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Applications of Magnetic Technology in Agriculture, A Novel Tool for Improving Water and Crop Productivity: 3. Faba Bean.

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ABSTRACT

Faba bean came in the first order compared others pulses crops as a main source of protein for a large sector of Egyptian people. Limited unite area in winter season, water scarcity and low fertile sandy soil led to agriculture scientist to work for producing more food from less water and optimization unit area production. One of promising and uncommon technique for improvement the water productivity and yield crop is utilization of magnetic water technology. Two field trials using Faba bean (var. Nubaria-1) were carried out at Research & Production Station (National Research Centre), district of Al Nubaria, Al Behaira, Egypt during seasons 2009/10 and 2010/11 for studying and evaluating the effect of magnetizing irrigation water on water productivity and Faba bean productivity. Results indicated that, irrigation Faba bean plants with water passed through magnetic device (2 inch, production with Magnetic Technologies L.C.C., Russia, branch United Arab Emirates) induced positive significant effect with all studied parameters i.e., growth, pigments, yield, yield components, nutritional and amino acids value in yielded seed seeds and water use efficiency compared to irrigation with normal water. The increase percent in seed, biological yields and straw per fed. (fed= 4200 m^2) were 7.25, 25.31 and 38.31%, respectively as compared with normal water. Treatment of magnetic water could be used to improve productivity of Faba bean and water productivity under sandy soil conditions.
Keywords: Faba bean, magnetized water, growth, nutritional value, amino acids, economic yield.

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INTRODUCTION

Arid regions culminated from water shortage. So, the agricultural sectors try to produce more food from less water. Magnetic water technology is one of hopeful technique to improve water and crop productivity. Reduction of water use and intelligent irrigation are becoming more of an important issue all over the world. Through the research there were no significant differences in wet yield weights or soil moisture retention between irrigated turf grass plants at 80 % rate of magnetized water and full field without the magnet. This is being said for superintendents looking to save water and money [1].Therefore, stimulatory impact for magnetic water probably linked to the increasing of plant growth and crop yield, where this technique proved that increasing in absorption and nutrients assimilation. Irrigation by using magnetic water probably considered a promising technique for improving growth and water content of broad bean plant. Irrigation by magnetic water should be used for increasing the chemical constituents (total available carbohydrates, chlorophyll a and b, protein, total amino acids, carotenoids, proline , total indole, GA_3, DNA, total phenol, RNA, kinetin) in addition to inorganic minerals (Na^+, K^+, P^{+3} and Ca^{+2}) contents in each parts of plant of broad bean with greenhouse conditions [2]. Morphological comparison of the treated seeds of *Satureja bachtiaria* by electromagnetic showed that the percentage of seed germination and average root length of enzymatic antioxidant the plants increased, but the difference in root length was not significant. Also, [3] found that pear seedling vegetative criteria and content of minerals (Na, Mg ,Fe, Zn, Ca, Mg and B) increased by irrigation with magnetic water however, proline gave the opposite trend. A significant decrease in the shoot length, leaf area, and fresh and dry weight was observed. Also, exposure to electromagnetic radiation caused significant decrease in the rate of chlorophyll a and chlorophyll b. [4]. In the same trend, monocotyledonous like flax and wheat and dicotyledonous like lentil plants and chick-pea, which irrigated by magnetic water displayed a remarkable increasing with vegetative growth in addition biochemical constitutions [5,6,7].

In addition,[8] revealed that irrigation by magnetic water for common bean plants achieved significantly increase in growth characteristics, GA_3, potassium, nucleic acids (RNA & DNA), kinetin and photosynthetic pigments (chlorophyll a, b, carotenoid), photosynthetic activity and translocation efficiency for photo assimilates. likewise, there are stimulation effects in the activity of antioxidant enzymes in magnetized plants more than translocation efficiency for photo assimilates in popular bean plants. Also, total protein and chlorophyll amounts, SOD, CAT, POX and APX enzyme activities of 2.2 and 19.8 s magnetic field applied experimental groups presented increase compared to the control, depending on applied magnetic field intensity [9] as well as phytohormones (GA, IAA, ABA and cytokinin) and proline contents of sunflower seedlings under magnetized water irrigation [10]. Moreover, significant response for plant was revealed with the ratio chlorophyll a to chlorophyll b indicate the magnetic fluid impact on light harvest complex II from plant chloroplasts. Different sensitivity of two plants (pumpkin and maize) to magnetic fluid management in the culture medium [11].Which reflected in increasing growth rate, relative growth rate in addition seed yield of lupine plant varieties [12] .In addition, [13] suggested that the impacts of magnetic treatment different with plant kind and the kind of irrigation water, and also, they indicated that, there were significant increases in the yield and water productivity of crop (kg $_{\text{grain or dry}}$ / m^3 $_{\text{water used}}$). Therefore, the goal of this work to evaluate the impact of magnetized of irrigation water on the growth, main crop yield, yield components, nutritional in addition amino acids value in yielded seed of faba bean (*Vicia faba* L) plant grown under sandy soil conditions.

MATERIALS AND METHODS

Two field trials using faba bean (var. Nubaria-1) were conducted at Research and Production Station, National Research Centre, Alemam Malek village, Al Nubaria district, Al Behaira Governorate, Egypt in 2009/10 and 2010/11 winter seasons to study and evaluate the effects of irrigation with magnetized water on growth, chemical constituent and Faba bean yield and its components. The experimental soil and water were analyzed according to the method described by [14] (Table 1).

Cultivation method and layout of Experiment: Seeds of the Faba bean crop were obtained from Legume Research Department, Field Crop Research Institute, Agriculture Research Centre, Giza, Egypt. Recommended rates of Faba bean seeds were planted in plots (10 length m x 12 width m) at the first week of November. Control treatment was irrigated with normal water, while the other treatment (magnetized water) was irrigated with water after magnetization through passing a two inch Magnetic device [U.T.3, Magnetic Technologies LLC PO Box 27559, Dubai, UAE]. Four replications were used in each treatment. The recommended NPK fertilizers for Faba bean crop were applied through the period of experiment. Sprinkler irrigation was applied as plants needed. The layout of the experiment was shown in (Fig 1).

Table 1. Soil and water analysis for site experiments.

	Soil depth (cm)		Irrigation water
Parameters	**0 -15**	**15 - 30**	
Particle size distribution			
Coarse sand	48.20	54.75	..
Fine sand	49.11	41.43	..
Clay + Silt	2.69	3.82	..
Texture	Sandy	Sandy	..
PH (1:2.5)	8.22	7.94	7.25
EC(dSm^{-1})(1:5)	0.20	0.15	0.50
Organic matter (%)	0.67	0.43	…
Soluble cations (mq/l)			
Ca^{++}	0.60	0.50	2.15
Mg^{++}	0.50	0.30	0.50
Na^{++}	0.90	0.80	3.00
K^{+}	0.20	0.10	0.31
Soluble anions (mq/l)			
CO^{-3}	-	-	0.01
HCO^{-3}	0.60	0.40	2.33
Cl^{-}	0.75	0.70	2.17
SO^{-4}	0.85	0.60	1.45

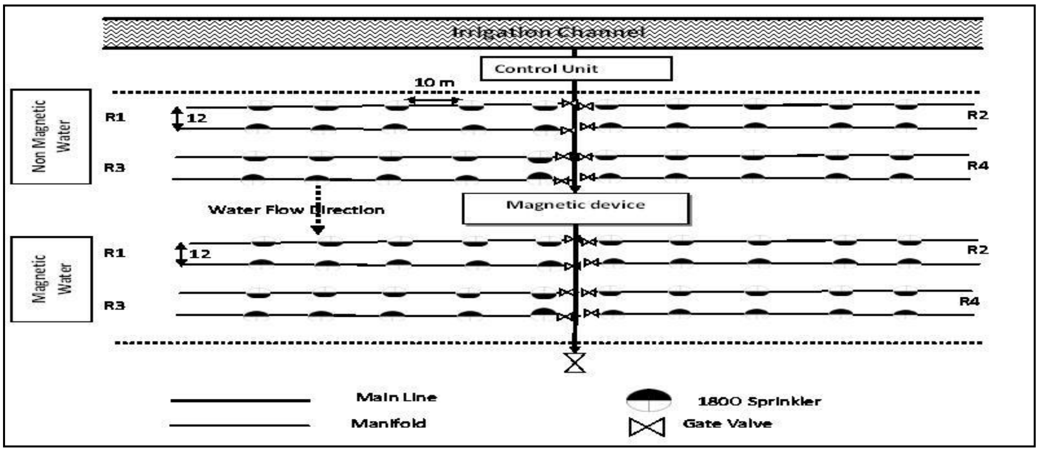

Fig 1. Layout of experiment under solid set sprinkler system.

Data recorded:

Growth parameters: After 85 days from sowing plant height, fresh and oven dry weight of 10 plants from each treatment were determined. Water content was determined according to [15] using the following formula: WC = 100×(fresh mass – dry mass)/fresh mass.

Photosynthetic Pigments: Total chlorophyll a and b and carotenoids contents in fresh leaves were estimated using the method of [16]. The fresh tissue was ground in a mortar and pestles using 80% acetone. The optical density (OD) of the solution was recorded at 662 and 645 nm (for chlorophyll a and b, respectively) and 470 nm (for carotenoids) using a spectrophotometer (Shimadzu UV-1700, Tokyo, Japan). The values of photosynthetic pigments were expressed in mg/100g FW.

Yield and yield components: At harvest stage, 20 plants were selected randomly to determined Faba bean yield components. The whole plot was harvested to determine the above ground biomass (biological yield), pods were threshed to determine seed yield, straw yield was calculated by subtracting seed yield from biological yield, and harvest and crop indexes were calculated by dividing seed yield/biological yield and straw yield, respectively.

Water productivity (WP): Water productivity (WP) values were calculated with the fowling Eqs: WUE =[(E_y/E_t], [17]. Where WP is the water productivity (kg $_{\text{faba bean seeds}}$/$m^3$ water); Ey is the economical yield (kg/fed./season); Et is the total applied of irrigation water, m^3/fed./season.

Nutritional value of yielded seeds: Macro (N, P, K, Ca and Mg) and microelement (Fe, Mn, Zn and Cu) contents in dried seeds were determined. Total N was determined by using micro-Kjeldahl method as described by [18]. Phosphorus was determined using a Spekol spectrocolorimeter (VEB Carl Zeiss; Jena, Germany, while, estimation of K^+ contents were done using a flame photometer. Mg, Fe, Mn, Zn and Cu were determined using the Atomic absorption spectrophotometer (Perkin Elemer 100 B).

Free amino acids: Free amino acid content was extracted according to the method described by [19]. Free amino acid was determined with the nin-hydrin reagent method [20]. 1 ml acetate buffer (pH 5.4) and 1 ml chromogenic agent were added to 1 ml free amino acid extraction. The mixture was heated in boiling water bath for 15 min. after cooled in tap water, 3 ml ethanol (60% v/v) was added. The absorbance at 570 nm was then monitored using Spekol Spectrocolollourimeter VEB Carl Zeiss.

Statistical analysis: Statistical analysis was carried out using SPSS program Version 16 [21]. A student t test (Independent *t*-test) was also carried out to find the significant differences between magnetic and nonmagnetic water treatments.

RESULTS AND DISCUSSION

Faba bean growth:

Table (2) showed that vegetative characteristics (Plant height , green & dry weight) were increased significantly by magnetized water application compared with normal water application .while, the plants water content of both treatments were similar. These results appeared that the magnetized water hasn,t any effect on water content and stable rate consumption for both treatments in metabolic processes .But ,the effect might be due to the stimulation effect on the biosyntheses of molecular structure and their interactions in the different processes in the plant. Whereas, the magnetic field has significant effects on decreasing the surface shipment on tiny particles, increasing the inclination to coagulate like great particles that lodging with the flow than depositing such as scale [22], that is related with physicochemical properties of water as shown as the decreasing of surface tension and increasing of viscosity over the treatment time. Water is more stabilized with magnetic treatment with minimal molecular energy while greater in activation energy [23]. All catalytic processes involving oxidation or reduction speed up, and cause an increase and accelerate the activity of growth and development of the plant as shown in Table (2), which is related to increase GA, RNA, DNA and enzyme activities. These effects caused enhancement the plant criteria. The previous stimulatory impact of irrigation by magnetized water on the growth parameters probably attributed to induction of mitosis and cell metabolism [5, 6] as well as [24, 25] they indicated that irrigation by magnetic water led to increasing in leaf, stem, root fresh, dry weight also, increasing in total biomass of cowpea , dura and bean crop plants as compared to ordinary water.

Table 2. Impact of irrigation by magnetic and normal water on the growth of Faba bean at 85 days after planting (average of 2009/10 and 2010/11 seasons).

Treatment	Mean ± SE		*t*-sig	Increase (+) (%) over control
Character	Normal water (control)	Magnetic water		
Plant height (cm)	47.50 ± 1.26	53.36 ± 0.60	***	12.34
Fresh weight (g/ plant)	48.15 ± 1.22	54.90 ± 1.07	***	14.02
Dry weight (g/ plant)	7.34 ± 0.02	8.35 ± 0.14	***	13.76
Water contents (%)	84.57 ± 0.36	84.67 ± 0.41	ns	0.12

N=20, *** *t* is Significant at the $P < 0.001$ levels, ns: non significant

Photosynthetic pigment:

Application of magnetized water caused a significant increases of photosynthetic pigments content (chl a, b and car.) of faba bean leave as shown in Fig. 2. Chlorophyll a was more affected than the other pigments content that reflected on increasing both Total (chl.a and b) and total pigments content significantly of faba bean leave. These results were related to enhancing effect of magnetically treated water on the photosynthetic pigments [26] on jojoba and [27] on date palm and [25] on bean plant, [28, 29] on lentil, flax, chickpea and wheat. Despite hydrogen ion volume, it is necessary in virtually each chemical reaction with water, plant, soil, animal and humans. Nowhere is this greater important than in cells where small organisms which called mitochondria, translate free electron with negative charge related to the H- molecule in ATP which supply the necessary energy for producing growth, reform and regeneration .

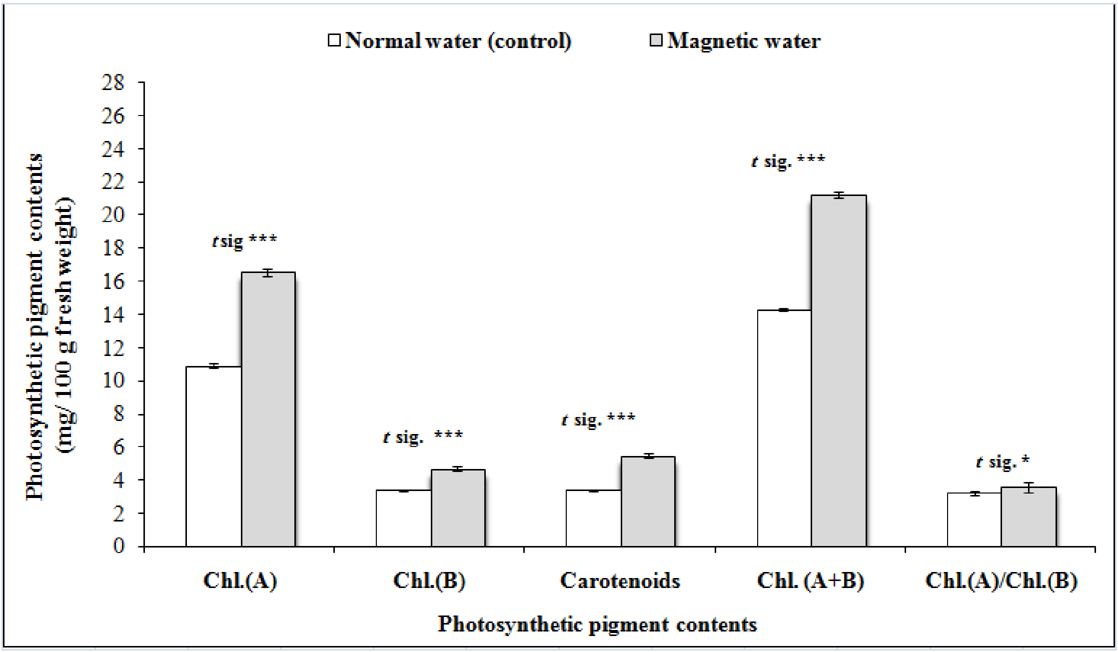

Fig 2. Effect of irrigation with magnetized and normal water on photosynthetic pigment contents in Faba bean shoot at 85 days after sowing. (Average of 2009/10 and 2010/11 seasons). N=8, *, *** *t* is significant at the $P < 0.05$, 0.001 level, respectively.

Faba bean yield and its components:

The vegetative characters (plant height , branches and straw weight plant $^{-1}$) yield components (Pods number and weight plant^{-1} ,seed number and weight pod-1 and biological yield plant^{-1}) at harvest stage were significantly affected with magnetized water irrigation as shown in Table (3).The results appeared that magnetized .The effect of magnetization might be due to its role in differentiation and development of plant organs during growth period of faba bean plant .This effect was related to stimulate the phytohormones (IAA,GA and cytokinins), enzymes and stimulate translocation and efficiency of photo assimilates , which led to differentiate and enlargement the cells .Therefore, the growth and yield appeared significant increase as a result to phytohormones stimulations .These results were agreement with [13] who suggested that the impacts of magnetic treatments various with plant kind and kind of water which used in irrigation, also, there were many significant increases with crop yield and water use efficiency. Irrigation by magnetic water led to increasing in stem, leaf also in root fresh & dry weight hence increasing in total biomass compared to irrigation water without magnetic [24]. It was find out that magnetic field catalyzed shoot development hence, led to increase in germinating energy, fresh weight also, shoot length of maize [30].

Faba bean yield is the end product (ton fed $^{-1}$) that significantly increased with irrigation by magnetic water compared with normal water irrigation as shown in Table 4. While, the normal water was significantly increased the harvest index and crop index. The increases in seed yield, biological and straw yield were 7.25 , 38.71 and 25.31 % respectively. These increases show that magnetized water had more effect on straw and biological yield and negative effect on harvest and crop index of faba bean plant. The results appeared that the increase or decrease in the measurements were due to enhance of the straw yield, that were related to faba bean characteristic. The mentioned results were agreement with [7] who cleared that yield increases of dicotyledonous were 24.92% for lentil and 38.46%, for check pea compared with irrigation by tap water. The increases were due to increasing of pods number per plant in addition to decreasing in plant losses in the same cultivated area [31].

Table 3. Impact of irrigation by magnetic and normal water on yield of faba bean and its components and water productivity. (Average of 2009/10 and 2010/11 seasons).

Treatment	Mean ± SE		*t sig.*	Increase (+) (%) over control
Character	Normal water (control)	Magnetic water		
Plant height (cm)	56.20 ± 0.52	63.50 ± 0.84	***	12.99
Branches (number plant $^{-1}$)	2.40 ± 0.11	2.75 ± 0.12	*	14.58
Pod weight (g)	3.13 ± 0.04	3.70 ± 0.05	**	18.21
Seed (number pod-1)	3.70 ± 0.16	4.30 ± 0.17	**	16.22
Pod (number plant $^{-1}$)	4.41 ± 0.09	5.17 ± 0.15	**	17.23
Pods weight (g plant $^{-1}$)	128.20 ± 0.31	154.50 ± 0.39	***	20.51
Seed weight (g plant $^{-1}$)	105.00 ± 0.36	120.50 ± 0.45	**	19.05
Straw weight (g plant $^{-1}$)	79.35 ± 0.38	106.00 ± 0.24	***	33.67
Biological weight (g plant $^{-1}$)	184.36 ± 0.51	226.50 ± 0.45	***	22.95
100-seed weight (g)	87.58 ± 0.34	97.00 ± 0.30	***	10.73
Seed yield (ton fed $^{-1}$)	0.69 ± 0.03	0.74 ± 0.02	*	7.25
Straw yield (ton fed $^{-1}$)	0.93 ± 0.03	1.29 ± 0.03	***	38.71
Biological yield (ton fed $^{-1}$)	1.62 ± 0.05	2.03 ± 0.03	***	25.31
Water productivity (kg $_{seed}$/m^3 water)	0.24 ± 0.89	0.26 ± 0.71	ns	8.04

N=20 for yield components and N=8 for yield per fed, *, **, *** *t* is Significant at the *P* < 0.05, 0.01 and 0.001 levels, respectively.

Table 4. Impact of irrigation by magnetic water on macro and micronutrients in seed yielded faba bean compared with normal water.

Treatment		Mean ± SD		*p value*	Increase (+) or decrease (-) % over control
Character		Normal water (control)	Magnetic water		
Macro-nutrient (%)	N	2.55	2.72	*	6.67
	P	0.70	0.74	*	5.71
	K	0.88	1.25	***	42.05
	Ca	1.05	1.10	Ns	4.76
	Mg	0.14	0.16	**	14.29
Micro-nutrients (ppm)	Fe	99.90	108.00	*	8.11
	Mn	13.00	14.00	*	7.69
	Zn	53.60	31.10	***	-41.98
	Cu	10.50	12.00	*	14.29

N=3, *, **, *** *t* is Significant at the *P* < 0.05, 0.01and 0.001 levels, respectively, ns: non significant

Water productivity (WP):

Data in Table 3 showed that there was insignificant effect on water productivity of faba bean plant compared with normal water irrigation, although increasing water use efficiency under using the magnetized water. The impact of magnetic relies on quality and ion-content of water and also on magnetization type, is too strongly species and genotype dependent [32]. Whereas, magnetic water increased stomatal conductance, efficiency of water use, leaf area, ratio of leaf area, and ratio of root weight than control [24]. Therefore, irrigation by magnetic water is recommended for saving irrigation water [33] and increasing efficiency of water use [26]. Moreover, Water use efficiency (WUE) increased as a result by irrigation with magnetic water compared to control treatment [34-37] on sugar beet, Canola, wheat and potato and [25] on faba bean were in agreement with [13] who suggested that the impacts of magnetic treatment varied with plant kind and the kind of irrigation water used, and there were significant increases in crop yield and efficiency of water use.

The basis of MRI measurements is the interactions between the external magnetic field, the electromagnetic waves and the hydrogen atoms of the material. The MRI measures the quantity and distribution of the protons. The relative biggest content of protons is presented in the water; therefore MRI is suitable for detection of plant- water relationship.MRI does not detect the particular anatomic structure, but the quantity and distribution of water that on the other hand determines the given anatomic structure [38,39]. Also water use efficiency was improved in the crops which irrigated by MTW as compared to control treatment.

Macro and micronutrients:

Data presented in Table (4) showed that macro and micro nutrients in seeds were significantly affected with magnetized irrigation compared with normal water irrigation. Potassium element was the most element content of the seeds. This effect may be due to magnetic effect on leaching nutrients and their absorption by plant root and translocate to faba bean seeds, which caused high content of macro and micro elements of the seeds. The results were agreement with [35-37] on canola, wheat and potato and [25] on faba bean. Also, the essential elements except sodium were increased significantly in jojopa plants irrigated with MTW compared to their control.

Amino acids contents in yielded seeds:

Amino acid contents (essential and nonessential) were enhanced significantly with magnetic field effect on water irrigation in faba bean seeds as shown in Table (5). Aspartic and proline amino acids were more affected with faba bean magnetized water irrigation. Static magnetic impacts have been cleared to cause reinforced hydrogen bonding [40] and increasing in ordered structure of water created around hydrophobic molecules and also, colloids [41] as shown by the increase in fluorescence of dissolved probes [42]. In addition to magnetic fields affect the infrared spectrum of water and these impacts remain for considerable time after magnetic field is removed [43].Which led to stimulate the reactive ions, cations and reactive group of the organic and inorganic materials to biosynthesis and convert to the essential content of the cell. Despite hydrogen ion volume, it is necessary in virtually each chemical reaction in soil, water, plant, animals and humans. Nowhere is this greater important than in the cells where tiny organisms, called mitochondria, interpret the free electron negative charge related to the H- molecule in the ATP which supply energy necessary for producing growth, repair and regeneration. It became generally recognized that the likely mechanism by which certain key energy transport molecules in living systems were formed and subsequently regenerated after being burned (e.g. NAD conversion to NADH), which is a coenzyme, was via donation of H- to the molecule by a donor molecule during photosynthesis .It is also used in other cellular processes most notable one being a substrate of enzymes that add or remove chemical groups from proteins in metabolism. So, the magnetic field impact can be used as an alternative to the chemical method of plant treatment for improving the production efficiency [30]. Investigations of MF on biological systems have demonstrated generalized increases in gene transcription and change the levels of specific m RNAs [44].

Table 5. Impact of irrigation with magnetic water on amino acids contents of yielded Faba bean compared with normal water.

Treatment / Amino acids (g/100 g seed dry weight)	Normal water (control)	Magnetic water	Increase (+) or decrease (-) over control
Aspartic	0.330	0.465	29.15
*Threonine	0.133	0.175	23.95
Serine	0.184	0.243	23.98
Glutamic Acid	0.637	0.806	20.99
Glycine	0.076	0.098	22.16
Alanine	0.281	0.364	22.72
*Valine	0.219	0.289	24.16
*Methionine	0.015	0.016	7.50
*Isoleucine	0.130	0.158	17.59
*Leucine	0.392	0.457	14.16
Tyrosine	0.148	0.174	15.30
*Phenylalanine	0.321	0.373	13.94
*Histidine	0.185	0.205	9.65
*Lysine	0.251	0.290	13.50
Ammonia	0.276	0.317	13.13
Arginine	0.540	0.637	15.21
Proline	0.251	0.442	43.27
Total	4.094	5.192	21.16
*Essential	1.65	1.96	16.12
Non-Essential	2.45	3.23	24.22
Total amino Acid	4.09	5.19	21.16
Ess./non-Ess.	0.67	0.61	-10.70

CONCLUSION

This study concluded that, irrigation by magnetic water could effectively increase quantity and quality traits of faba bean under newly reclaimed sandy soils.

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