effect of Co on the increase happened in the total mineral content could be deduced to the positive role of Co in water movement and its tendency towards the rhizosphere area near the plant root zone and consequently, the enhancement occurred in the mineral uptake by the growing plant, particularly in case of water stress as mentioned by[31]. The increase in macro and micronutrients were more pronounced, particularly at the use of the larger dose of Co amendments up to concentration of 15 ppm. These results are in coinciding with those detected by Hala, Kandil[18], Nadia Gad *et al*[19] and Nadia Gad[32].

Water Use Efficiency (kg seeds/m3 water):

Data presented in Table 9 show water use efficiency expressed as kg grains/m3 water consumed. The results indicate that WUE increased as water stress increased. Gradual increases in WUE were reported when water requirement reduced from 100 to 75 and 50%. Cobalt addition of faba bean plants resulted in obvious efficiency of faba bean plants in using water unit compared to the untreated plants. Moreover, application of cobalt concentration at 15 ppm with 75% of the irrigation water requirements could effectively produce similar seed yield to that achieved when the recommended treatment was applied (100%).

Eventually, it could be concluded that applying 100% or 75% water requirements and when addition of 15 ppm cobalt was the best combination for enhancing yield, its attributes and quality of faba bean seeds. Also, increase tolerance of the plants to water shortages under sandy soil conditions.

References

1. Ahmed, M.K.A., Zeidan M.S. and El-Karamay M.F., 2003 . Effect of foliar nutrition with potassium sources on growth, yield and quality of faba bean (*Vicia faba* L.). Egypt. J. Agron., 25: 53-58.
2. Hopkins W. G., 1995. Introduction to Plant Physiology. John Wiley& Sons, Canada.
3. Lambers H., Chapin F.S. and Pons T. L., 1998. Plant Physiological Ecology. Springer-Verlag, New York.
4. Abou Zied M., 2000. Egypt water resource management and policies. Al- Mohandeseen Magazin., pp: 528.
5. Tayel M.Y., El Gindy A.M., Abd- El- Hady M. and Ghany H.A., 2007. Effect of irrigation systems on: yield, water and fertilizer use efficiency of grape. Applied Sciences Research, 3(5): 367-372.
6. Ghassemi-Golezani K., Ghanehpoor S. and Dabbagh Mohammadi-Nasab A., 2009. Effects of water limitation on growth and grain filling of faba bean cultivars. Journal of Food, Agriculture & Environment, , 7 (3&4) : 442 - 447.
7. Grashoff C., 1990. Effect of pattern of water supply on *Vicia faba* L. II. Pod retention and filling, dry matter portioning, production and water use. J. Agric. Sci., 38:131-143.
8. Cláudio Cost L., Morison J. and Dennett M., 1997. Effects of water stress on photosynthesis, respiration and growth of faba bean (*Vicia faba* L.) growing under field conditions. Revista Brasileira de Agrometeorologia, 5:9-16.
9. Smith R. M., 1991. Trace elements in human and animal nutrition. Micronutrients News Information, 119.
10. Young S.R., 1983. Recent advances of cobalt in human nutrition. Victoria B.C. Canada. Micronutrient News and Information, 3: 2-5.
11. Basu M., Bhadoria P. B. S. and Mahapatra S.C., 2006. Influence of microbial culture in combination with micronutrient in improving the groundnut productivity under alluvial soil of India. Acta Agricultural Slovenica, 87: 435-444.
12. Cottenie A., Verloo M., Kiekens L., Velgh G. and. Camerlynck R.,1982. Chemical Analysis of Plant and Soil. Lab. Anal. Agrochem. State Univ. Gthent, Belgium, 63.
13. Allen R. G., Pereira L. G., Raes D. and Smith M., 1998. Crop evapotranspiration - Guidelines for computing crop water requirements − FAO Irrigation and drainage paper 56. FAO − Food and Agriculture Organization of the United Nations, Rome.
14. James, L.G., 1988. Principles of farm irrigation system design. John Willey & sons. Inc., Washington State University, pp. 73, 152-153, 350-351.
15. Gomez K. A. and Gomez A. A., 1984. Statistical Procedures for Agriculture Research., A Wiley − Inter Science Publication, John Wiley & Sons, Inc., New York, USA.
16. Tayel M. Y. and Sabreen, Kh. P., 2011. Effect of Irrigation Regimes and Phosphorus Level on Two *Vica faba* Varieties: 1- Growth characters. Journal of Applied Sciences Research, 7(6): 1007-1015.
17. Jana, P.K., Karmakar S., Ghatak S., Barik A., Naybri A., Souda G., Mukher A.K. and Saren, B.K., 1994. Effect of cobalt and rhizobium on yield, oil content and nutrient concentration in irrigated summe groundnut. Ind. J. Agric. Sci., 64: 630-632.
18. Hala, Kandil, 2007. Effect of cobalt Fertilizer on growth, yield and nutrients status of faba bean (*Vicia faba* L.) plants. Journal of Applied Sciences Research, 3(9): 867-872.

19. Nadia Gad, Fatma Abd el Zaher H., Abd El Maksoud H. K. and Abd El-Moez M. R., 2011. Response of faba bean (*Vicia faba* L.) to cobalt admendments and nitrogen fertilization. The African of Plant Science and Biotechnology, 5 (1) : 41-45.
20. Das, D.K., 2000. Micronutrients: Their behaviour in soil and plants. Kalyani Publishers, UP, India.
21. Mohamad Zabawi A.G. and Dennett M.D.D, 2010. Responses of faba bean (*Vicia faba*) to different levels of plant available water: I. Phenology, growth and biomass partitioning. J. Trop. Agric. and Fd. Sc. 38(1): 11–19.
22. Ouda, S.A., 2006. Predicting the effect of water and salinity stresses on wheat yield and water needs. In Journal of Applied Sciences Research, vol. 2, pp. 750–756 . http://www.aensiweb.com/old/jasr/jasr_october_.html.
23. Fageria N. K., Baligar V.C. and Jones C.A., 2010 . Growth and Mineral Nutrition of Field Crops. Third Edition. CRC Press, Taylor & Francis Group, 586 pp. ISBN 9781439816950.
24. Hegaba,A.S.A., Fayed M.T.B., Maha M.A.H. and Abdrabbo M.A.A., 2014. Productivity and irrigation requirements of faba-bean in North Delta of Egypt in relation to planting dates. Annals of Agricultural Sciences, 59 (2): 185–193.
25. Ouda, S.A., Shreif M.A. and Abou Elenin R., 2010. Increasing water productivity of faba bean grown under deficit irrigation at middle Egypt. Fourteenth International Water Technology Conference, IWTC 14, Cairo, Egypt, pp, 45-55.
26. Balai, C.M. and Majumdar, S.P., 2005. Metabolites content and water relations of cowpea [*Vigna unguiculata* (L.) Walp] as influenced by different levels of compaction, potassium and cobalt. Current Agriculture, 31(1/2): 47-53.
27. Basu, M., Mondal P., Datta A. and Basu,T. K., 2003. Effect of cobalt, Rhizobium and phosphobacterium inoculations on growth attributes of summer groundnut (*Arachis hypogaea* Linn). Environment and Ecology, 21(4): 813-816.
28. Nadia Gad, Mohammed A.M. and Bekbayeva L.K., 2013. Response of Cowpea (*Vigna unguiculata*) to Cobalt Nutrition. Middle-East Journal of Scientific Research, 14 (2): 177-184.
29. EL-Metwally, I. M., Ramadan A. E., Ahmed M. A., Oussama Mounzer, Juan Jose Alarcon and Abdelhamid M. T., 2015. Response of wheat (*Triticum aestivum* L.) crop and broad-leaved weeds to different water requirements and weed management in sandy soils. Agriculture (Poľnohospodárstvo), 61 (1): 22-32.
30. Bisht, J. C., 1991. Interrelations between mineral plant tissue, iron and cobalt. Pescui Agropecu. Bras., 16: 739-746.
31. Nadia Gad, 2012. Role and Importance of Cobalt Nutrition on Groundnut (*Arachis hypogaea*) Production. World Applied Sciences Journal, 20 (3): 359-367

*****