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Original Research Paper

Effect of irrigation with magnetically treated water on faba bean growth and composition

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A pot experiment was conducted to investigate the effect of irrigation with different magnetized water on faba bean (*Vicia faba* L) growth and composition. Prepared sandy soil was packed in plastic pots (5 kg capacity) at a rate of 4 kg. Faba bean seeds were cultivated at rate of 4 seeds/pot. After the germination,faba bean plants were thinned into 2 plants/pot. Both sewage sludge compost (SSC) and tricalcium phosphate (TCP) were added to the soil at a rate of 25 tones ha^{-1} and 720 kg ha^{-1},respectively. Irrigation water sources were magnetized by passing throws a magnetic field 1000 gauss magnetron unit of 0.5 inch diameter. Plant length, shoot and root fresh and dry weights of faba bean were significantly increased by using the different magnetized irrigation water sources compared with the non-magnetized water. Only root fresh and dry weights of faba bean plant were significantly increased by using magnetized irrigation water and the different soil organic and inorganic treatments. On the other, plant length, shoot and fresh and dry weights were not significantly affected by the combined effect of magnetism and soil treatments. Shoot N, P and K contents and uptake of faba bean were significantly increased by the individual and the combined application of SSC and TCP to soil compared with untreated soil. Shoot N, P and K contents and uptake of faba bean was significantly increased by using magnetized irrigation water compared with the non-magnetized water.Generally, using different magnetized irrigation water sources, soil salinity, soluble cations and anions were significantly decreased by using magnetized water. Soil salinity, soluble cations and anions were significantly increased by adding both the individual and the combined SSC and TCP. Available soil N, P and K were significantly increased by adding both the individual and the combined SSC and TCP. Using different magnetized water sources, available soil N, P and K were significantly increased.

Key words: Magnetized water, faba bean , NPK uptake sandy soil.

INTRODUCTION

Soil scientists have shown great interest in the effect of magnetic field on soil and plants. The prospect of using cheap magnetic energy to improve the properties of soil and plant growth and development may be of great practical importance. Magnetic treatment of soil proved to have a favorable effect in plant growth and development. In general, the enhancement of plant growth under magnetic conditions appears to have been confirmed by many scientists. Aladjadjiyan (2002) detected that exposure to a 150 mT magnetic field stimulated shoot development and led to increase of the germination, fresh weight and shoot length of maize plants. Magnetic field beneficial effects on plants have been discussed for more than a decade (Aladjadjiyan and Ylieva, 2003). Magnetic fields have a highly stimulating effect on cell multiplication, growth and development (Yokatani et al., 2001).

Some studies reported that magnetic field had a positive effect on the number of flowers and total yield (Podlesny et al., 2005), seed germination percentage and nutrient uptake (Esitken and Turan 2003). In addition, application of a magnetic field to irrigation water was shown to increase plant nutrient content (Moon and Chung, 2000). Grewal and Maheshwari (2011) showed that magnetic treatment of irrigation water led to a significant increase in shoot dry weight (25% for snow pea and 20% for chickpea) and contents of N, K, Ca, Mg, S, Na, Zn, Fe and Mn in both seedling varieties compared to control seedlings. Likewise, there were significant increases in shoot dry weight (11% for snow pea and 4% for chickpea). The results of this study suggest that both magnetic treatment of irrigation water and seeds have the potential to improve the early seedling growth and nutrient contents of seedlings.

Maheshwari and Grewal (2009) found that the effects of magnetic treatment varied with plant type and the type of irrigation water used, and there were statistically significant increases in plant yield and water productivity. In particular, the magnetic treatment of recycled water and 3000 ppm saline water increased celery yield by 12% and 23%, respectively. For snow peas, there were 7.8%, 5.9% and 6.0% increases in pod yield with magnetically treated potable water, recycled water and 1000 ppm saline water, respectively. The water productivity of snow peas increased by 12%, 7.5% and 13%, respectively, for magnetically treated potable water, recycled water and 1000 ppm saline water. On the other hand, As to soil properties after plant harvest, the use of magnetically treated irrigation water reduced soil pH but increased soil EC and available P in celery and snow pea. Overall, the results indicate some beneficial effect of magnetically treated irrigation water, particularly for saline water and recycled water, on the yield of celery and snow pea plants under controlled environmental conditions.

Turker et al. (2007) reported an inhibitory effect of static magnetic field on root dry weight of maize plants, but there was a beneficial effect of magnetic field on root dry weight of sunflower plants. Hilal et al (2002) found that the mobility of nutrient elements in root zone of citrus differed greatly from element to another according to element magnetic susceptibility. Induced magnetic increase of nutrient extraction from soil was the highest for iron; extracted Fe reached 9 times as much as that extracted from normal plots. Zinc increased 5 times, P increased 3 times and that increase in Mn was only 80%. Also, he found that Mn content of citrus leaves showed the maximum increase, followed by Zn while Fe content was the least affected.

In two pot experiments, Hozayn and Amira (2010) found that, irrigation with magnetized water induced positive significant effect on the percent of increase in seed of chickpea, straw and biological yields per plant were 39.64, 41.03 and 39.85%, respectively, compared with tap water. Magnetic water treatment could be used to enhance growth, chemical constituents and productivity of chickpea under greenhouse condition. Under the same conditions, Amira and Hozayn (2010) found that irrigation with magnetized water significantly improvement the growth, yield and yield components and chemical constituents of lentil plant. The improvement in growth and chemical constituents parameters reflected in increasing seed, straw and biological yield per plant by 24.98, 26.69 and 25.82%, respectively over the control treatment. It appears that utilization of magnetized water technology may be considered a promising technique to improve lentil yield productivity.

Therefore, the present study was carried out to investigate the applicability of using of magnetized saline irrigation water in evaluation growth, some of the growth component characters and NPK contents and uptake of faba bean. Also, some of the soil chemical changes were evaluated.

MATERIALS AND METHODS

A pot experiment was conducted to investigate the effect of irrigation with different magnetized saline irrigation water (i.e. Ismailia Canal, El-Salam Canal and Abou-Sewer well water) on faba bean (*Vicia faba* L) growth and composition. Prepared sandy soil was packed in plastic pots (5 kg capacity) at a rate of 4 kg. Soil chemical and physical properties are presented in Table (1). Faba bean seeds were cultivated at rate of 4 seeds/pot. After germination, faba bean plants were thinned into 2 plants/pot. Both nitrogen and potassium fertilizers were added at total rates of 0.8 g/pot and 0.8 g/pot as urea (46% N) and potassium sulphate (48% K_2O), respectively. Total rates of applied N and K were divided into three doses, the first dose was applied after germination and the second and the third doses were applied after 15 and 30 days from the germination. Faba Experimental treatments were designed as follows:

1. Soil (Control)
2. Soil + 25 tones sewage sludge compost ha^{-1} (SSC)
3. Soil + 720 kg tricalcium phosphate ($Ca_3(PO_4)_2$) ha^{-1} (TCP)
4. Soil+25 tones sewage sludge compost+720 kg tricalcium phosphate ha^{-1} (SSC + TCP)

Both sewage sludge compost (Table 3) and tricalcium phosphate were added to the soil and homogeneously mixed before sowing at a rate of 25 tones ha^{-1} and 720 kg ha^{-1}, respectively. Irrigation water sources (Table 2) were magnetized by passing a magnetic field and will acquire a magnetic moment for 48-72 hours after crossing the magnetic field. However, such time is good enough for magnetized irrigation water to impose magnetic effect on the soil plant– water system. The water passed throws 1000 gauss magnetron unit of 0.5 inch diameter which produced by magnetic technologies (Takatchenko, 1997). Soil pots were irrigated every 2 days, with normal and magnetized Ismailia Canal, El-Salam and Abou-Sewer well

Table 1. Some chemical and physical characteristics of used soil.

Characteristic	Value
pH	7.60
EC_e, dSm^{-1}	2.10
Ca^{2+}, $meql^{-1}$	5.70
Mg^{2+}, $meql^{-1}$	5.30
Na^{+}, $meql^{-1}$	8.10
K^{+}, $meql^{-1}$	1.20
HCO_3^{-}, $meql^{-1}$	4.80
Cl^{-}, $meql^{-1}$	7.50
SO_4^{-2}, $meql^{-1}$	8.30
Available N, (ppm)	8.00
Available P, (ppm)	5.00
Available K, (ppm)	10.5
Available Fe, (ppm)	5.36
Available Mn, (ppm)	4.78
$CaCO_3$, %	0.69
Organic matter, %	0.43
Water holding capacity, %	16.0
Mechanical analysis	
Sand, %	88.2
Silt, %	9.40
Clay, %	2.40
Texture class	Sandy

water according to faba bean water requirement. After 70 days from the beginning of the experiment, plant length, fresh weight of shoots and roots of faba bean were estimated. Shoots and roots were oven dried at 70 ^oC for two days, and dry weights of both shoots and roots of plant were measured. Plant materials were ground and wet digested for plant N, P and K contents. Also, faba bean N, P and K uptake were calculated. At the end of the experiment, soil samples were air dried, thoroughly sieved by 2.0 mm sieve and homogeneously mixed and analyzed.

Soil water holding capacity and mechanical analysis were determined according to Richards, (1954). Electrical conductivity was measured in the saturated soil paste extracts and expressed as dSm^{-1} using conductivity meter model 710 according to Richards (1954). The pH of the soil samples is determined by bench type Beckman glass electrode pH meter in 1: 2.5 soil water suspension according to Page et al, (1982). Soil extracts were used for the determinations of soluble anions (HCO_3^-, Cl^-, and SO_4^{2-}) and soluble cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) according to Richards (1954). Available K was determined in ammonium acetate extract by using flame photometer and Available P was determined calorimetrically in 0.5 M $NaHCO_3$ extract according to Jackson (1958). Available N was determined in 2 M KCl extract by using modified Khjeldahl method according to Chapman and Pratt (1961). Available Mn and Fe as extracted from the soil samples by DTPA and also soluble Mn and Fe in soil extract (1:5) were determined by atomic absorption spectrometry (Lindsay and Norvell, 1978).

Electrical conductivity and soluble –K^+, -Ca^{2+}, -Mg^{2+}, Na^+ and Cl^- in sewage sludge compost extract (1:1) and pH in sewage sludge compost suspension (1:2.5) were determined as described by APHA, (1985). Sewage sludge compost sample was digested for the determinations of total-N, and P according the method described in APHA (1985). Available Mn and Fe were extracted from the compost samples by DTPA and determined by atomic absorption spectrometry (Lindsay and Norvell, 1978).

Electrical conductivity and pH in both irrigation water sources was measured using conductivity meter model 710 and pH meter, respectively, according to APHA, (1985). Anions of HCO_3^-, Cl^-, and SO_4^{2-}, cations of Ca^{2+}, Mg^{2+}, Na^+ and K^+ and phosphorus were determined according to APHA, (1985). Manganese and iron were determined by atomic absorption spectrometry (APHA, 1985).

The plant materials were digested by wet oxidation method according to Jackson (1958). Potassium was determined using the flame photometer according to Chapman and Pratt, (1961). Nitrogen was determined by the Kjeldahl method as described by Chapman and Pratt, (1961). Phosphorus was determined calorimetrically after digestion according to Jackson (1958).

RESULTS AND DISCUSSION

A pot experiment was conducted to investigate the effect of irrigation with different magnetized water qualities and the individual and combined application of sewage sludge compost (SSC) and tricalcium phosphate (TCP) on faba bean (*Vicia faba* L) growth characters and composition.

Faba bean growth characters

Data obtained on the effect the different magnetized water qualities and soil treatments on plant length, shoot and root fresh and dry weights of faba bean are presented in Figure (1). There are highly significant differences in plant length shoot and root fresh and dry weights of faba bean between the different soil treatments. The higher values of plant length, shoot and root fresh and dry weights of faba bean when soil received 25 t SSC + 720 kg TCP ha^{-1}, while the lowest values were obtained for faba bean plants grown on untreated soil. The SSC treated soil give much higher values of plant length, shoot and root fresh and dry weights of faba

Table 2. Some chemical properties of the used water sources before and after magnetizing.

Parameter	Non-magnetized water			Magnetized water		
	Ismailia Canal	El-Salam Canal	Abou Sewer Well	Ismailia Canal	El-Salam Canal	Abou Sewer Well
pH	7. 30	7.66	8.20	7.20	7.49	8.10
EC, dSm^{-1}	0.32	1.36	3.70	0.33	1.37	3.81
Ca^{2+}, $meql^{-1}$	0.84	3.00	13.0	0.99	3.05	14.1
Mg^{2+}, $meql^{-1}$	0.73	1.00	4.40	0.79	1.02	4.47
Na^{+}, $meql^{-1}$	1.02	9.29	18.7	0.92	9.29	18.64
K^{+}, $meql^{-1}$	0.61	0.40	0.95	0.63	0.40	0.96
HCO_3^{-}, $meql^{-1}$	1.30	3.70	5.40	1.28	3.70	5.30
Cl^{-}, $meql^{-1}$	1.21	7.50	25.2	1.20	7.50	25.2
SO_4^{-2}, $meql^{-1}$	0.83	2.50	6.30	0.82	2.56	7.67
Soluble P, ppm	3.21	3.86	4.12	3.39	3.98	4.23
Soluble Fe, ppm	-	27.9×10^{3}	83.1×10^{-3}	-	29.8×10^{-3}	83.1×10^{-3}
Soluble Mn ppm	-	9.20×10^{3}	69.2×10^{-3}	-	9.20×10^{-3}	69.8×10^{-3}

Table 3. Some properties of sewage sludge compost

Parameter	Value
pH	7.20
EC, dSm^{-1}	4.70
Ca^{2+}, $meql^{-1}$	15.4
Mg^{2+}, $meql^{-1}$	12.3
Na^{+}, $meql^{-1}$	16.5
K^{+}, $meql^{-1}$	3.40
Cl^{-}, $meql^{-1}$	18.2
Total N, %	1.30
Total P, %	0.44
Available Fe, ppm	35.3
Available Mn, ppm	18.9
Organic matter, %	17.0
Moisture content , %	20.5

bean compared with TCP treated soil.

Similar results were obtained by Mabrouk and Aly (1998) as result of applying of mineral fertilization plus SSC on plant height, fresh and dry weights of maize. El-Fakhrani (1999) found that plant growth and straw yield of barley were significantly increased as result of adding TCP and poultry manure. Khalil et al. (1991) studied the effects of 3 types of organic manure (town refuse, sewage sludge and sheep dung). They found that increasing the manure addition from 1 to 2% increased grain and straw yields. El-Garhi and Mohamed (1991) found that increasing addition of mineral fertilization (NPK) combination, associated with rabbit waste manure caused the dry weight of maize leaves and grains and NPK uptake to be increased. Mikhaeel et al., (1996) showed that the application of organic manure to a soil enhanced wheat growth as indicated by dry weight. They also found that plants grown in soil treated with sewage sludge gave the highest increase in dry weight compared with untreated soil. El Nadi et al. (1995) found that town refuse compost and chicken manure contain the principal elements needed for healthy plant growth. However, chicken manure contains more inherent characteristics, which render its application to soil advantageous than does town refuse compost. Thus, being entirely organic in origin, chicken manure has, not unexpectedly, a higher content of nutrients. Moreover, it has a higher degree of a water-holding capacity and also easier to handle for practical use.

Generally, increasing irrigation water salinity significantly decreased plant length, shoot and root fresh and dry weights of faba bean. Besides the highest values for plant length shoot and root fresh and dry weights were observed when faba bean plants were irrigated with Ismailia canal water while the lowest values were observed with the irrigation with Abou Sewer well water (Table 4, Figure 1). Irrigation water quality can have a profound impact on crop production. All irrigation water contains dissolved salts, but the concentration and composition of the dissolved salts very depending on the source of the irrigation water (Maas and Grattan, 1999).

Concerning magnetized irrigation water, plant length, shoot and root fresh and dry weights of faba bean were significantly increased as the result of the individual

Table 4. Effect of different magnetized water and soil treatments on plant length, shoot and root fresh and dry weights of faba bean.

Factor	$LSD_{0.05}$				
	Plant length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight
Magnetism	0.78	0.54	0.19	0.02	0.08
Water Type	2.10	1.38	0.17	0.02	0.03
Treatments	2.36	0.94	0.18	0.02	0.06

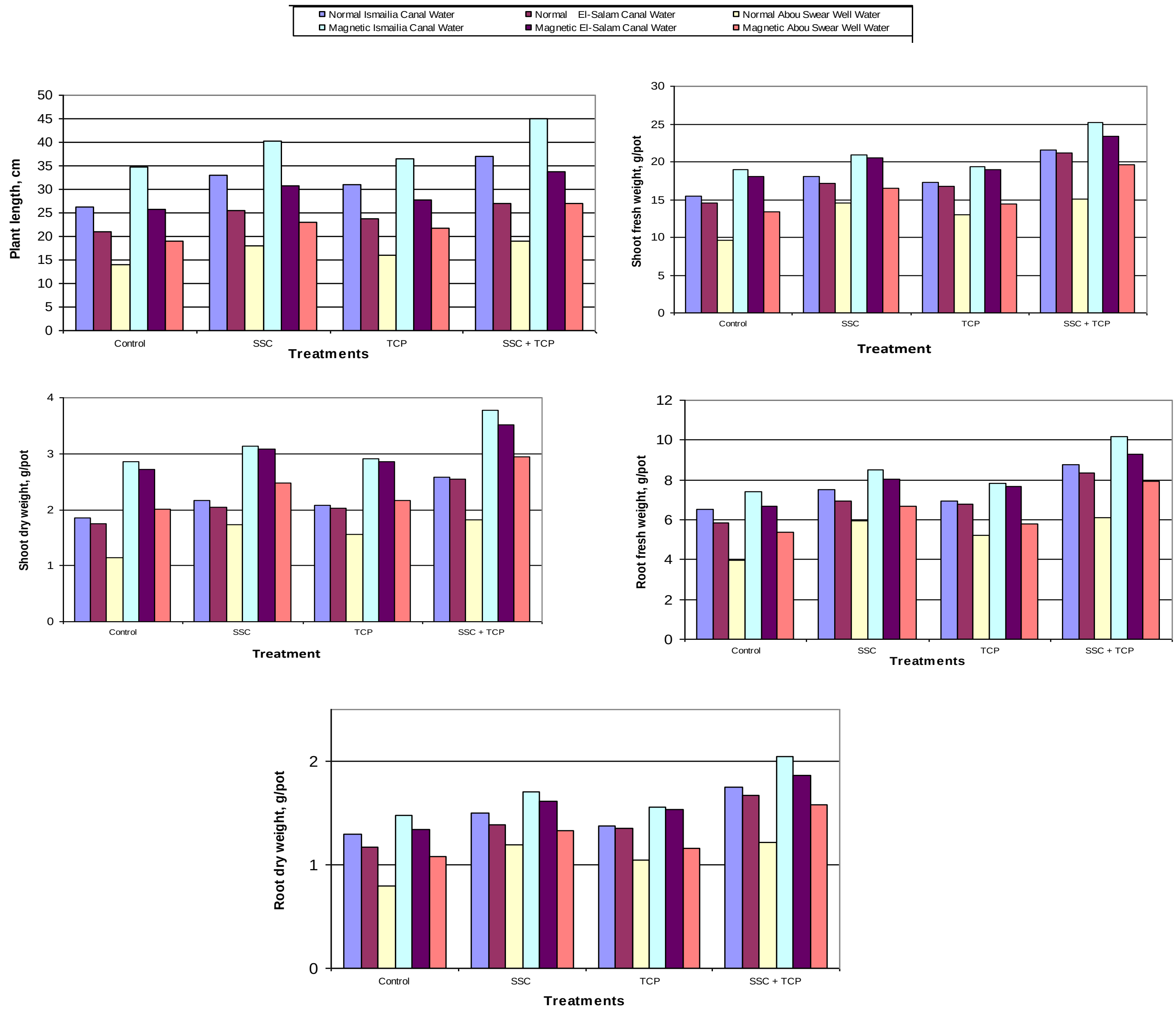

Figure 1. Effect of different magnetized water and soil treatments on plant length, shoot and root fresh and dry weights of faba bean (SSC = sewage sludge compost and TCP = tricalcium phosphate).

magnetism effect. Also the investigated faba bean characters were significantly increased by using the magnetized different water sources compared with the non-magnetized water as result of the combined effect of both magnetism and water quality. Only root fresh and dry weights of faba bean plant were significantly increased by using magnetized water and the different soil organic and inorganic treatments. On the other, plant length, shoot and fresh and dry weights were not significantly affected by the combined effect of magnetism and soil treatments.

Maheshwari and Grewal (2009) studied the beneficial effects of magnetic treatment of different irrigation water types on water productivity and yield of snow pea, celery and pea plants. Replicated pot experiments involving magnetically treated and non-magnetically treated potable water (tap water), recycled water and saline water (500 ppm and 1000 ppm NaCl for snow peas; 1500 ppm and 3000 ppm for celery and peas) were conducted in glasshouse under controlled environmental conditions. They found that there were statistically significant increases in plant yield and water productivity. In particular, the magnetic treatment of recycled water and 3000 ppm saline water, respectively, increased celery yield by 12% and 23% and water irrigation efficiency by 12% and 24%. For snow peas, there were 7.8%, 5.9% and 6.0% increases in pod yield with magnetically treated potable water, recycled water and 1000 ppm saline water, respectively. The water productivity of snow peas increased by 12%, 7.5% and 13%, respectively, for magnetically treated potable water, recycled water and 1000 ppm saline water. Generally, the results indicate some beneficial effect of magnetically treated irrigation water, particularly for saline water and recycled water, on the yield and water productivity of celery and snow pea plants under controlled environmental conditions.

Amira and Hozayn (2010) found that irrigation with magnetized water significantly improved growth, yield, yield components and chemical constituents of lentil plant. The improvement in growth and chemical constituents reflected in increasing seed, straw and biological yield per plant by 25, 27 and 26%, respectively, over the control treatment. It appears that utilization of magnetized water technology may be considered a promising technique to improve lentil yield productivity. Muraji et al. (1992) demonstrated an enhancement in root growth of maize by exposing the maize seedling to magnetic fields of 500 gauss. Highest growth rate of maize roots was achieved in a magnetic field of 5 mT (Muraji et al., 1998). Turker et al. (2007) reported an inhibitory effect of static magnetic field on root dry weight of maize plants, but there was a beneficial effect of magnetic field on root dry weight of sunflower plants.

Faba bean shoot and root N, P and K contents

Data obtained on shoot N, P and K contents of faba bean as result of using the different magnetized water and soil treatments are presented in (Table 5 and Figure 2). Shoot N and K contents were highly significant increased by the individual and the combined application of SSC and TCP to soil compared with untreated soil. Using the combined application of SSC and TCP, much higher shoot N and Kcontents were obtained compared with the individual application of SSC and TCP, and the individual application of SSC was much effective in increasing shoot N and K contents compared with the individual application of TCP. Slight increases in faba bean shoot P content was noticed between the different soil treatments. Since, Faba bean shoot P content significantly influenced by treating the soil with either the individual or the combined application of SSC and TCP.

There are significant increases in Faba bean shoot N, P and K contents between the different irrigation water quality sources. The highest shoot N, P and K contents were usually corresponded with the low water salinity content. Since, the highest values for N, P and K contents were observed when faba bean plants irrigated with Ismailia canal water while the lowest values were observed with the irrigation with Abou Sewer well water (Table 5,Figure 2). With this respect, Maas and Grattan (1999) all irrigation water contains dissolved salts, but the concentration and composition of the dissolved salts very depending on the source of the irrigation water.

Shoot N, P and K contents of faba bean was significantly increased by using different magnetized irrigation water qualities compared with the normal or non-magnetized water. This is true with using the different water qualities and the different soil treatments. Similar results, for both shoot and root N, P and K contents, were obtained by De Haan (1985), Khalil *et al.* (1991) and El-Garhi and Mohamed (1991).

Root N, P and K contents were highly significant increased by the individual and the combined application of SSC and TCP to soil compared with untreated soil. Using the combined application of SSC and TCP, much higher shoot N and K contents were obtained compared with the individual application of SSC and TCP, and the individual application of SSC was much effective in increasing shoot N, P and K contents compared with the individual application of TCP (Table 6,Figure 3).

There are significant increases in Faba bean root N, P and K contents between the different irrigation water quality sources. The highest shoot N, P and K contents were usually corresponded with the low water salinity content. Since, the highest values for root N, P and K contents were observed when faba bean plants irrigated with Ismailia canal water while the lowest values were observed with the irrigation with Abou Sewer well water (Table 6,Figure 3).

Mabrouk and Aly (1998) found that N content in roots of maize significantly increased with both separate and combined applications of organic and mineral N sources. The highest N values were recorded with the combined N sources as compared with the control or with the separate N sources. The same trend was observed with the K as a result of the application of separate or combined N sources at both seasons. However, there was no significant increase in root content of P to due the treatments.

Table 5. Effect of different magnetized water and soil treatments on shoot N, P and K contents of faba bean plant.

Factors	LSD$_{0.05}$		
	Shoot N content	Shoot P content	Shoot K content
Magnetism	0.08	0.24	0.02
Water Type	0.09	0.18	0.05
Treatments	0.06	N.S	0.06

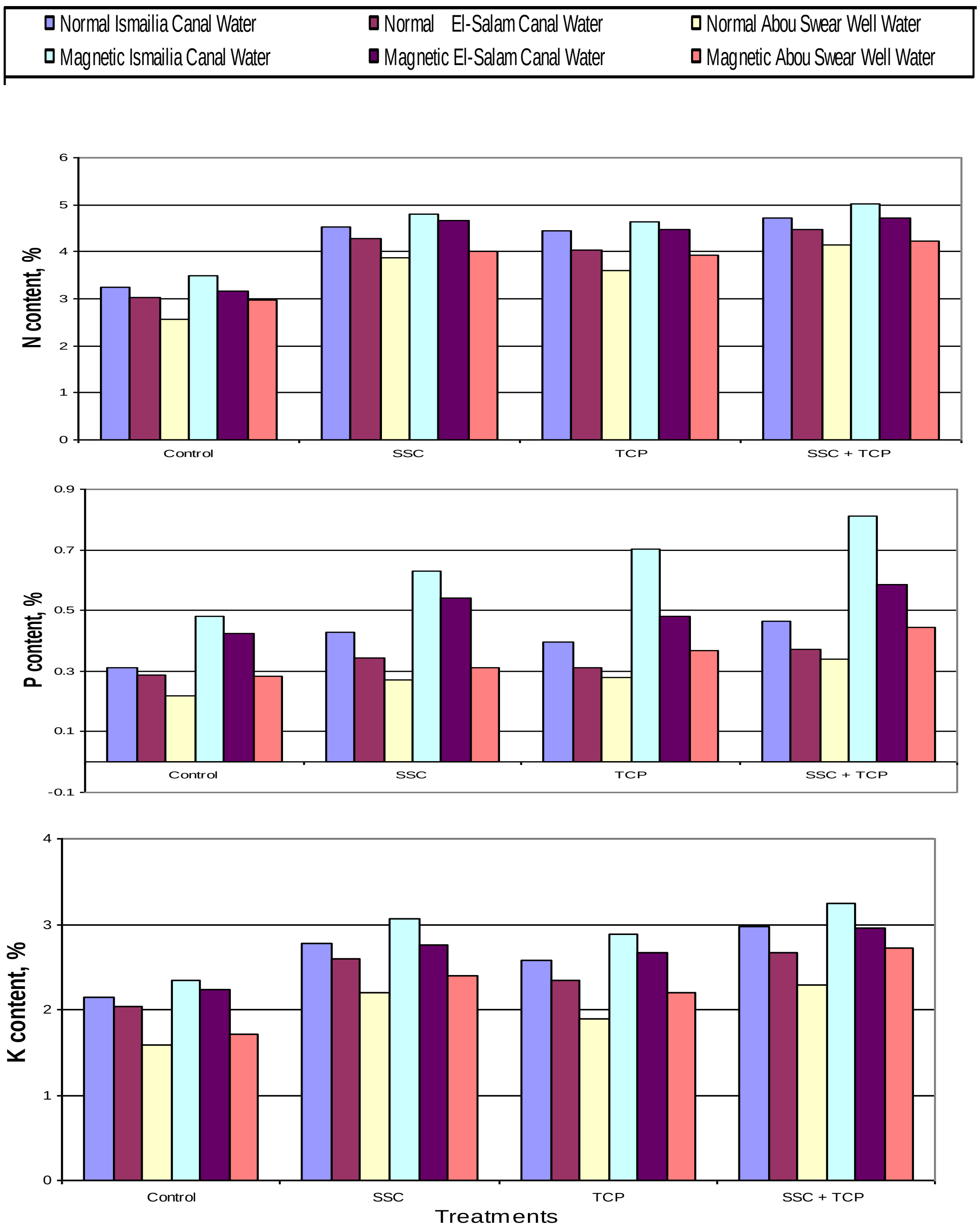

Figure 2. Effect of different magnetized water and soil treatments on shoot N, P and K contents of faba bean plant (SSC = sewage sludge compost and TCP=tricalcium phosphate)

Table 6. Effect of different magnetized water and soil treatments on root N, P and K contents of faba bean plant

Factors	LSD0.05		
	Root N content	**Root P content**	**Root K content**
Magnetism	0.05	3.25	0.04
Water Type	0.03	10.50	0.03
Treatments	0.04	8.99	0.04

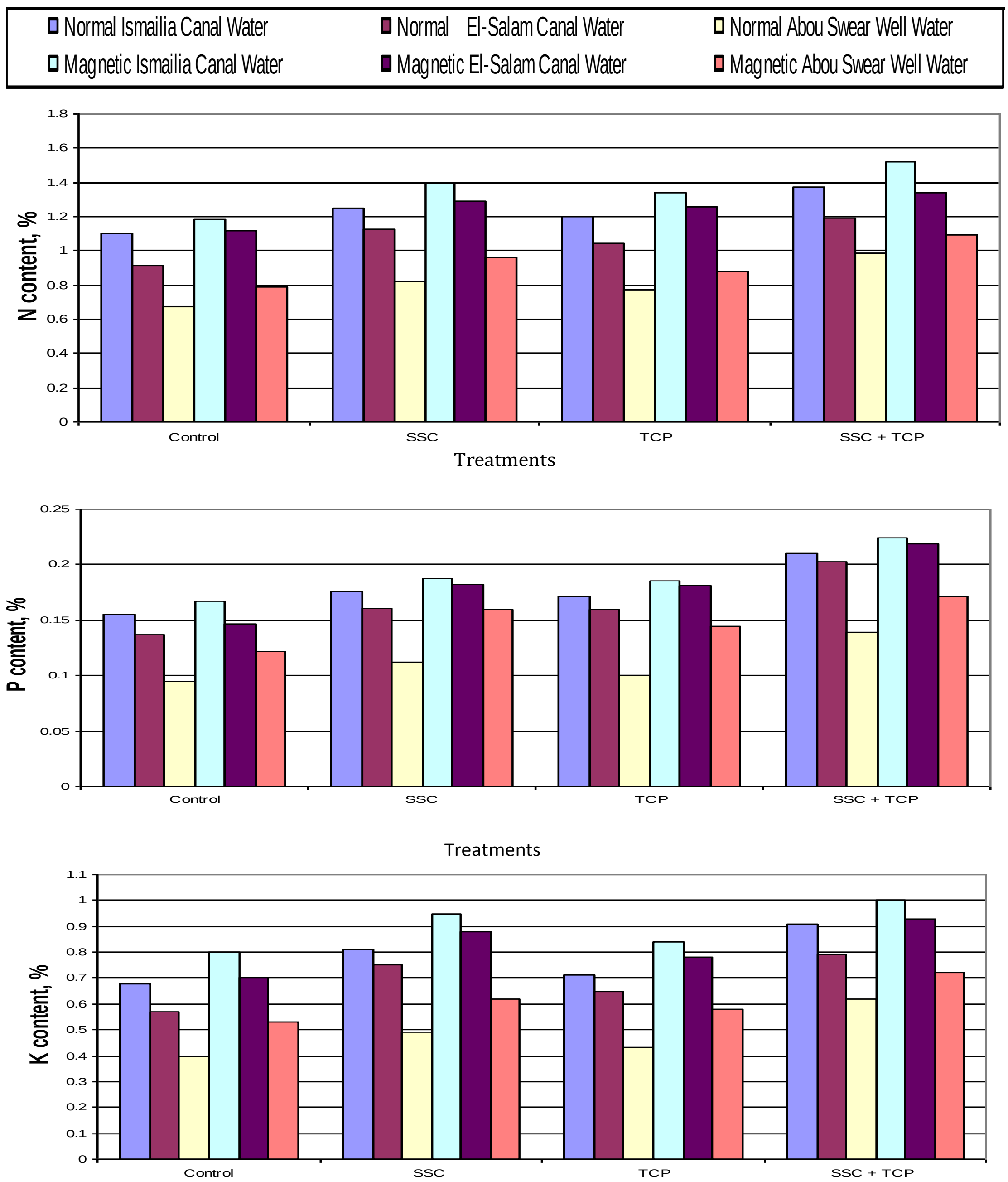

Figure 3. Effect of different magnetized water and soil treatments on root N, P and K contents of faba bean plant (SSC = sewage sludge compost and TCP = tricalcium phosphate

Table 7. Effect of different magnetized water and soil treatments on shoot N,P and K uptake of faba bean plant

Factors	**LSD$_{0.05}$**		
	Shoot N uptake	**Shoot P uptake**	**Shoot K uptake**
Magnetism	3.22	6.30	5.13
Water Type	10.66	4.45	6.16
Treatments	10.27	5.16	6.51

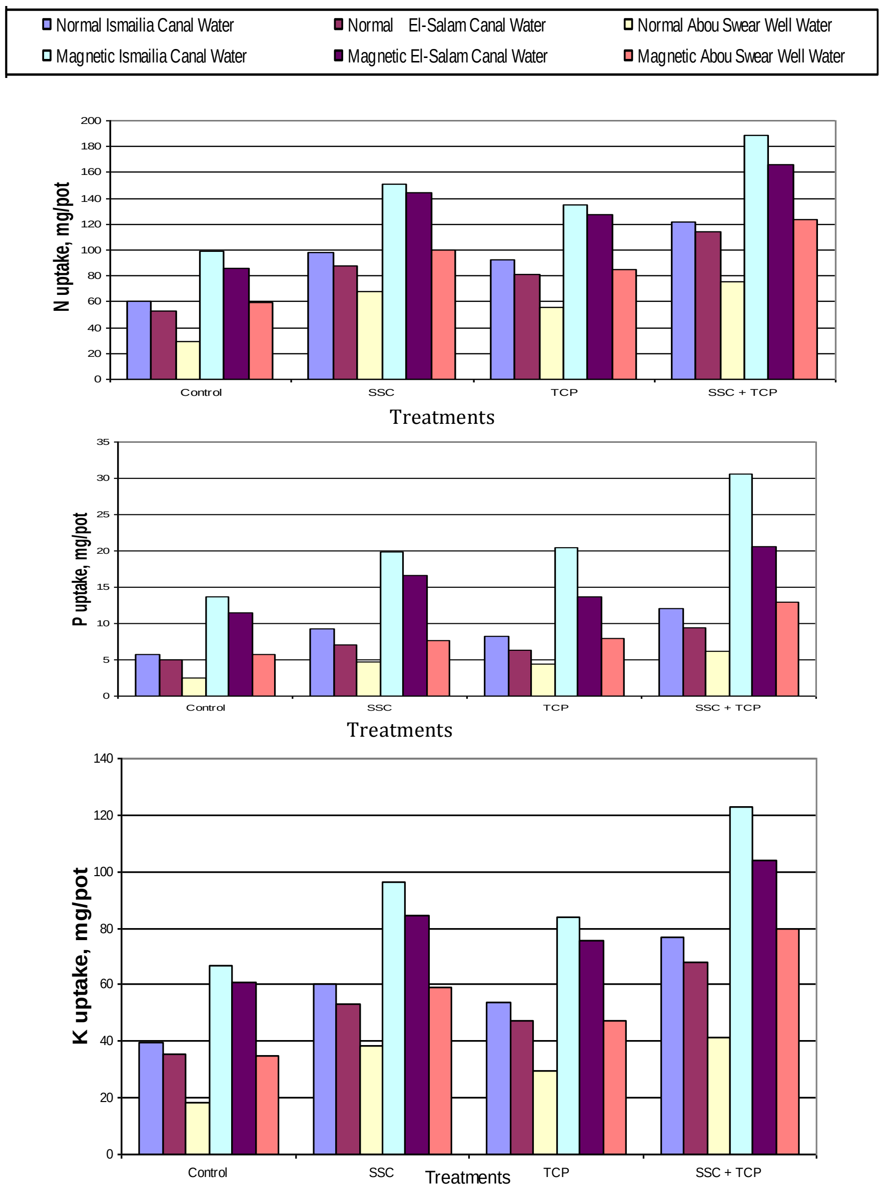

Figure 4. Effect of different magnetized water and soil treatments on shoot N, P and K uptake of faba bean plant (SSC = sewage sludge compost and TCP = tricalcium phosphate).

Faba bean shoot and root N, P and K uptake

Data obtained on shoot and root N, P and K uptake of faba bean as result of using the different magnetized irrigation water qualities and soil treatments are presented in (Table 7 Figures 4; Table 8, Figure 5). Similar trend in shoot and root N, P and K uptake as shown in shoot and root N, P and K contents, since they were significantly increased by the

Table 8. Effect of different magnetized water and soil treatments on root N, P and K uptake of faba bean plant

Factors	LSD$_{0.05}$		
	Root N uptake	Root P uptake	Root K uptake
Magnetism	0.59	0.29	0.92
Water Type	0.72	0.05	0.58
Treatments	0.85	0.14	0.72

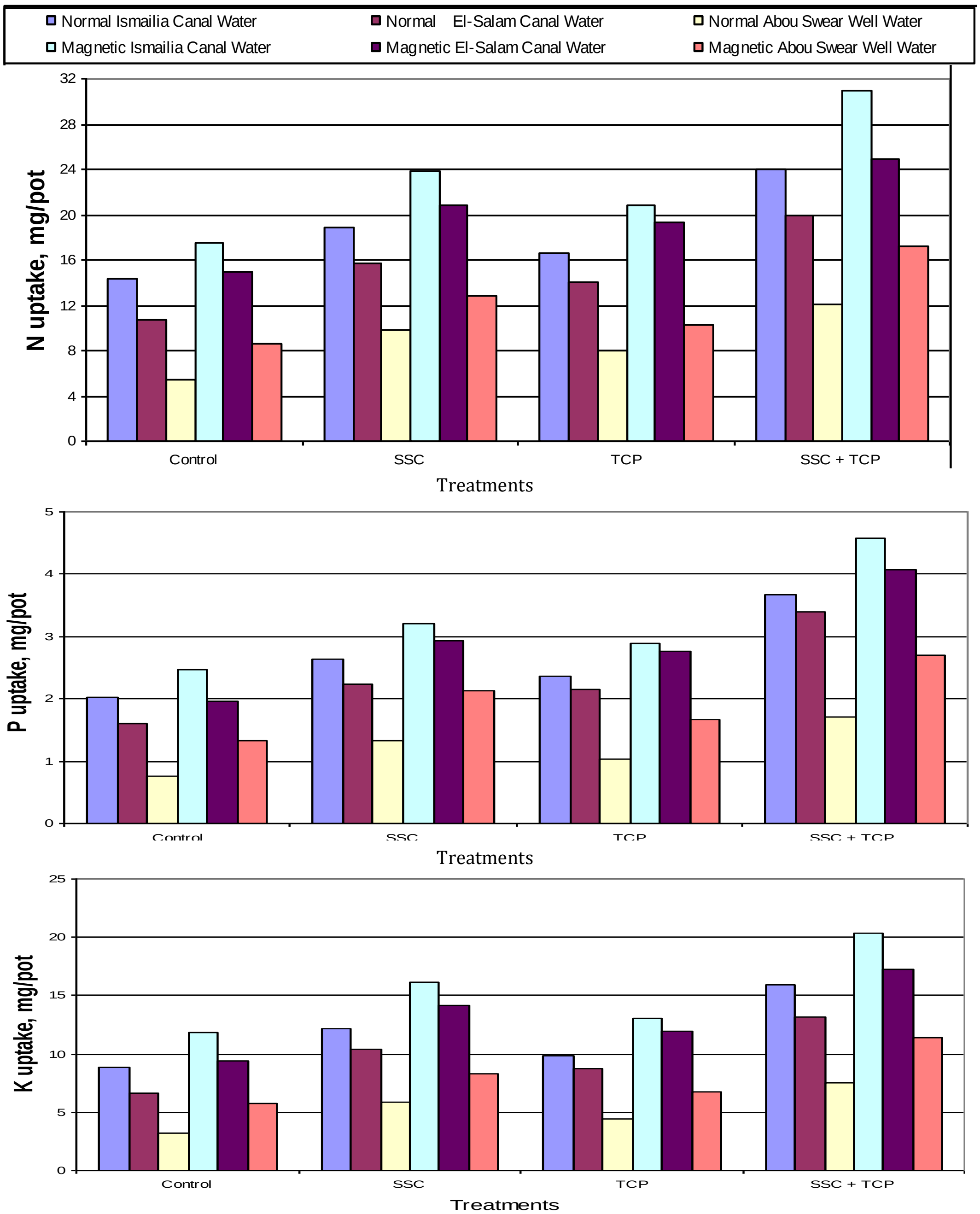

Figure 5. Effect of different magnetized water and soil treatments on root N, P and K uptake of faba bean plant (SSC = sewage sludge compost and TCP = tricalcium phosphate).

individual and the combined application of SSC and TCP to soil compared with untreated soil. Using the combined application of SSC and TCP, much higher shoot N and K uptake were obtained compared with the individual application of SSC and TCP, and the individual application of SSC was much effective in increasing shoot and root N, P and K uptake compared with the individual application of TCP.

There are significant increases in Faba bean shoot and root N, P and K uptake between the different irrigation water quality sources. The highest shoot and root N, P and K uptake were usually corresponded with the low water salinity content. Since, the highest values for N, P and K uptake were observed when faba bean plants irrigated with Ismailia canal water while the lowest values were observed with the irrigation with Abou Sewer well water (Table 7 Figures 4; Table 8,Figure 5).

Shoot and root N, P and K uptake of faba bean were significantly increased by using different magnetized irrigation water compared with the normal or non-magnetized water. This is true with using the different water qualities and the different soil treatments. Similar results, for both shoot and root N, P and K uptake, were obtained by De Haan (1985), Khalil *et al.* (1991) and El-Garhi and Mohamed (1991). Maas and Grattan (1999) pointed out that all irrigation water contains dissolved salts, but the concentration and composition of the dissolved salts very depending on the source of the irrigation water.

Changes in some soil chemical properties after plant harvest

Soil salinity

There are highly significantly differences in soil salinity (EC_e, dSm^{-1}) in saturated soil past extract after harvest of faba bean as result of the soil treatments. Soil salinity was significantly increased by adding both the individual and the combined SSC and TCP. Using the combined SSC and TCP was more effective in increasing soil salinity compared with the individual one. Also, adding SSC to the soil resulted in increasing its salinity compared with TCP. Generally, water salinity of Ismailia canal was lower than both El-Salam canal and Abou-Sewer well (Table 9, Figure 6). Water magnetizing treatment resulted in decreasing soil salinity with using the three used water types. Maheshwari and Grewal, (2009) found that the use of magnetically treated irrigation water increased soil salinity.

Soluble Soil cations and anions

Changes in soluble soil cations and anions (in soil saturated paste extract) under using the different magnetized irrigation water qualities and soil treatments are presented in (Table 10, Figure 7). There are significantly differences in soluble soil cations and anions as result of the soil treatments. Soluble soil cations of K^+, Mg^{2+} and Ca^{2+} were significantly increased by adding both the individual and the combined SSC and TCP. Using the combined SSC and TCP was more effective in increasing soluble soil K^+, Mg^{2+} and Ca^{2+} compared with the individual one. Also, adding SSC to the soil resulted in increasing its soluble K^+, Mg^{2+} and Ca^{2+} compared with TCP. It was found that soil soluble Na^+ was significantly decreased by using the same individual and combined soil treatments. Generally, using different magnetized water sources, soluble soil K^+, Mg^{2+} and Ca^{2+} were significantly increased. In opposite, soil soluble Na^+ was decreased by using magnetized water.

Similar trend in soluble soil HCO_3^- and Cl^- as well as soluble soil K^+, Mg^{2+} and Ca^{2+} under the effect of both soil treatments and different magnetized irrigation water sources. Also, similar trend in soluble soil SO_4^{2-} as well as soluble soil Na^+ under the effect of both soil treatments and different magnetized irrigation water sources (Table 11,Figure 8).

The mechanism of the magnetically treated water activity in the soil is yet unclear. There is a possibility that the effect is physical, viz. through a change in the solvent capacity of water. An increase in that capacity can be the explanation of the differences detected while examining the soluble fraction of the soil, between the ordinary water and magnetically treated water These differences varied between 50 percent to 300 percent (Harari and Lin, 1991).There is a conjecture that water has a direct effect on physiological processes in the plant cells, and it is possible that the reactions of the plant are of secondary importance. The direct influence is concentrated mainly on the composition or the mineral structure of the soil. (Bresler, 1975).

Available soil N, P and K

Data obtained on the effect both soil treatments and using different magnetized irrigation water sources on available soil N, P and K are presented in (Table 12,Figure 9). There are significantly differences in available soil N, P and K as result of applying the individual and the combined SSC and TCP. Available Soil N, P and K were significantly increased by adding both the individual and the combined SSC and TCP. Using the combined SSC and TCP was more effective in increasing available soil N, P and K compared with the individual one. Also, adding SSC to the soil resulted in increasing its available N, P and K compared with TCP.

Generally, using different magnetized water sources, available soil N, P and K were significantly increased. As to soil properties after plant harvest, the use of magnetically treated irrigation water increased soil available N, P and K. Overall; the results indicate some beneficial effect

Table 9. Soil salinity changes at the end of the experiment of faba bean irrigated with different magnetized irrigation water and soil treatments

Factors	$LSD_{0.05}$
Magnetism	0.05
Water Type	0.02
Treatments	0.01

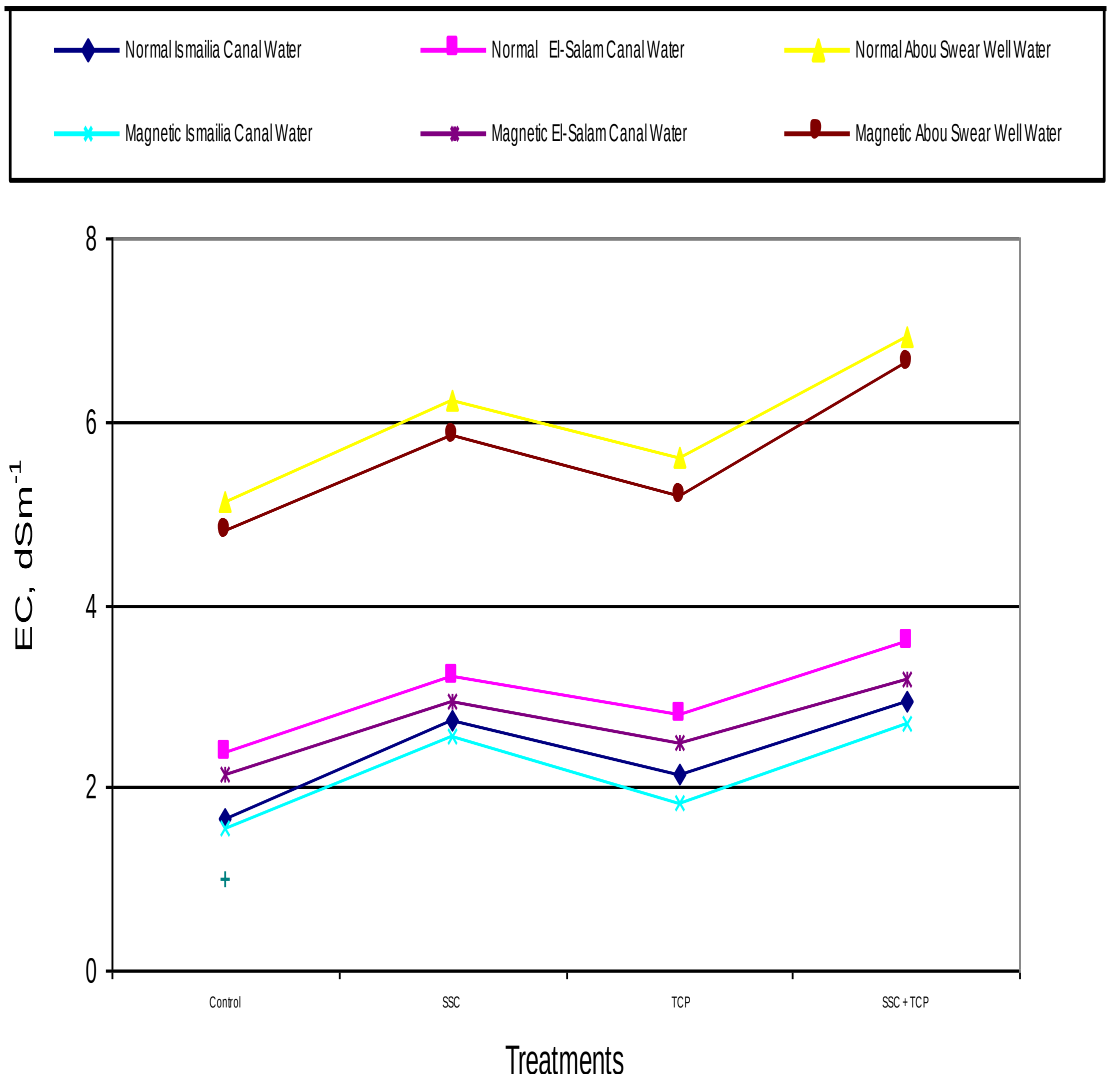

Figure 6. Soil salinity changes at the end of the experiment of faba bean irrigated with different magnetized irrigation water and soil treatments (SSC = sewage sludge compost and TCP = tricalcium phosphate).

of agnetically treated irrigation water, particularly for saline water and recycled water, on the yield and water productivity of celery and snow pea plants under controlled environmental conditions. While the findings of this glasshouse study are interesting, the potential of the magnetic treatment of irrigation water for crop production needs to be further tested under field conditions to demonstrate clearly its beneficial effects on the yield and water productivity (Maheshwari and Grewal, 2009).

Noran et al. (1996) observed differences in the concentrations of N, P, K in soils irrigated with magnetically treated water when compared those with normal water. They argued that magnetic treatment of water slows down the movement of minerals, probably due to the effect of

Table 10. Changes of soluble soil cations after harvest of faba bean irrigated with different magnetized water and different soil treatments

Factors	LSD$_{0.05}$			
	Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}
Magnetism (M)	0.80	0.06	0.05	1.35
Water Type (W)	0.57	0.02	0.02	0.46
Treatments (T)	0.73	0.02	0.02	0.43

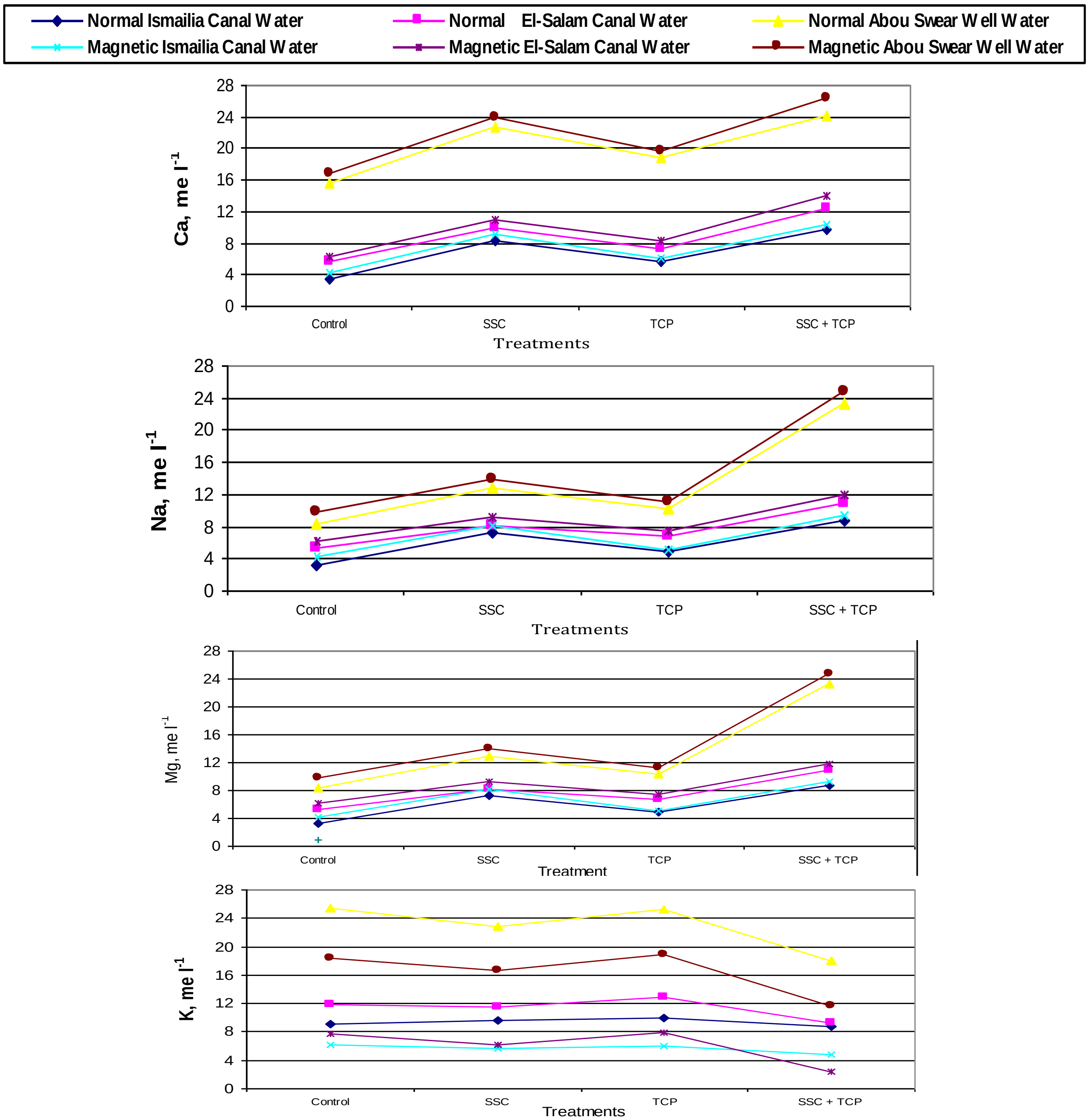

Figure 7. Changes of soluble soil cations after harvest of faba bean irrigated with different magnetized water and different soil treatments (SSC = sewage sludge compost and TCP = tricalcium phosphate).

Table 11. Changes of soluble soil anions harvest of faba bean irrigated with different magnetized water and different soil treatments

Factors	LSD0.05		
	HCO_3^-	Cl^-	SO_4^{2-}
Magnetism (M)	0.04	0.04	0.34
Water Type (W)	0.05	0.06	0.18
Treatments (T)	0.02	0.04	0.08

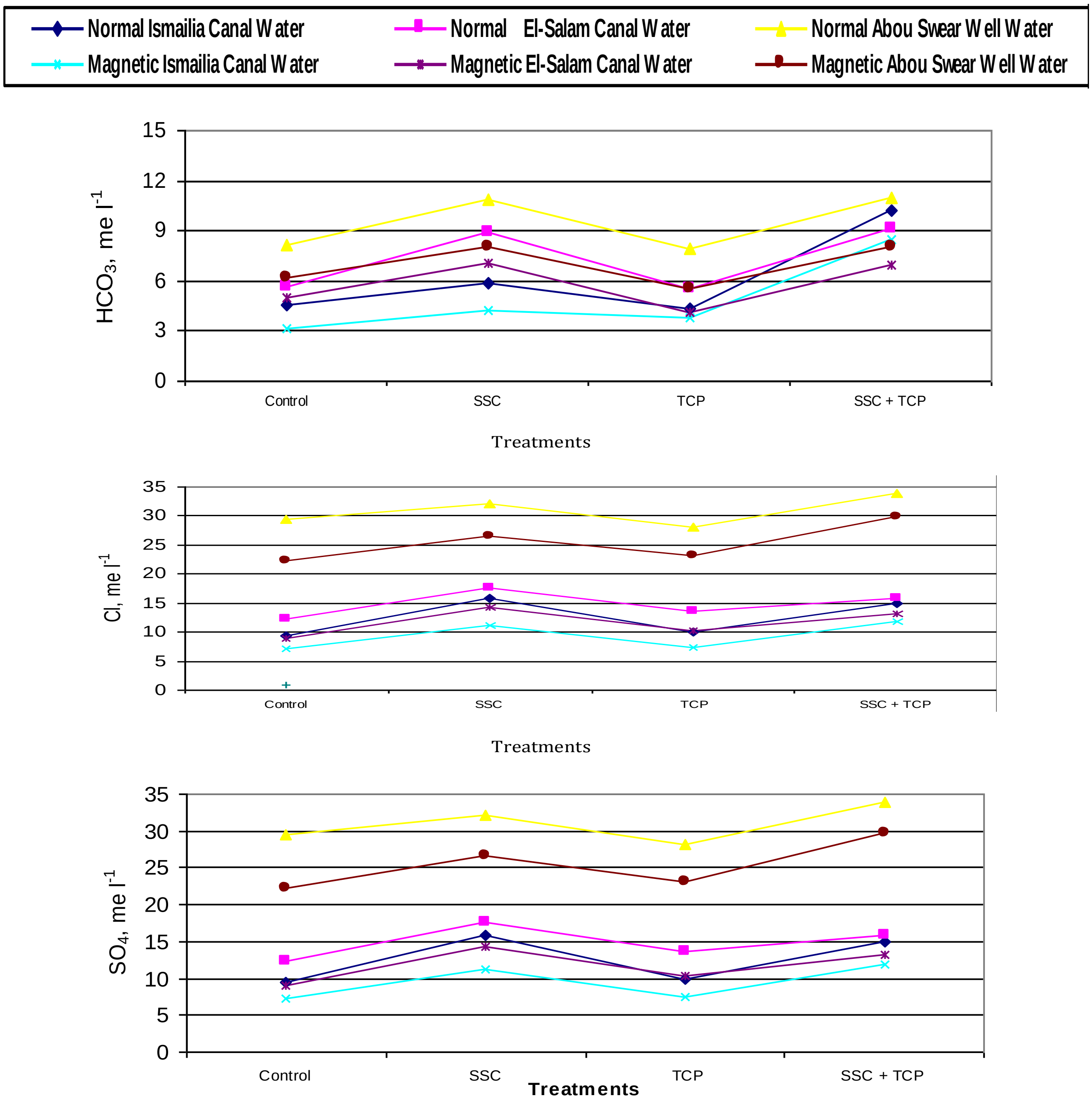

Figure 8.Changes of soluble soil anions harvest of faba bean irrigated with different magnetized water and different soil treatments (SSC = sewage sludge compost and TCP = tricalcium phosphate)

Table 12.Available soil N, P and K changes after harvest of faba bean irrigated with different magnetized water and different soil treatments

Factors	LSD$_{0.05}$		
	N	P	K
Magnetism	8.01	3.37	6.14
Water Type	2.49	0.79	0.91
Treatments	0.89	1.97	1.31

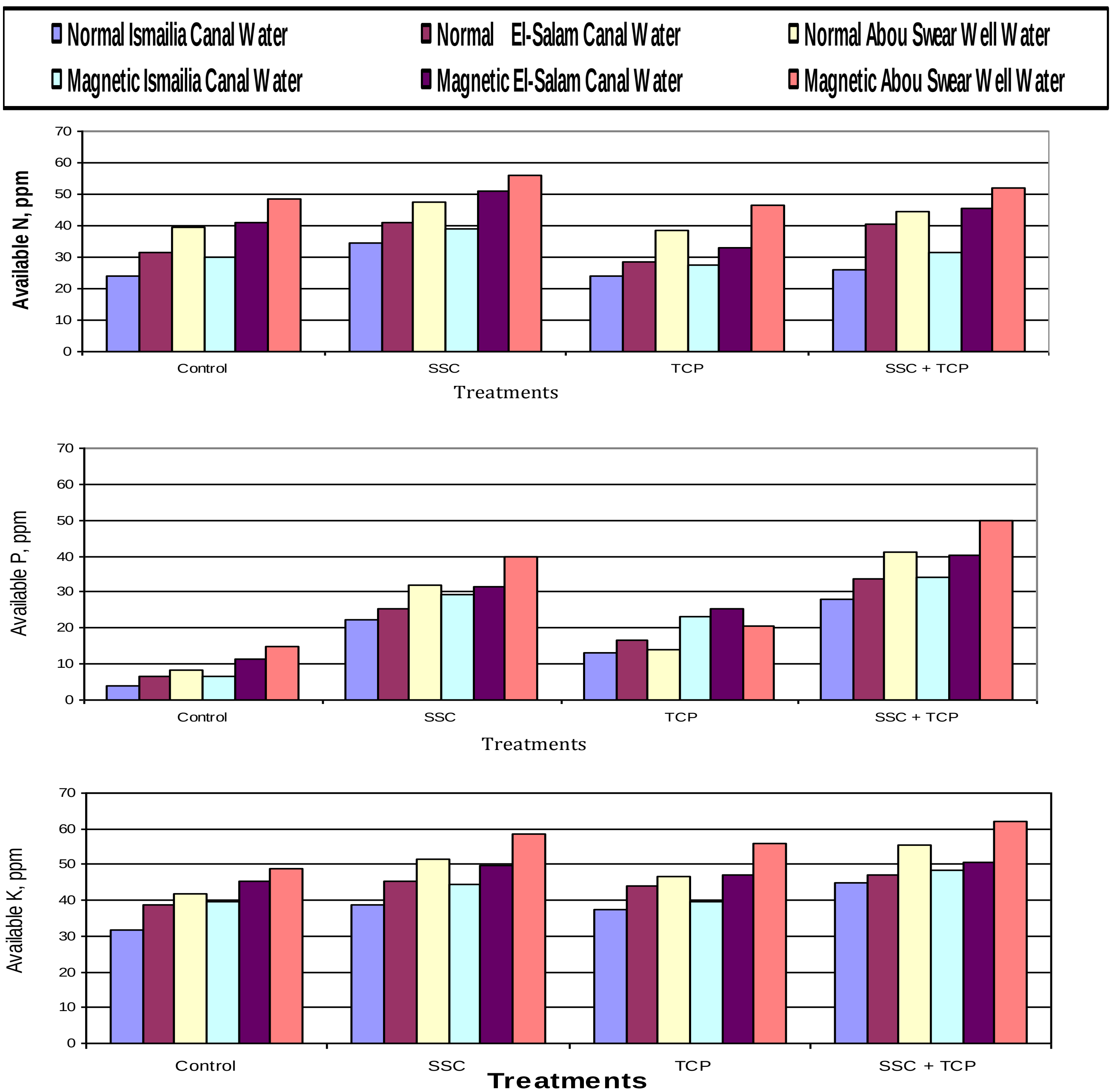

Figure 9. Available soil N, P and K changes after harvest of faba bean irrigated with different magnetized water and different soil treatments (SSC= sewage sludge compost, TCP= tricalcium phosphate).

acceleration of the crystallizations and precipitation processes of the solute minerals. Maheshwari and Grewal (2009) found that an increase in soil available P and extractable K, particularly under magnetically treated recycled water and saline water irrigation, appears to have played some role in improving yield and water productivity of celery plants. Magnetic treatment of water may be influencing desorption of P and K from soil adsorbed P on colloidal complex, and thus increasing its availability to plants, and thus resulting in an improved plant growth and productivity.

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