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Studying the Effect of Spraying Magnetized Fulvate and Humate Solutions on Phosphorus Availability in Sandy Soil Cultivated by Faba Bean (*Vicia faba* L.)

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TWO FIELD experiments were carried out in sandy soil at the Ismailia Agricultural Research Station during winter seasons of 2017/2018 – 2018/2019. The aim is to study the effect of magnetized aqueous solutions (0.5% v/v) of potassium fulvate (KF) and/or potassium humate (KH) sprayed in presence of soil applied rock phosphate (RP) and/or super phosphate (SP) fertilizers (16.09 Kg P ha^{-1} application rate) on faba been (*Vicia faba* L.) plant. Spraying of solutions was applied four times 30, 50, 70 and 90 days after sowing. Control treatments (0 additions), magnetized (KFM and/or KHM) and non-magnetized (mixed with tab water, KFT and/or KHT) treatments were distributed in a complete randomized block design. Cultivation was performed as recommended by the Ministry of Agriculture. At maturity stage and after harvest, yield (Mg ha^{-1}) and some yield components, percentage (%) of N, P, and K available in soil and total in plant, pH and EC were estimated. Results showedthe magnetic treatments KFM and KHM resulted in the most significant increase of the available P (mg kg^{-1}) in soil for RP and SP treatments and the available N for RP. The increase in the available K in soil was non-significant. Magnetic solutions of KFM and KHM also exhibited a significant increase in the seed weight and dry weight of pods (g plant^{-1}) but the increase in the yield of seeds and straw (Mg ha^{-1}) was non-significant. Foliar application of magnetic fulvate and humate solutions may enhance the efficiency of phosphorus fertilization under sandy soil conditions.

Keywords: Humic substances, K-humate; K-fulvate, Phosphorus availability.

Introduction

Magnetic treatment technology was promising in agriculture for irrigation water and soaking seeds as indicated by many studies. Irrigation using magnetized saline water significantly improved wheat growth and yield as well as soil pH, EC, Na^+, Cl^-, SAR, available N, P and K compared to the non-magnetized water. It could be attributed to the leach ability of salts downwardssoil column, minimized salt accumulation within surface soil and increased phosphorus fertilizer use efficiency (Abd-Elrahman and Shalaby, 2017). Consistent results were obtained forapricot, peach, seedless grape using magnetized saline ground water for irrigation (Fanous et al., 2017).

Seeds of vegetative crops like tomato, eggplant, cucumber, and squash were induced by soaking in amagnetic field of 4 × 10^3 Gauss (G) strength for one hour along with irrigation by magnetized water (Aladjadjiyan, 2007). Irrigation by magnetic water as well as soaking seeds of cucumber up to 300 minutes at rates (0.0, 2.0, 4.0 and 6.0 x 10^{3}G) increased yield components, growth parameters, improved N, P, K content in plant and decreased soil EC (Shahin et al., 2016). Magnetic water increased the nitrogen N content and protein and improved the yield quality. Magnetizing water at an intensity of 11000 G had positive effects on plant (Babaloo et al., 2015). Application of four levels of water magnetically-treated at 0, 10, 30 and 50 × 10^3 G increased cotton seedling, dry weight and increased N uptake under salt stress conditions. Magnetic intensity of 7 × 10^{3}G exhibited positive effects on the growth of many crop species (Hirano et al., 1998).

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Humic substances including humic acid (HA), fulvic acid (FA) humate and fulvate salts (*e.g.* K- humate and K- fulvate). Humic acid is soluble under alkaline aqueous solution conditions, while fulvic acid is soluble under alkaline, acidic and neutral aqueous solution conditions, fulvic acids included carbon (C) 53.8- 58.7% and nitrogen (N) 0.8-4.3% (Pettit, 2004). Their application can prevent precipitation of ions, ions fixation and nutrients leaching in soil (Kadam et al., 2010). Humic acid application increased phosphorus (P) availability and prevented precipitation of P (Wang et al., 2016). Application of humic acid 5% had a positive effect on faba been growth parameters, seed yield, and yield components (Dawood et al., 2019). Humic acid have been applied at rates of 0, 25, 50, 75 and 100 mg kg^{-1} refined sand along with Ca and/or Fe acetate form (CH_3COO-) at rates of 0, 25, 50 and 100 mg kg^{-1}. Increased application rate of HA and Ca or Fe increased the uptake of Ca and Fe by both shoots and roots of sorghum plants. Fertilizer efficiency was improved and enhanced sorghum plants, quantitatively and qualitatively (Hamad and Tantawy, 2018).

Foliar applications of humic and fulvic acids have improved root growth, plant growth parameters, increased crop yield. Foliarapplication of humic (0.4 %), fulvic acid (4%) and chelated calcium on amino acids (0.25 %) either individual or incombinations increased vegetative growth, yield, fruit quality anddecreased the incidence of blossom end rot in tomato fruits (Abou El Hassan and Husein, 2016). Foliar application of liquid HAs (0.1 and 0.2%) under salt stressed sandy soil increased the uptake of N, P and K by corn (Khaled and Fawy, 2011) and increased percentage of protein and N contents in broad bean seeds (Shafeek et al., 2013).

Potassium humate (K- humate) and K-fulvate applied in the form of spray solutions at rate 0.5 to 10% in water showed positive effects on seed germination and plant root, and soil available NPK under the soil salinity levels (Merwad, 2017; Patti et al. 2013). Yield of sweet potato was increased in sandy soil (Abd-All et al., 2017). Different application rates of K-humate solution (0.5%, 1.0%, 0.4% (4 g L^{-1})) were found to increase yield and yield components and plant growth parameters (Quilty & Cattle, 2011 and Thakur et al., 2018). Additionally, K-humate improves soil physical, chemical properties and nutrient movements and reduces hard effects of salt stress (Ibrahim and Ali, 2018 and Sherif & Hedia, 2015). Humate in sandy soil showed positive effect on available N, P, K nutrient, soil chemical properties and fertility (El-Etr and Hassan, 2017).

Fulvic acid (FA) mixed with phosphorus (P) fertilizers and added to soil increasedavailable P, increased the organic carbon content and improved phosphorous mobility within soil matrix (Yang et al., 2013). Foliar application of FA at rates 0.3% (v/v) and 0.9% (9 g L^{-1}), increased faba bean plant height, number of branches per plant, number of pods per plant, 100-seed weight, yield and protein and NPK content (Noor Al-jana et al., 2018 and Abdel-Baky et al., 2019).

Soil application of rock phosphate (RP) and/or superphosphate followed by application ofhumic substances showed positive effects on soil properties and major of the plant growth parameters. Humic acid applied at rates up to 9.52 kg ha^{-1} increased weight of seeds/plant, number of pods/plant and protein content. Application of phosphorus fertilizer up to 56.6 kg P ha^{-1} increased number of branches and pods/plant, number of seeds, weight of seeds/plant, biological yields and protein content (El-Kholy et al., 2019). Application of rock phosphate (RP) with humic substance to sandy soil increased soil available NPK, nutrients content in plant, increased yield of green pea, straw, pods, biological yield, soil EC and decreased pH (Osman, 2015).

The aim of this study is to indicate the effect of foliar spray of magnetized humate and fulvate aqueous solutions combined with soil applied rock phosphate (RP) and superphosphate (SP) on faba bean yield and growth parameters, productivity in sandy soil.

Materials and Methods

Area of study

The study was conducted under sandy soil conditions (*Typic Torripsamment; Entisol* [Arenosol AR] at the farm of the Ismailia Agricultural Research Station, Agricultural Research Center (ARC) - Egypt (30° 35’ 41.9” N 32°16’50” E elevation 3 m)at which two field experiments were carried outduring the winter seasons of 2017/2018 – 2018/2019.

Extraction of fulvate and humate solutions from the compost

Both humic and fulvic acids were extracted from compost prepared at the Ismailia farm) according to the standard method of Sánchez-Monedero et al. (2002). Compost was soaked in de-ionized water at 1:5 w/v ratio (200 g in 800 mL) then treated by 0.5 N KOH to extract humic substances. The obtained dark brown extract contained solubilized humic and fulvic acids, which were precipitated from solution by adjusting the pH using HCl. Humic acid was separated from humus extract by acidification with 0.1 MHCl to reach a pH 2.0, after being left over night. Humic acid (HA) precipitates were the separated from soluble fulvic acids by centrifugation at 6000 rpm for 15 min. Fulvic acid was passed through activated charcoal followed by elution of the charcoal (Susilawti et al., 2007). The humic acid precipitate at 40°Cobtain concentrated and having a pH 2 adjusted to a pH of 6 for the application (Munawar and Wanti, 2016). Humic acid extracted (at pH 4) contained 46.2% total organic carbon, 4.33% N, 0.41% K and 0.38% P. Fulvic acid extracted (at pH 4) contained 45.7% total organic carbon, 3.54% N, 0.29% K and 0.25% P. Potassium fulvate (KF, 9.15% K_2O) and potassium humate (KH, 10.2% K_2O) solutions were prepared by re-dissolving fulvic and/or humicacid in KOH solution (8% K_2O) and purified by passage through activated charcoal and transferred to a membrane filter (Essawy et al., 2017).

Treatments used in the study

The study included soil applied treatments of phosphorous (P) fertilizers and spray treatments of liquid fulvate and humate fertilizers. Soil applications were two main treatments in which surface soil was mixed with rock phosphate (RP, 131 g P kg^{-1}) and/or super mono-phosphate (SP, 67.39 g P kg^{-1}) at application rate for both types 16.09 kg P ha^{-1}, in addition to the control treatment not fertilized by phosphorous (P_0). Spray treatments included aqueous solutions prepared by mixing KF and/or KH with water in a v/v mixing ratio 0.5% (8 L ha^{-1} in 1600 L ha^{-1}, EC: 493 – 541 mg kg^{-1}) then left for an hour to equilibrate (Babaloo et al., 2015). Water used for mixing was obtained from the Ismailia canal. Some water was magnetized by passing through a water-magnetizing device (14,000 G field strength) for only few minutes (10 min). Magnetized (M) spray solutions of KF and/or KH were obtained using magnetized water for mixing to prepare the KFM and/or KHM treatments. Non-magnetized spray solutions were obtained using normal tab water for mixing to prepare the KFT and/or KHT treatments. Four spray applications were 30, 50, 70 and 90 days after sowing. Control treatments not sprayed by any solution were included for comparison. All treatments (128 plots for thirty-two treatments mentioned) were arranged in a factorial complete randomized block design with four replicates (Scheme 1). Some chemical and physical properties of the experiment soil and materials used in the present study are shown in Tables 1 and 2.

TABLE 1. Some properties of soil, compost used for humic substances extractionand rock phosphate (RP) used in the experiment before cultivation

Particle size distribution (%) of the experiment soil				
Coarse Sand	**Fine Sand**	**Silt**	**Clay**	**Texture**
52.02	41.24	4.79	1.95	Sand
Properties		**Soil**	**Compost**	**RP**
$CaCO_3$(gkg^{-1})		8.64	32.4	114.0
Organic Matter (g kg^{-1})		1.51	242.1	--
pH (1:2.5 soil: water suspension)		8.00	6.95*	6.02
Saturation Percent (SP) %		20.80	58.7	--
EC (dS m^{-1}, soil paste extract)		1.19	8.30	31.5*
Bulk density Mg m^{-3}		1.80	0.582	--
CEC (cmol$_c$ kg^{-1})		1.02	19.6	--
Available nutrients (mg kg^{-1})				
N		10.91	75.9	0.80
K		59.6	43.2	26.9
P		2.90	33.5	48.1
Total P (g kg^{-1})		--	--	131.0

* Compost or rock phosphate 1: 10 water suspension

Scheme 1. Complete randomized blocks distribution (CRBD) of treatments in a replicate

Without phosphorus P_0	Rock phosphate RP	Superphosphate SP
Control	KHM	KFM
KFT	KFM	KHM
KFM	KHT	Control
KHT	KFT	KFT
KHM	Control	KHT

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.

Planting and growth parameters

Seeds of Fababean (*Vicia faba* L., improved Giza 3 cultivar) recommended for sandy soil were obtained from Field Crops Institute, ARC - Egypt. Two seedswere manually sown in hills 20 cm apart (16.0 m^2 plot area) in the second week of November 2017 and 2018. Fertilization during the cultivation season was as follows: ammonium sulfate (200 g N kg^{-1}) at rates of 47.6 Kg N ha^{-1} added to soil after sowing, and potassium sulfate (400 g K kg^{-1}) at rate 95 Kg K ha^{-1} added to soil after sowing and flowering. At harvest, (April 2018 and April 2019); plant samples from each plot were selected and air-dried. Seeds were picked up by hand and air-dried. Yield components such as dry weight/plant (g), plant height (cm), 100-seed weight (g), seeds yield (Mg ha^{-1}), straw yield (kg ha^{-1}), seed weight/plant, dry weight of pods $plant^{-1}$, and some soil chemical properties were estimated.Mean of the two seasons was recorded.

Analysis of soil and plant samples

Soil samples were air-dried, sieved by 2 mm sieve and kept for analysis. Plant samples were oven-dried at 70^0C for 48h and digested using 1:1 acid mixture (H_2SO_4: $HClO_4$) (Chapman,1978). Available Nwasextracted in KCl (1: 10 w/v), available P was extracted in 0.5 N $NaHCO_3$ as well as soluble Pin water, while available K was extracted by 1 N NH_4OAc (pH 7.0). Concentration of the total and available N, P, and K were estimated by distillation using Kjeldahl apparatus, colorimetrically by UV-Vis. Spectrophotometer using stannous chloride ($SnCl_2$)indicator**,** by the flame photometer, (Black, 1982 and Page et al., 1982). Protein percentage (%) in grains was calculated as an N(%) × 6.25.

Statistical analysis

Effect oforganic treatments (KFT, KHT, KFM and KHM) and P fertilizers (RP and SP) were statistically analyzed byanalysis of variance (ANOVA) test, using the Co-State software to calculate the LSD at asignificance level $P \leq 0.05$ (Gomez and Gomez, 1984).

Results and discussion

Magnetic treatments and fulvate and humate solutions

Table 2 indicates that magnetization of fulvate KFM and humate KHM solutions decreased their pH and EC, content of Ca, and Mg (g kg^{-1}) while increased CEC ($Cmmole^+$ kg^{-1}), Total carbon, and content of N, P, and K (g kg^{-1}). It can be attributed to the effect of the electromagnetic field throw which the solution passes on the solvated species in solution. Linkage between water molecules and soluble salts and/or humate and fulvateligand may be disrupted that increases the liberation of available N, P, K. Additionally, water molecules activated by magnetic field may activate the cation exchange sites on soil surface which in turn alters the content of soluble cations like Ca, and Mg (g kg^{-1}) (Fanous et al., 2017).

Humic substances andavailable N, P and K

Data presented in Tables 3 and 4 showed that the effect of KFM, KHM, KFT and KHT combine with rock phosphate (RP) or superphosphate (SP) application was not significant compared to the control on available N and K at ripeness stage. KFM and KHM combine with rock phosphate were significant on available $P_{(NaHCO3)}$, the increases averaged 21.31% and the relative increase in available $P_{(NaHCO3)}$were 65.52 and 68.97% respectively, depending on the LSD values for different treatments. KFM, KHM and KHT combine with superphosphate were significant on available $P_{(NaHCO3),}$ the increases averaged 31.4% and the relative increase in available P_{NaHCO3} were 72.41, 86.21 and 68.97% respectively. Available P was obtained and significant by rock phosphate and superphosphate, while the high relative increases with KHM.

TABLE 2. Some chemical characteristics of KHT, KFT, KHM and KFM solutions used in this study

Property	KH	KF	KHM	KFM
EC (dS m^{-1}) (solution 1:5)	7.80	8.75	7.46	7.95
pH (solution 1-5)	7.93	6.71	7.53	6.59
Total carbon (g kg^{-1})	509	485	512	510
CEC ($cmol_c$ kg^{-1})	410	350	432	361
Total N (g kg^{-1})	36.2	28.0	53.0	49.1
Total P (g kg^{-1})	3.10	2.6	3.80	3.40
K (g kg^{-1})	102.0	91.5	109.0	101.0
Ca (g kg^{-1})	6.0	5.4	4.60	4.50
Mg (g kg^{-1})	11.0	9.3	8.10	8.70

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.

TABLE 3. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rockphosphate (RP) application on soil available N and K (mg Kg-1) at ripeness stage of faba been plant growth

Treatments	P_0	RP	SP	Mean	P_0	RP	SP	Mean
	Available N (mg kg^{-1})				Available K (mg kg^{-1})			
Control	11.9a	12.0d	12.3a	12.1	60.2a	61.3a	61.9a	61.1
KFT	12.0a	12.2c	12.6a	12.3	61.5a	62.1a	62.9a	62.2
KFM	12.0a	12.5b	12.7a	12.4	61.1a	62.3a	64.5a	62.6
KHT	12.3a	12.5b	12.7a	12.5	61.9a	62.9a	63.1a	62.6
KHM	12.3a	12.9a	13.0a	12.7	62.3a	64.4a	65.1a	64.1
Mean	12.1	12.4	12.7		61.4	62.6	63.5	
F-test	ns	***	ns		ns	ns	ns	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.
The footnotes (a–d) indicate the non-significance ranges at a significance level P ≤ 0.05 for the different treatments.

TABLE 4. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rockphosphate (RP) application on soil available P (mg Kg-1) at ripeness stage of faba been plant growth

Treatments	P_0	RP	SP	Mean	P_0	RP	SP	Mean
	Available P_{NaHCO3} (mg kg^{-1})				Soluble P_{water} (mg kg^{-1})			
Control	2.90c	3.90d	4.00d	3.60	0.35c	0.60b	0.60c	0.62
KFT	3.60b	4.10c	4.70c	4.33	0.40c	0.80ab	0.95ab	0.72
KFM	3.90a	4.80a	5.00b	4.53	0.60b	1.00a	1.10a	0.90
KHT	3.90a	4.60b	4.90bc	4.47	0.48bc	0.90a	0.80bc	0.63
KHM	4.00a	4.90a	5.40a	4.47	0.90a	0.90a	1.10a	0.97
Mean	3.66	4.44	4.82		0.55	0.78	0.97	
F-test	**	**	**		**	*	**	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.
The footnotes (a–d) indicate the non-significance ranges at a significance level P ≤ 0.05 for the different treatments.

These data were confirmed with the results, which obtained by Abdel-Rahman (2017) and Abdel-Baky et al. (2019). FA increased the movement of P in soil depth, phosphorus and FA together can be the improvement of P availability and chemical soil properties (Yang et al. 2013). It has been reported that application of K-humate increased availability of nutrient in soil (Osman, 2015 and Hui et al., 2016). Humic and fulvic acid can be prevents of precipitation, ions fixation and nutrients leaching in soil (Kadam et al., 2010). Liquid humic and fulvic substances improve nutrients availability in soil (Quilty and Cattle, 2011). Magnetic water improves some available N, P, and K (Aladjadjiyan, 2007 and Shahin et al., 2016). As stated earlier, magnetic treatment may change some physical and chemical properties of water such as surface tension, viscosity, conductivity, solubility of salts and pH.It weakens the intra clusters hydrogen bonds, breaking the larger clusters, forming smaller clusters with stronger inter cluster hydrogen bonds. Tiny and uniform cluster can easily pass throw plant cell membranes. In soil, magnetized water increases leaching of excess soluble salts, decreasessoil pH, enhances the dissolution of slightly soluble salts like carbonates, phosphates and sulfates. It also decreases the hydration of salt ions, accelerates coagulation and salt crystallization, increases the efficiency of added fertilizers, increases nutrient mobility in soil and enhances extraction and uptake of N, P, K, Fe and Zn by plants and improves the microbiological content of soil (Abd-Elrahman and Shalaby, 2017).

Effect of humic substances on soil salinity and soil pH

Data presented in Table 5 showed that the effect of KFM, KHM, KFT and KHT combine with rock phosphate or superphosphate application not significant on soil EC (dSm^{-1}) after faba bean harvesting, data show that for all treatments slightly increase in soil EC_e but there increase was not significant affected, also too data in Table 5 revealed that soil pH slightly decreased after faba bean harvesting. The slightly affected of soil EC_e and soil pH may be the effect of humic substances, superphosphate, rock phosphate on root zone due to uptake and consumption by plant and removal by leaching because percolation of sandy soil very high. With respect the slight change to soil EC_e and soil pH at ripeness stage of plant growth, may be the effect of foliar application, chemical and physical properties of sandy soil (Quilty and Cattle, 2011). Fulvic and humic acids added to the soil improve adsorption and pH (Khaled and Fawy, 2011). Humic and fulvic substances improve the soil's physical properties and soil productivity (Yang et al., 2013; Osman 2015; El-Etr and Hassan, 2017; Abdel-Baky et al. 2019). Magnetic water at 15 min was positive effect on decrease of, electric-conductivity (EC), total dissolved salts (TDS) and pH (Babaloo et al., 2015 and Shahin et al., 2016).

Humic substances andyield and its components

Data in Tables 6 and 7 reveal that addition of KFM, KHM, KFT and KHT combine with rock phosphate or superphosphate on faba been yield and yield component significantly increased seed weight $plant^{-1}$, dry weight of pods $plant^{-1}$, seed yield and straw yield and the highest relative increase due to KFM, KHM. The increases averaged 18.38, 7.74, 2.40 and 5.33% for rock phosphate, where 21.32, 23.23, 10.00 and 13.17% for superphosphate respectively. Considering the single effect due to addition of KFM with rock phosphate, the results show significant increases of seed weight $plant^{-1}$, dry weight of pods $plant^{-1}$, seed yield and straw yield over control due to

TABLE 5. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rock phosphate (RP) application on soil ECe and soil pH at ripeness stage of faba been plant growth

Treatments	P_0	RP	SP	P_0	RP	SP
	(soil $Ec_e dSm^{-1}$)			Soil pH		
Control	1.25	1.29	1.28	8.00	8.10	8.10
KFT	1.29	1.31	1.29	7.90	8.00	7.97
KFM	1.30	1.30	1.29	7.99	7.90	7.89
KHT	1.29	1.30	1.32	7.90	7.91	7.96
KHM	1.32	1.35	1.35	7.95	7.85	7.88

Soil EC in soil saturation extract and soil pH, soil:water (1:2.5 w/w)
Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.

addition of KFM with rock phosphate were 28.0, 12.8, 15.8 and 17.5% where 31.0, 28.2, 25.4 and 27.8% with superphosphate, while due to addition of KHM with rock phosphate were 32.0, 23.4, 15.4 and 20.6%, where 35.2, 34.9, 27.6 and 29.9% with superphosphate, respectively. Rock phosphate combine with KHM being much more effective on faba been yield and yield component than superphosphate with KFT or KHT. These results are in harmony with those obtained by Khaled and Fawy (2011), Sherif and Ali (2018) and Ahmed et al. (2019). El-Etr and Hassan (2017) reported that Potassium humate in sandy soil showed positive effect of yield and yield components, and soil fertility. Foliar application of potassium humate in sandy soil increased yield, yield components of sweet potato (Ahmed et al., 2017). Similar results humic acids or Fulvic acids they are most positive effective on plant growth, yield and yield components (Robert, 2004). Magnetic water effect increase yield components (Aladjadjiyan, 2007; Babalooet al., 2015 and Shahin et al., 2016).

Humic substances and Plant growth parameters

Results in Table 8 reveal that combination between KFT, KHT, KFM and KHM with superphosphate and rock phosphate significantly increased plant height and dry weight (g plant^{-1}) at ripeness stage, the increases averaged 5.28 and 3.03% for rock phosphate where 14.91 and 9.92% for superphosphate, respectively. The high significantly increased showed that with KFM and KHM for plant height and dry weight plant^{-1}. The corresponding relative increases reached over the control for KFM with rock phosphate 30.4 and 13.6% where 44.2 and 21.0% with superphosphate while 33.3 and 14.8% due to addition of rock phosphate with KHM where 47.4 and 25.9% for KHM with superphosphate, respectively.

TABLE 6. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rockphosphate (RP) application on seed weight (g plant-1) and dry weight of pods (g plant-1) at ripeness stage of faba been plant

Treatments	P0	RP	SP	Mean	P0	RP	SP	Mean
	Seed weight (g plant^{-1})				Dry weight of pods (g plant^{-1})			
Control	12.5a	15.9d	16.0e	14.8	14.9b	15.1b	15.5b	16.2
KFT	12.9a	16.2b	16.5c	15.2	15.1ab	16.1b	18.7a	16.6
KFM	13.6a	16.0c	16.4d	15.6	15.9ab	16.8ab	19.1a	17.2
KHT	13.2a	15.9d	16.8b	15.3	15.3ab	16.3b	19.5a	16.8
KHM	15.6a	16.5a	16.9a	16.1	16.5a	18.4a	20.1a	18.3
Mean	13.6	16.1	16.5		15.5	16.7	19.1	
F-test	ns	**	**		ns	*	**	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.
The footnotes (a–d) indicate the non-significance ranges at a significance level P≤0.05 for the different treatments.

TABLE 7. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rock phosphate (RP) application on seed yield and straw yield at ripeness stage of faba been plant

Treatments	P0	RP	SP	Mean	P0	RP	SP	Mean
	Seed yield (Mg ha^{-1})				Straw yield (Mg ha^{-1})			
Control	2.28a	2.46a	2.50a	2.41	2.91a	3.19a	3.45a	3.18
KFT	2.40a	2.54a	2.61a	2.52	3.13a	3.31a	3.39a	3.28
KFM	2.61a	2.64a	2.86a	2.70	3.30a	3.42a	3.72a	3.48
KHT	2.52a	2.55a	2.85a	2.64	3.21a	3.38a	3.70a	3.43
KHM	2.60a	2.63a	2.91a	2.71	3.38a	3.51a	3.78a	3.56
Mean	2.50	2.56	2.75		3.19	3.36	3.61	
F-test	ns	ns	ns		ns	ns	ns	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.
The footnotes (a–d) indicate the non-significance ranges at a significance level P ≤0.05 for the different treatments.

TABLE 8. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rock phosphate (RP) application on some growth parameters at ripeness stage of faba been plant

Treatments	P0	RP	SP	Mean	P0	RP	SP	Mean
	Plant height (cm)				Dry weight (g/plant)			
Control	44.1b	52.2a	55.1b	50.9	8.10c	8.20e	8.50c	8.30
KFT	53.3a	53.7a	59.0ab	57.0	8.50b	8.60d	8.90c	8.66
KFM	53.2a	57.5a	63.6a	55.7	8.50b	9.20b	9.80b	9.07
KHT	57.2a	56.9a	61.8ab	59.2	8.90a	8.84c	9.60b	9.11
KHM	57.2a	58.8a	65.0a	59.9	8.90a	9.30a	10.2a	9.57
Mean	53.0	55.8	60.9		8.57	8.83	9.42	
F-test	*	ns	ns		**	**	**	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.
The footnotes (a–d) indicate the non-significance ranges at a significance level P ≤ 0.05 for the different treatments.

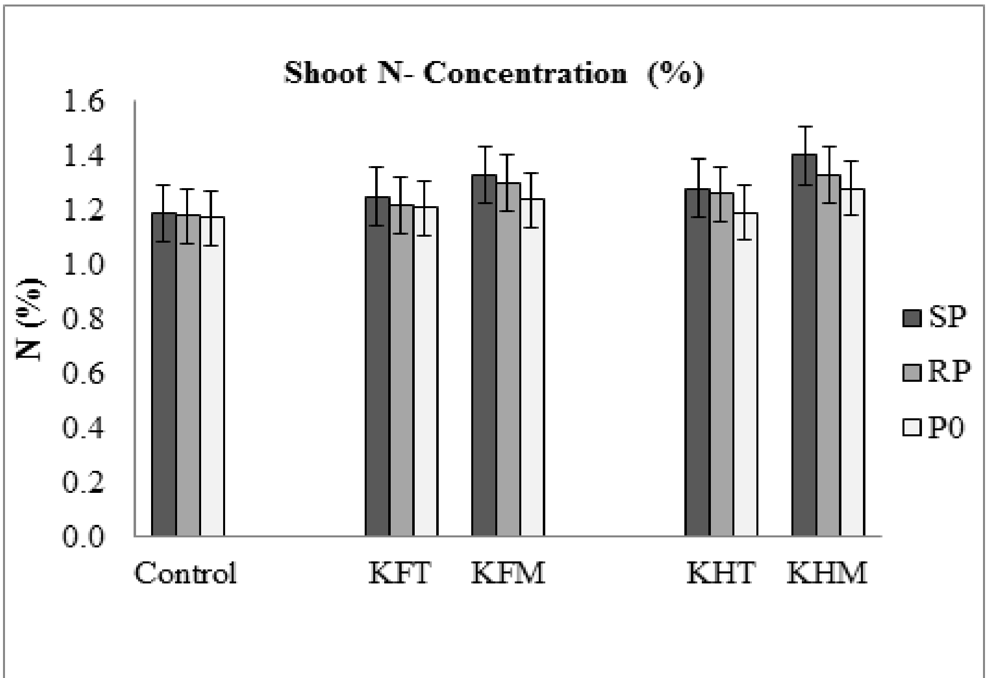
Results in Table 8 reveal that plant height and dry weight plant^{-1} were significantly increased due to KFT, KHT, KFM and KHM combine with rock phosphate and super phosphate but the inter action effect observed was significantly increased for KFM, KHM and KHT combine with superphosphate where significantly increased for KFM, and KHM combine with rock phosphate. These results are in line with those obtained Robert (2004), Khaled and Fawy (2011), Shafeek et al. (2013), Osman (2015), Mohamed et al. (2018), Harshad et al. (2018) and Abdel-Baky et al. (2019).

Humic substances andnutrient contents

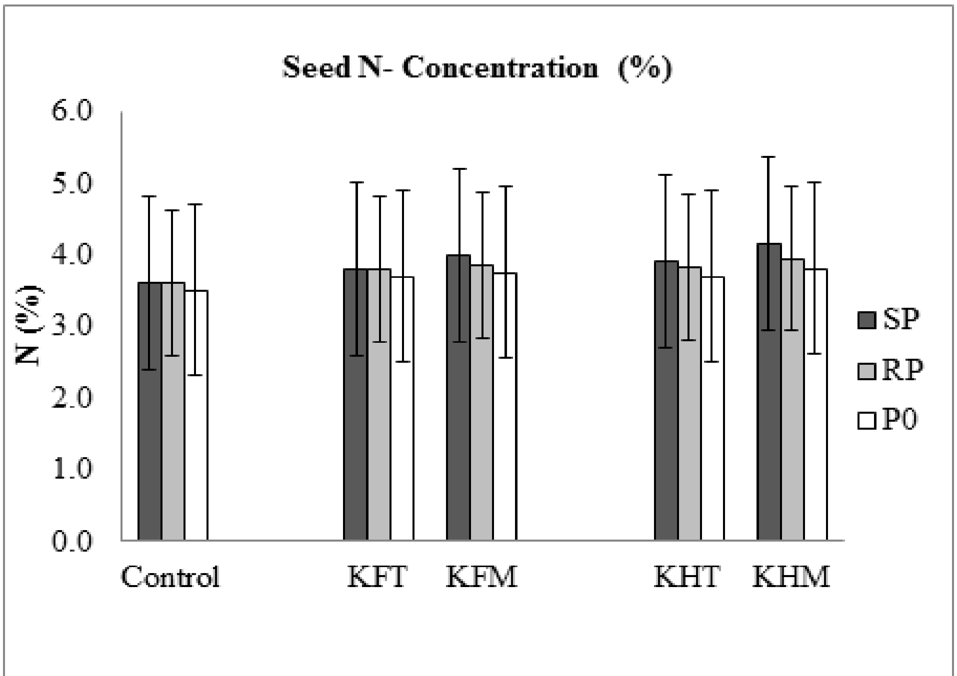
Data presented in Fig. 1, 2 and 3 (a and b) show that effect of KFM, KHM, KFT and KHT combine with rock phosphate or superphosphate on percentage values of N, P and K concentration in straw and seeds of faba been plant at ripeness stage. The increases averaged of shoot N, P and K content were 3.28, 42.12 and 9.28% for rock phosphate, where 5.74, 63.16 and 11.34% for superphosphate respectively. The increases averaged of seed N, P and K content were 2.98, 39.13 and 22.4% for rock phosphate, where 5.69, 47.83 and 25.60 % for superphosphate, respectively.

Percentage values of N content significantly affected of KFM and KHM with rock phosphate and the relative increase over control in shoot were 11.11 and 13.68% and seeds were 11.14 and 12.86%, but N content due to addition of KFM, KHM and KHT with superphosphate significantly increased and the relative over control in shoot were 13.68, 19.66 and 9.40% and seeds were 14.00, 18.57 and 10.57%, respectively. Similar results were obtained previously (Bayoumi and Selim, 2012). These data showed that the positive related between rock phosphate. K-humate magnetic solution. Percentage values of P content in shoot significantly affected by KFM and KHM with rock phosphate and the relative increase over control were 88.9 and 105.5% but P content in seeds significantly affected by KFM, KHM and KHT and the relative increase over control were 68.2, 72.8 and 50.0% respectively , where P content due to addition of KFM, KHM and KHT with superphosphate significantly and the relative increased over control in shoot were 100.0, 116.6 and 72.2% and seeds were 77.8, 86.4 and 59.1% respectively. This data showed that the positive related between rock phosphate with humic substances.

Percentage values of K content of faba bean plant significantly affected by KFT, KHT, KFM and KHM with rock phosphate and the relative increase over control were 12.2, 15.6, 22.2 and 28.9% in shoot where 25.9, 31.3, 52.7 and 57.1% in seeds and the relative increase over control with superphosphate were 13.3, 16.6, 26.7 and 31.1% and seeds were 30.4, 33.9, 55.4 and 63.4% respectively. This data showed that the positive related between rock phosphate with all K-humate substances. These data are with line of data obtained by Khaled and Fawy (2011), Shafeek et al. (2013), Abdel-Rahman (2017), Sherif and Ali (2018) and Abd-El Baky et al. (2019). Ahmed et al. (2017) who find that Potassium humate improve NPK movements. Foliar application of potassium humate in sandy soil increased total NPK contents, (El-Etr and Hassan, 2017). Humic acid can be increasing nitrogen uptake and transport of nutrients to plant (Mohamed et al. 2018). Magnetic water improved some nutrients (N, P and K uptake at 15 min from start irrigation (Babaloo et al., 2015 and Shahin et al., 2016).



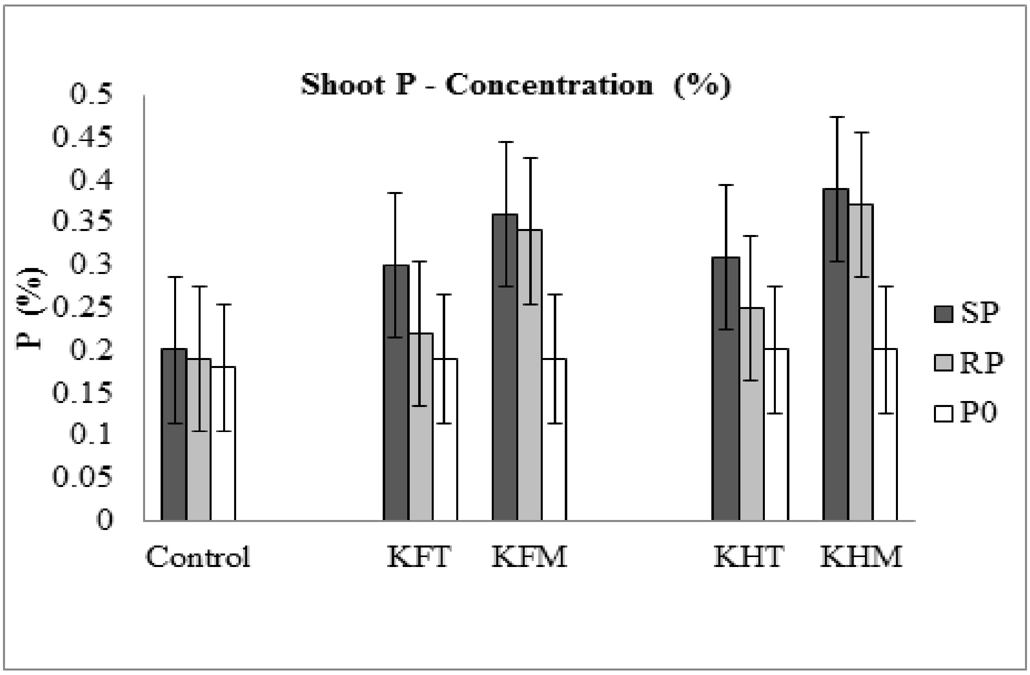
(a)



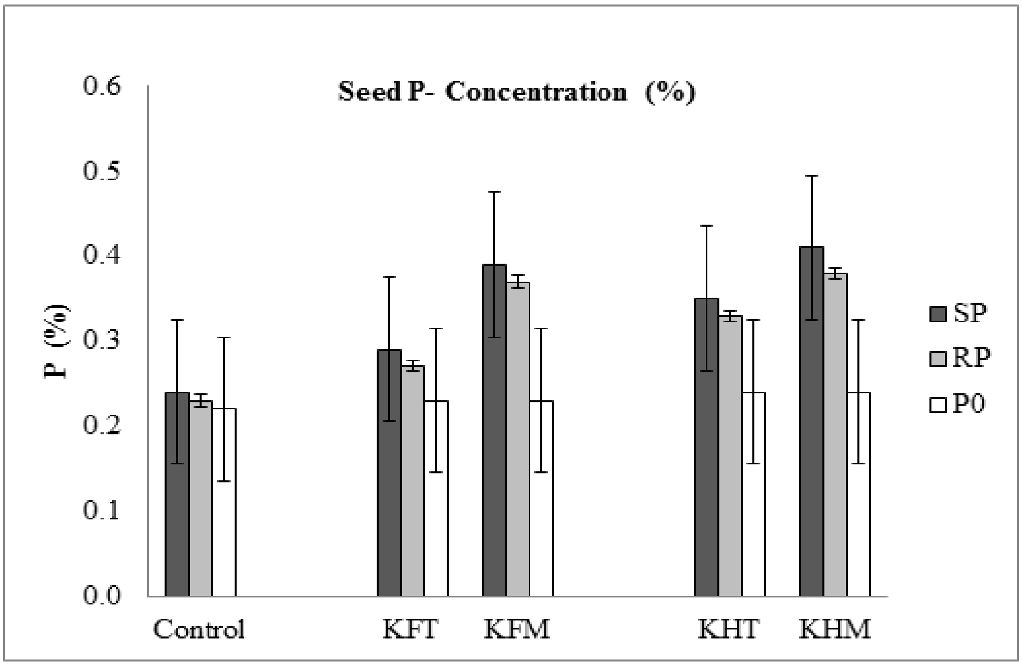
(b)

Fig. 1. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rock phosphate (RP) application on N content (%) in straw (a) and seed (b) of faba been plant at ripeness stage growth

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.



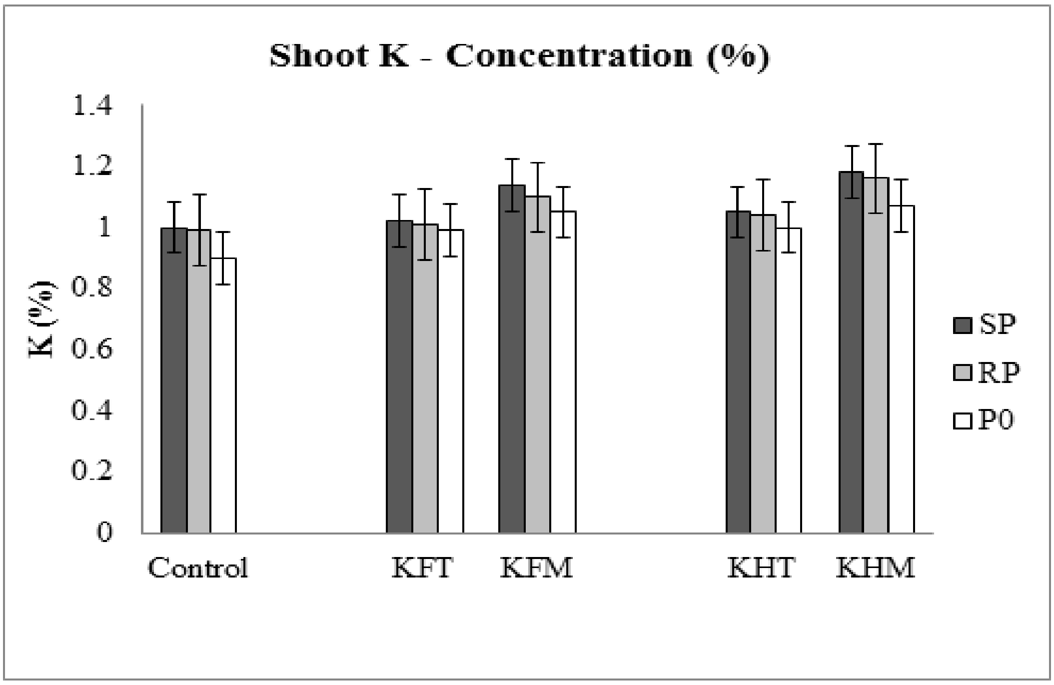
(a)



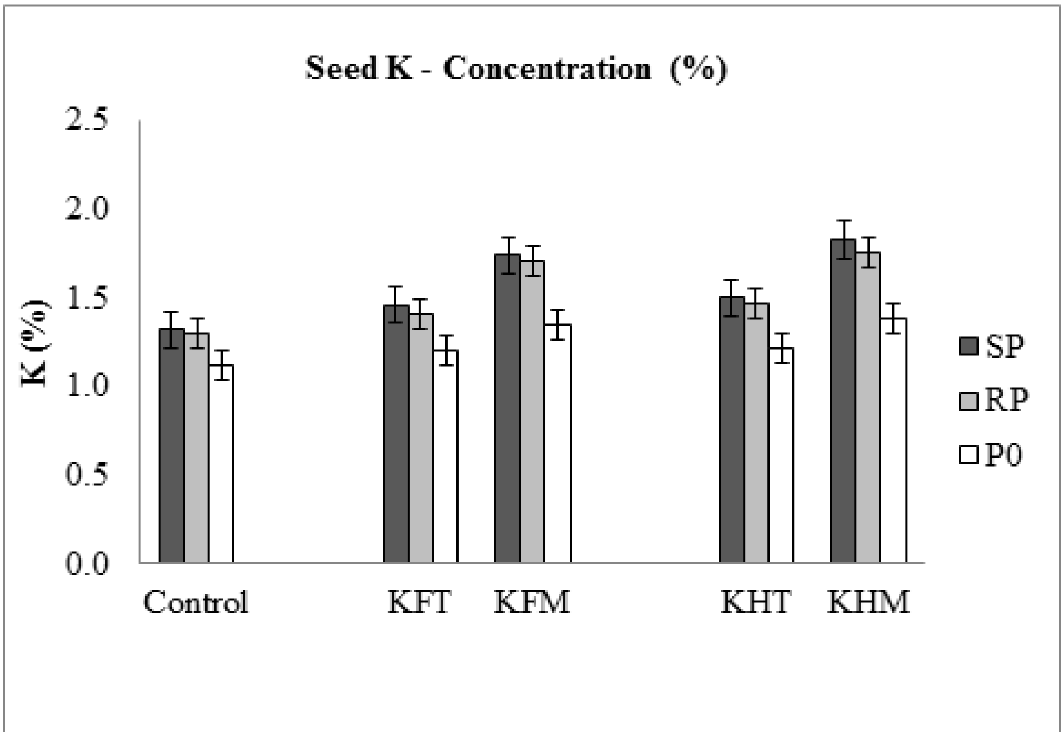
(b)

Fig. 2. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rock phosphate (RP) application on P content (%) in straw (a) and seed (b) of faba been plant at ripeness stage growth

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.



(a)



(b)

Fig. 3. Effect of KFT, KHT, KFM, KHM, superphosphate (SP) and rock phosphate (RP) application on K content (%) in straw (a) and seed (b) of faba been plant at ripeness stage growth

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.

Humic substances and K and P accumulation after spray

Table 9 and10 showed that the mobility of K and P in green part of faba been after5 days from the second and third spray (active green of plant growth)but four spray at maturity stag from table 9 and 10.Data in Table 9 and 10reveal that KFT, KHT, KFM and KHM with superphosphate and rock phosphate significantly increased ofKconcentration (%) in green part of plant, butP concentration (%) significantly increasedreveal that KHT, KFM and KHM with superphosphate and KFM and KHM with rock phosphate.Corresponding high significantly increase of K and P content for KFM and KHM with superphosphate and rock phosphate more than KFT and KHT, while the high relative increased of K% afterthe third spray more than the second and the fourth spray, but the high relative increased of P% after the fourth spray more than the second and the third spray. The increases averaged of K content were 9.26 and 12.96% for rock phosphate and superphosphate at the second spray, where 10.91 and 13.64% at the third spray, where 9.27 and 11.34% at the fourth spray respectively.Considering the single effect of KFMwith rock phosphate and superphosphate on K content over the control were 25.0 and 28.0% at the second spray where after the third spray were 31.0 and 35.0 %, but KHM with rock phosphate and superphosphate were 26.0 and 31.0% at the second spray where after the third spray were 33 and 36%, respectively. The increases averaged of P content were 27.27 and 36.36 % for rock phosphate and superphosphate at the second spray, where 30.43 and 0.50% at the third spray, where 42.11 and 63.32% at the fourth spray respectively. Considering the single effect of KFM with rock phosphate and superphosphate on P content over the control were 55.0 and 75.0% at the second spray, where after the third spray were 76.2 and 85.7%, but KHM with rock phosphate and superphosphate were 80.0 and 90% at the second spray where after the third spray were 81.0 and 95.0%, respectively.

TABLE 9. Concentration of K% in green part of faba been after the second and third spray of KFT, KHT, KFM and KHM.

Treatments	K (%) in 2$^{nd.}$ Spray			Mean	K (%) in 3rdSpray			Mean
	P_0	RP	SP		P_0	RP	SP	
Control	1.01c	1.07e	1.05b	1.07	1.00a	1.06b	1.12b	1.06
KFT	1.12a	1.15d	1.18ab	1.15	1.14a	1.18ab	1.19ab	1.17
KFM	1.07b	1.26b	1.29a	1.21	1.06a	1.31a	1.35a	1.24
KHT	1.10b	1.17c	1.21ab	1.16	1.16a	1.20ab	1.22ab	1.19
KHM	1.14a	1.27a	1.32a	1.24	1.16a	1.33a	1.36a	1.28
Mean	1.08	1.18	1.22		1.10	1.22	1.25	
F-test	**	**	*		ns	*	ns	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.

The footnotes (a–d) indicate the non-significance ranges at a significance level P 0.05 for the different treatments.

TABLE 10. Concentration of P% in green part of faba been after the second and third spray of KFT, KHT, KFM and KHM.

Treatments	P (%) in 2$^{nd.}$ Spray			Mean	P (%)3rd Spray			Mean
	P_0	RP	SP		P_0	RP	SP	
Control	0.20d	0.21a	0.23a	0.21	0.21d	0.23a	0.26a	0.24
KFT	0.21c	0.25a	0.26a	0.24	0.21d	0.25a	0.28a	0.25
KFM	0.22b	0.31a	0.35a	0.29	0.24b	0.37a	0.39a	0.33
KHT	0.23a	0.27a	0.29a	0.26	0.22c	0.29a	0.31a	0.27
KHM	0.23a	0.36a	0.38a	0.32	0.25a	0.38a	0.41a	0.35
Mean	0.22	0.28	0.30		0.23	0.30	0.33	
F-test	**	ns	ns		**	ns	ns	

Abbreviations: potassium fulvate (KF); potassium humate (KH); rock phosphate (RP); phosphate (SP); magnetized KFM or KHM; non-magnetized or mixed with tab water KFT or KHT.

The footnotes (a–d) indicate the non-significance ranges at a significance level P 0.05 for the different treatments.

These data were confirmed with the results, which obtained by Shafeek et al. (2013), Yang et al. (2013), Patti et al. (2013), Harshad et al. (2018), Dawood et al. (2019) and Ahmed et al. (2019). In sandy soil rock phosphate and humic substance effect on increasing soil availability of P compared to superphosphate and increased of soil availability of K (Osman, 2015). In leaves faba been were increased by FA total carbohydrates, crude protein, P and K content (Abdel-Baky et al., 2019). Fulvic, humic Acid increased P content and available indirectly and directly via exchangeable of P adsorption with fulvic or and metal complexion (Kadamet al., 2010 and Hui, 2016).

Conclusion

These experiments showed that the effect of KFM, KHM, KFT and KHTcombine with rock phosphate, superphosphate at rates 0.5% (v/v) and four spray on faba been under sandy soil. The relative effect KFT< KHT< KFM < KHM, respectively), but KFT slowly effect on major parameters. The highest relative of all parameters impacted by KFM < KHM respectively. The highest accumulation of P contents due tohumic substancescombine with rock phosphate or superphosphate after the third spray (75 days). The relative increased of K in shoot affected by different treatments until full maturity stage. All plant parameters and nutrients affected by KFM, KHM, KHT but KFT slowly affect. Humic substances magnetic water solution may be had become interest method for foliar application in the future.

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دراسة تأثير رش محاليل الهيومات والفالفات الممغنطة على تيسر الفوسفور فى الأراضى الرملية المنزرعة بالفول البلدى

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اجريت تجربتان حقليتان تحت ظروف الارض الرملية بمحطة البحوث الزراعية بالإسماعيلية (موسمى شتاء ٢٠١٧/٢٠١٨–٢٠١٨/٢٠١٩) و كان الهدف منهما دراسة تأثير الرش بالمحلول المائى الممغنط لكل من فالفات البوتاسيوم وهيومات البوتاسيوم (٠,٥٪ v/v) على تيسر الفوسفور من سماد صخر الفوسفات او سوبر فوسفات الكالسيوم الاحادى بمعدل اضافة ١٦,٠٩ كجم فوسفور/هكتار وكذلك على انتاج الفول البلدى (Vicia Faba L.) النامى فى ارض رملية . تم رش المحاليل الممنغنطة وغير الممغنطة أربع مرات بعد ٣٠ و ٥٠ و ٧٠ و ٩٠ يوم من الزراعة وكانت المعاملات (١) كنترول بدون اضافة فوسفور او مركبات هيومية (٢) المحلول المائى الممغنط فالفات و/او هيومات البوتاسيوم (٣) المحلول المائى غير الممغنط (مخلوط بماء الصنبور) فالفات و/او هيومات البوتاسيوم فى وجود وعدم وجود سماد صخر الفوسفات و/أو السوبر فوسفات الكالسيوم ضمن تصميم قطاعات كاملة العشوائية . تمت الزراعة والتسميد طبقا لتوصيات وزارة الزراعة . عند النضج والحصاد تم تقديروحسابببيانات المحصول و مكونات المحصول و محتوى النبات والتربة من النيتروجين والفوسفوروالبوتاسيوم والرقم الهيدروجينى و التوصيل الكهربى للتربة فى مرحلة النضج وكذلك درست حركة الفوسفور والبوتاسيوم فى الاجزاء الخضراء للفول بعد الرشة الثانية و الثالثة و مقارنة ذلك بالتحليل النباتى بعد فترة الرشة الرابعة (تمام النضج) . بينت النتائج ما يلى : كان اعلى تراكم للفوسفور و البوتاسيوم فى المجموع الخضرى لكل المركبات الهيومية مع صخر الفوسفات والسوبر فوسفات بعد الرشة الثالثة. كل محاليل الرش مع صخر الفوسفات او السوبر فوسفات اعطت تاثير معنوى على ارتفاع النبات و وزن البذور/ نبات و وزن المادة الجافة/ نبات و وزن القرون/ نبات محصول البذور و محصول القش ومحتوى البوتاسيوم فى القش و فى البذور « المحاليل الممغنطة و البوتاسيوم هيومات مع السوبر فوسفات اعطت تاثير معنوى على محتوى النيتروجين و الفوسفور فى القش و البذور و الفوسفور الميسر بالتربة بالاضافة الى محتوى الفوسفور بالبذور فى حالة صخر الفوسفات بينما المحاليل الممغنطة فقط مع صخر الفوسفات اعطت تاثير معنوى على محتوى النيتروجين و الفوسفور فى القش و الفوسفور الميسر بالتربة. النيتروجين و البوتاسيوم الميسر بالتربة وتركيز الاملاح بالتربة لم يعطى فروق معنوية كما لوحظ انخفاض لدرجة الحموضة فى التربة مع المحاليل الممغنطة. إن الإضافة بالرش لمحاليل الفالفات والهيومات الممغنطة قد تزيد من فعالية التسميد الفوسفاتى تحت ظروف الأراضى الرملية.