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Sustainable Management of Kidney Bean Plants by Soil Application of Humic Substances and Foliar Application of Molybdenum

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ONLY few publications focus on the effect of humic substances plus foliar spraying with molybdenum on plants. Therefore, the objective of this study was to determine the influence of some humic substances (*i.e.*, potassium fulvate and humate as a single treatment or in a combination) and the foliar application of molybdenum element (*i.e.*, 0.0 and 50 mg L^{-1} as ammonium molybdate) on kidney bean (*Phasuolas vulgaris* L.;varitety Nebraska) plants. The field trial was carried out in a private farm at Tanah Village, El-Mansoura District, El-Dakahlia Governorate, Egypt during two consecutive growing seasons 2017 and 2018. The experimental design was a split-plot with three replicates. The findings showed that the combined treatment of potassium fulvate with potassium humate under foliar application of Mo at rate of 50 mgL^{-1} was the superior treatment for vegetative growth criteria, *i.e.* fresh and dry weights of shoot and plant height, chemical constituents in leaves (*i.e.* chla, chlb, chla+b), N, P, K , Mo and NPK nutrients uptake at a period of 45 days from sowing as well as yield, *i.e.* pods and seeds weights and nutritional elements concentration in seeds, *i.e.* nitrogen, phosphorus, potassium, molybdenum and NPK nutrients uptake at harvest stage of kidney bean plants. While the lowest values of all aforementioned traits were recorded with untreated plants (without both humic materials and Mo). Also, available N, P and K in soil after harvesting kidney bean plants pronouncedly differed due to all studied treatments.

Keyword: Potassium fulvate, Potassium humate, Molybdenum and *Phasuolas vulgaris* L.

Introduction

Humic materials are complex aggregates of brown to dark colored amorphous. Fulvic and humic acids are the main parts of humic substances which causes improve soil fertility and nutrients availability, thus plant growth in agricultural crops (Khaled and Fawy, 2011, Ali, 2015; Abd-Elrahman and Taha, 2018; Samie et al. 2018; El-Naqma, 2020). Potassium fulvate and potassium humate are humic acid and fulvic acid potassium salts, completely water-soluble (Taha et al. 2016). Hanafy et al. (2010) stated that humic acid (20g L^{-1}) significantly increased yield and its components of snap bean plants (*i.e.,* total green pod yield, No. of pods $plant^{-1}$ and pods weights $plant^{-1}$). Hemida et al. (2017) showed that potassium humate improved N, P, K, Ca, ascorbic acid, glutathione, catalase, and superoxide dismutase and guaiacol peroxidase of *Phaseolus vulgaris* plants compared to untreated plants. Also, humic acid state creating more accessibility for the nutrients by reduction soil pH value as well as increasing the action of soil organisms. Addition of potassium humate (70 or 140 kg ha^{-1}) to soils has been shown to increase N, P and K leaf contents and increment photosynthesis, plant growth and yield of bean plants (Taha and Osman, 2018). Potassium plays an important role as a macronutrient in sustainable crop production and plant growth (Alshaal and El-Ramady 2017; El-Akhdar et al. 2018; Shawer, 2019 and Marzouk et al. 2020). Potassium fulvate contains both HA and FA, is mainly extracted from lignite (Sarlaki et al. 2019). As it possesses good water solubility and strong resistance to hard water, it is mainly

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used as a soil addition or with Sprinkler irrigation and drip irrigation. Abdel-Baky et al. (2019) showed that fulvic acid application (3,6 and 9 g L^{-1}) led to increase all growth parameters and total photosynthetic pigments content in leaves of faba bean plants as compared to plants untreated. Omar et al. (2020) reported that fulvic acid could easily enter squash plants due to the comparatively little size of the molecules.

Molybdenum is one of the essential micronutrients which plays a crucial part in the regulation of different plant functions. Vieira et al. (1998) reported that foliar application of molybdenum on common bean at the period of 25 days from planting emergence decreased nodule number per plant, while after 45 days the nodule weight was increased; they suggested that molybdenum maintains nodules effective for a longer period, which means increasing nitrogen fixation. Plants need the smallest quantities from it. The normal range for most plant tissue is between 0.3-1.5 mg kg^{-1}. Molybdenum toxicity or deficiency is not very common. Like any nutrient toxicity or deficiency, it needs to be corrected before there is an adverse effect on crop growth and quality. It is an essential component in two enzymes that convert nitrate into ammonia in plant tissue. It also needed by symbiotic nitrogen-fixing bacteria in legumes to fix atmospheric nitrogen. Plants also use it to convert inorganic P into organic forms (Kaiser et al. 2005; Steiner and Zoz, 2015; Rana et al. 2020).Vieira et al. (2011) reported that foliar application of Mo increased plant growth parameters, yield and plant N status in common bean plants. Fawy et al. (2016) demonstrated that incorporating humic acid along with molybdenum fertilizer has a beneficial influence on faba bean performance.

Kidney bean (*Phaseolus vulgaris* L.) is one of the most popular leguminous vegetable crops. It considered as a good source of calories, dietary fibers, proteins, minerals and vitamins for millions of people in both developing and advanced countries worldwide. In Egypt, it is considered as a substantial crop for either local consumption or exportation, where the total cultivated area of Kidney bean plants is (60000 feddans) which produces annually about 28530 tons (Rady et al.2016; Fouda et al. 2017).

Thus, the aim of this study is to investigate the effect of potassium fulvate, potassium humate and foliar applications of molybdenum on Kidney bean plants. Also, increasing soil fertility and improving physical and chemical soil properties by soil addition of humic substances.

Material and Methods

Experimental setup

A field trial was carried out in a private farm at Tanah village, El-Mansoura District, El-Dakahlia Governorate, Egypt (31^{o} 02’7268” N latitude and 31^{o} 57’ 9290’ E longitude) during two consecutive growing seasons 2017 and 2018. The experimental design was a split-plot with three replicates. There are 2 factors under the experiment: Main plots were soil addition of humic substances [*i.e*. without addition (control), potassium fulvate as a single treatment (at a rate of 2 kg fed^{-1}), potassium humate as a single treatment (at a rate of 2 kg fed^{-1}) and both together as a combined treatment at the same rates (K-fulvate plus k-humate)], while sub plots were foliar application of molybdenum [without Mo (0.0 mgL^{-1}) and 50 mgL^{-1} as ammonium molybdate [$(NH_4)_6 Mo_7O_{24}.4H_2O$)]. Kidney bean seeds (*Phasuolas vulgaris* L.; variety Nebraska) were sown at rate of 40 Kg Fed^{-1} on 2nd of March during the both seasons, in five ridges of 0.60 m wide and 3.5 m long with plant spacing of 7 cm in plots (experimental unit area = 3×3.5m (10.5 m^2). The normal agricultural practices were done for the kidney bean production according to the Ministry of Agriculture and Soil Reclamation (MASR). Prior to sowing, kidney bean seeds were inoculated with the rhizobium bacteria “Okadin bio fertilizer” which obtained from the Agricultural Research Center (ARC) at the rate of 800 g fed^{-1}. Arabic gum was added as an adhesive agent. Chemical fertilization (N,P and K) was done as recommended by MASR. Before sowing, calcium super phosphate (15.5 % P_2O_5) was applied at a rate of 200 kg fed^{-1}. Elemental sulfur (98%) was added at rate of 50 Kg fed^{-1}. While N fertilizer was applied as ammonium sulphate (20.6 %N) at a rate of 60 unit fed^{-1} in two doses; the first was with the first irrigation and the second was at 15 days after the first. Also, potassium sulphate (48 % K_2O) was applied at rate of 50 Kg fed^{-1}. Potassium fulvate and potassium humate were applied twice (the first before sowing and the second after 20 days from sowing) at the above mentioned. Potassium humate and potassium fulvate were purchased from the agriculture commercial market and were analyzed according to Buurman et al. (1996) as shown in Table 2. Foliar application of Mo was done at two different periods from sowing (after 20 and 35 days). Mo as ammonium molybdate (98%) was obtained from Al - Gomhoria Company for medicines and medical supplies. Irrigation was done as plants needed. At the start of the experiment, the soil of the experimental site was analyzed as a routine work according to Buurman et al. (1996). Average of soil properties and main specification of humic substances are presented in Tables 1 and 2, respectively.

Vegetative growth criteria

Five plant samples were randomly taken from each plot to measure fresh and dry weights of shoot (g $plant^{-1}$) and plant height (cm) of kidney bean plant at a period of 45 days after sowing.

Pigments and chemical composition

At 45 days from sowing, chlorophyll *a, b and (a+b)* were measured by spectrophotometer as the method described by Sadasivam and Manickam (1996), while carotene was determined according to Ranganna (1997). Pigments were determined in fresh leaves samples. The samples of leaves were dried at 70^0C to determine N % according to the methods described by Jones et al. (1991) and both P and K% according to Peters et al. (2003). Molybdenum content was determined using Atomic Absorption Spectrophotometer (FAAS Perkin Elmer HGA 4000 programs, USA). Nutrients uptake was determined according to the following formula

$$\text{Nutrients uptake (mg plant} - 1) = \frac{\textit{Nutrient concentration} \text{ x dry weight (mg plant} - 1)}{100}$$

Yield and its components

Pods of each plot were harvested at the proper maturing stage. The pods weight (g $plant^{-1}$) and seeds weight (g $plant^{-1}$) were recorded then converted to ton per feddan for seeds weight.

Chemical composition of seeds

At harvest stage, N, P, K and Mo were determined as formerly mentioned in leaves. Crude protein content was calculated by multiplying the total N by the factor 6.25 (A.O.A.C., 2007). Nutrients uptake was determined according to the following formula

$$\text{Nutrients uptake } kg\,fed - 1 = \frac{\textit{Nutrient concentration x seed yield } (kg\,fed - 1)}{100}$$

Residues nutrients in soil

After kidney bean harvesting; soil samples from each experimental sub plot at the depth of 0-20 cm were randomly taken to determine available N, P and K (mg kg^{-1}) according to Reeuwijk (2002).

TABLE 1. Physical and chemical properties of the experimental soil (combined seasons)

Particle size distribution (%)				class textural	EC, dSm^{-1}	pH	$CaCO_3$	O.M	SP
C. sand	F. sand	Silt	Clay				g kg^{-1}		(%)
3.41	15.76	32.16	48.67	Clay	0.41	7.98	10.3	15.2	71.13

Soluble cations (mmole L^{-1})				Soluble anions (mmolc L^{-1})				Available element, mg kg^{-1}			
Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	N	P	K	Mo
1.55	1.31	1.05	0.18	N.D	0.70	2.08	1.31	42.5	13.1	289.6	0.08

Notes: Soil Electrical Conductivity (EC) and soluble ions were determined soil solution extract (1:5).
Soil pH was determined in soil suspension (1: 2.5); ND: Note detected.

TABLE 2. Some characteristic of potassium humate and potassium fulvate

Humic substances	HA	FA	Solubility	Moisture	pH	Total macro element		
						N	P	K
	%					%		
Potassium humate	60.00	3.00	100	5.82	8.50	0.45	1.10	11
Potassium fulvate	3.70	65.00	100	5.75	5.61	0.55	2.97	8

Where: HA:Humic Acid and FA: Fulvic Acid

Statistical analysis

Results from identical experiments of the 2 years were combined for analysis. Significant differences among treatments means were determined at P ≤ 0.05 by using LSD test and Duncan's Multiple Comparisons Test. Data of the present study were statistically analyzed using CoSTATE Computer Software, according to Gomez and Gomez (1984).

Results

Vegetative growth and its parameters

The effect of some humic substances (*i.e.* potassium humate and potassium fulvate) as soil addition with foliar spraying of molybdenum on vegetative growth criteria (*i.e.* fresh and dry weights of shoot and plant height) and some chemical constituents [*chl.a*, *chl.b, chl(a+b),* carotene, N, P, K and Mo in leaves of kidney bean plants] as well as NPK nutrients uptake by kidney bean plants grown on clay soil at a period of 45 days from sowing during 2017 and 2018 seasons are presented in Tables 3 and 4. The soil addition of potassium fulvate as a single treatment and potassium humate as a single treatment as well as combined of them (K-humate+K-fulvate) significantly increase all aforementioned traits compared to untreated plants (without humic substances), where treatments sequence from top to less is the combined treatment (K-humate+ k-fulvate) > potassium fulvate alone > potassium humate alone > control (without humic substances). Concerning the influence of molybdenum as a foliar application, data indicate that the foliar spraying with Mo at rate of 50 mg L^{-1} significantly increase all aforementioned traits as compared to untreated plants, where the plants sprayed with Mo record performance better than untreated plants. Regarding the interaction impact among the studied treatments, the findings in Tables 3 and 4 illustrate that the values of all above mentioned traits are significantly affected due to the addition of all investigated treatments. The highest values are recorded when plants treated with combined treatment of potassium fulvate and potassium humate with spraying molybdenum at rate of 50 mg L^{-1} Mo, while the kidney bean plants untreated with humic substances and molybdenum give the lowest values of all aforementioned traits.

Yield and chemical composition of seeds at harvest stage

Listed data presented in Tables 5 and 6 reflect the effect of potassium fulvate and potassium humate with foliar spraying of molybdenum on yield, *i.e.* pods and seeds weights, nutritional elements concentration in seeds, *i.e.* nitrogen, phosphorus, potassium, molybdenum, NPK uptake and protein of kidney bean plants at harvest stage. The combined treatment of K-humate and K-fulvate realized the highest values for all aforementioned traits followed by potassium fulvate alone, potassium humate alone and control treatment, respectively. Concerning the influence of molybdenum foliar spraying, it is evident that foliar spraying with ammonium molybdate (50 mgL^{-1}) significantly increase all aforementioned traits compared to control treatment (untreated plants).

Regarding the interaction effect, according to the data illustrated in the same Tables, kidney bean plants treated with combined treatment of potassium fulvate and potassium humate with spraying molybdenum at rate of 50 mgL^{-1} Mo gives the highest values of yield, *i.e.* pods and seeds weights, nutritional elements concentration in pods, *i.e.* nitrogen, phosphorus, potassium, molybdenum, NPK uptake and protein. On the other hand, the kidney bean plants untreated with humic substances and molybdenum give the lowest values of all aforementioned traits.

Available concentrations of N, P and K in soil after harvesting

Average concentrations of available N, P and K in soil (mg kg^{-1}) (combined data over both seasons) after harvesting kidney bean plants as affected by soil addition of some humic substances with foliar spraying molybdenum are showed in Fig. 1, 2 and 3, where the concentrations of N, P and K in the soil after harvesting generally increase over that before sowing; as shown in materials. This attributes to the impact of roots activity, which affect greatly the soil pH, thus increases the availability of these elements. On the other hand, the seed inoculation increased nitrogen in soil due to N-fixation in the root nodule. Also, the concentrations of available N, P and K are significantly affected due to the humic substances treatments; which already contain moderately amount of N, P and K (Table 2). On the other hand, molybdenum treatment leads to decrease the average concentration of available nitrogen, phosphorus and potassium in the soil after harvesting kidney bean plants due to the role of Mo in improving plant status, thus the plants absorb more N, P and K with foliar application of Mo at rate of 50 mg L^{-1} more than untreated plants (without Mo). Generally, the concentrations of N, P and K in the soil after harvesting decrease due to foliar application of Mo.

TABLE 3. Effect of some humic substances, molybdenum and their interactions on vegetative growth and chemical constituents (combined data over both seasons) of kidney bean plant leaves at 45 days from sowing

Treatments	Growth criteria			Pigments			
	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	Plant height (cm)	Chlorophyll content (mg g FW^{-1}) *a*	*b*	*a+b*	Carotene
Humic substances as soil addition							
Without addition	21.46d	2.34d	31.80d	0.361d	0.084d	0.446d	0.073d
Potassium humate	31.32c	3.52c	36.66c	0.371c	0.106c	0.477c	0.085c
Potassium fulvate	37.08b	4.14b	38.68b	0.392b	0.116b	0.508b	0.095b
Both together	40.28a	4.45a	45.07a	0.418a	0.127a	0.545a	0.112a
Molybdenum as foliar application							
0.0 mg Mo L^{-1}	27.20b	3.19b	33.63b	0.373b	0.095b	0.468b	0.080b
50 mg Mo L^{-1}	31.32a	3.49a	37.02a	0.389a	0.105a	0.493a	0.092a
Interaction							
Without addition							
0.0 mg Mo L^{-1}	14.71h	1.75g	26.17h	0.352f	0.053e	0.405h	0.057d
50mg Mo L^{-1}	21.03g	2.36f	33.07g	0.360ef	0.085d	0.445g	0.073c
Potassium humate							
0.0 mg Mo L^{-1}	24.00f	2.88e	33.67f	0.358e	0.090c	0.455f	0.072cd
50 mg Mo L^{-1}	30.47e	3.33d	35.47e	0.374d	0.099bc	0.473e	0.087ab
Potassium fulvate							
0.0 mg Mo L^{-1}	33.77d	3.92c	35.67d	0.376d	0.107b	0.483d	0.086bc
50 mg Mo L^{-1}	35.10c	4.07b	38.07c	0.399c	0.116a	0.515c	0.098ab
Both together							
0.0 mg Mo L^{-1}	36.35b	4.02b	39.00b	0.409b	0.123a	0.532b	0.105a
50 mg Mo L^{-1}	39.29a	4.21a	40.48a	0.423a	0.129a	0.541a	0.111a

TABLE 4. Effect of some humic substances, molybdenum and their interactions on nutrients N, P, K (%) and Mo (mg kg-1) and their uptake (mg plant-1) (combined data over both seasons) of kidney bean plant leaves at 45 days from sowing

Treatments		Nutrients				Nutritional elements uptake		
		N	P	K	Mo	N	P	K
		%			mg kg^{-1}	(mg plant^{-1})		
Humic substances as soil addition								
Without addition		2.91d	0.233d	1.71d	0.343d	68.0d	5.5d	40.0d
Potassium humate		3.00c	0.273c	2.31c	0.377c	105.5c	9.6c	81.3c
Potassium fulvate		3.08b	0.282b	2.63b	0.414b	127.6b	11.7b	108.9b
Both together		3.17a	0.295a	2.96a	0.544a	140.9a	13.1a	131.6a
Molybdenum as foliar application								
0.0 mg Mo L^{-1}		2.82b	0.233b	2.21b	0.220b	89.9b	7.4b	70.5b
50 mg Mo L^{-1}		3.12a	0.265a	2.45a	0.438a	109.0a	9.2a	85.5a
Interaction								
Without addition	0.0 mg Mo L^{-1}	2.74f	0.219g	1.43e	0.163f	45.2h	4.1h	26.5g
	50mg Mo L^{-1}	2.96d	0.231f	1.81de	0.343c	69.9g	5.5g	42.7f
Potassium humate	0.0 mg Mo L^{-1}	2.77f	0.231f	2.19cd	0.210e	79.8f	6.7f	63.1e
	50 mg Mo L^{-1}	3.07c	0.268c	2.32bc	0.373bc	102.2e	8.9e	77.3d
Potassium fulvate	0.0 mg Mo L^{-1}	2.84e	0.236e	2.38bc	0.236de	111.3d	9.3d	93.3c
	50 mg Mo L^{-1}	3.17b	0.276b	2.67ab	0.413b	129.0b	11.2b	108.7b
Both together	0.0 mg Mo L^{-1}	2.9e	0.244d	2.83a	0.273d	116.6c	9.8c	113.8b
	50 mg Mo L^{-1}	3.27a	0.286a	2.96a	0.623a	137.7a	12.0a	124.6a

TABLE 5. Effect of some humic substances, molybdenum and their interactions on yield and chemical composition of seeds (combined data over both seasons) of kidney bean plant at harvest stage

Treatments		Yield		
		Pods weight	seed weight	seed Yield
		(g plant^{-1})		(ton fed^{-1})
Humic substances as soil addition				
Without addition		20.73d	15.70d	1.061d
Potassium humate		24.78c	19.65c	1.351c
Potassium fulvate		27.39b	21.46b	1.395b
Both together		28.87a	22.93a	1.478a
Molybdenum as foliar application				
0.0 mg Mo L^{-1}		23.49b	17.40b	1.250b
50 mg Mo L^{-1}		25.09a	19.74a	1.329a
Interaction				
Without addition	0.0 mg Mo L^{-1}	18.22h	13.18f	0.983h
	50 mg Mo L^{-1}	20.80g	15.50e	1.058g
Potassium humate	0.0 mg Mo L^{-1}	23.53f	17.49d	1.298f
	50 mg Mo L^{-1}	24.24e	19.26c	1.356d
Potassium fulvate	0.0 mg Mo L^{-1}	25.92d	18.67cd	1.327e
	50 mg Mo L^{-1}	26.94b	21.14b	1.413b
Both together	0.0 mg Mo L^{-1}	26.52c	19.29c	1.392c
	50 mg Mo L^{-1}	28.38a	23.07a	1.489a

TABLE 6. Effect of some humic substances, molybdenum and their interactions on chemical composition of seeds and their uptake (kg fed-1) (combined data over both seasons) of kidney bean plant at harvest stage

Treatments		Chemical Composition of seeds					Nutritional elements uptake		
		N	P	K	Mo	Protein	N	P	K
		%			mg kg^{-1}	%	Kg fed^{-1}		
Humic substances as soil addition									
Without addition		1.88d	0.369d	1.66d	0.216b	11.90d	20.03d	3.92d	17.12d
Potassium humate		2.01c	0.384c	1.75c	0.276ab	12.54c	27.17c	5.19c	25.45c
Potassium fulvate		2.11b	0.397b	2.00b	0.290ab	13.17b	29.46b	5.54b	27.97b
Both together		2.20a	0.407a	2.20a	0.303a	13.71a	32.57a	6.03a	32.70a
Molybdenum as foliar application									
0.0 mg Mo L^{-1}		1.83b	0.367b	1.69b	0.152b	11.41b	22.92b	4.62b	21.39b
50 mg Mo L^{-1}		2.13a	0.393a	1.92a	0.260a	13.42a	28.55a	5.25a	25.89a
Interaction									
Without addition	0.0 mg Mo L^{-1}	1.71f	0.344h	1.43e	0.08c	10.71f	16.80h	3.38h	14.08h
	50 mg Mo L^{-1}	1.91d	0.369f	1.67d	0.21ab	12.40d	20.94g	3.90g	17.66g
Potassium humate	0.0 mg Mo L^{-1}	1.79e	0..363g	1.68d	0.10c	11.21e	23.23f	4.74f	20.76f
	50 mg Mo L^{-1}	2.09c	0.387d	1.83c	0.24ab	13.08c	28.34c	5.24d	24.81d
Potassium fulvate	0.0 mg Mo L^{-1}	1.87d	0.376e	1.84c	0.13bc	11.71d	24.80e	4.98e	24.41e
	50 mg Mo L^{-1}	2.21b	0.404b	1.90b	0.28a	13.79b	31.22b	5.70b	26.84b
Both together	0.0 mg Mo L^{-1}	1.93d	0.388c	1.89b	0.15bc	12.02d	26.87d	5.40c	26.31c
	50 mg Mo L^{-1}	2.31a	0.414a	2.31a	0.31a	14.42a	34.39a	6.16a	34.24a

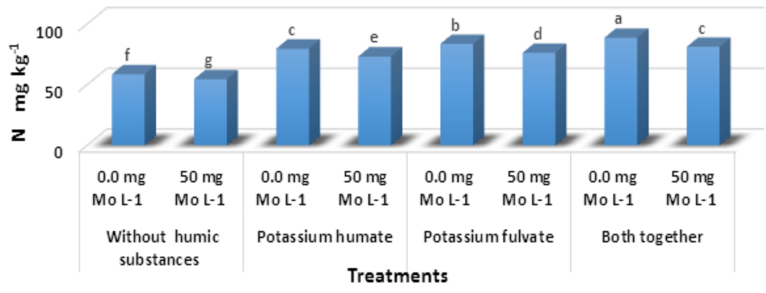

Fig. 1. Available N in soil (mg kg-1) (combined data over both seasons) after harvesting as affected by soil addition of some humic substances with foliar spraying of molybdenum at different rates

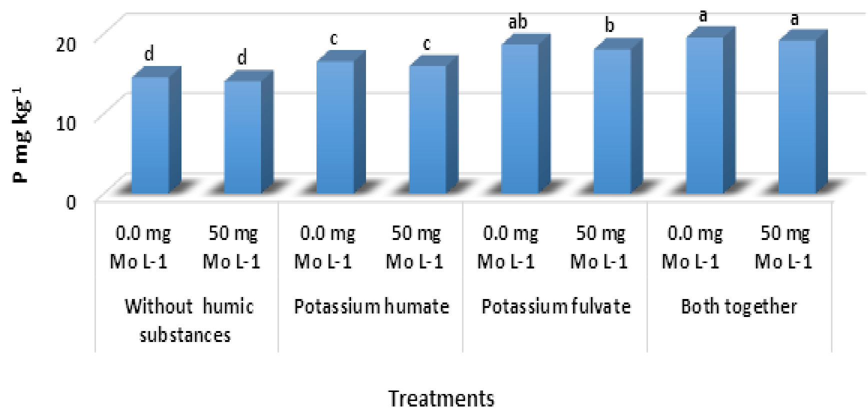

Fig. 2. Available P in soil (mg kg-1) (combined data over both seasons) after harvesting as affected by soil addition of some humic substances with foliar spraying of molybdenum at different rates

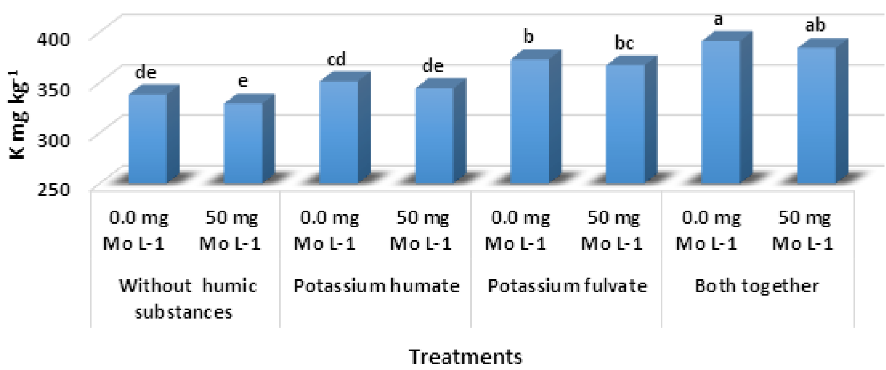

Fig. 3. Available K in soil (mg kg-1) (combined data over both seasons) after harvesting as affected by soil addition of some humic substances with foliar spraying of molybdenum at different rates

Discussion

Potassium humate and fulvate increase the organic matter of the soil and improve soil structure, accordingly largely promote the buffering power of the soil and these effects reflect on the growth of kidney bean plants. The superior of K-fulvate may be due to its high content of FA, N and P (%) more than K-humate (Table2). These results are in agreement with Omar et al. (2018) who extracted fulvic and humic acids from different feed stocks and found that fulvic acid contains phenolic -OH, COOH and alcoholic- OH groups more than that of the humic acid. For example, COOH groups in fulvic acids were between 7.3 to 8.4 (mmole/g. FA.), while varied from 3.8 to 4.1(mmole/g. HA) for humic acid. Generally, the high content of fulvic acid in potassium fulvate with small molecular weight and short molecular chain, easy to be absorbed by plants.

These results are in harmony with the finding of Gatabazi, (2014) who found that potassium humate and potassium fulvate reduced leaching of N and P. On the contrary, N, P and K uptake by plants were higher for the soils treated with humate or fulvate. Beside, Taha et al. (2016) who indicated that lettuce plants treated with fulvic acid as soil addition had growth parameters higher than that treated with humic acid as soil addition at the same dose and the lowest values were recorded with untreated plants. Also, Hemida et al. (2017) reported that potassium humate significantly improved soil characteristics, which positively reflected on growth and performance of *Phaseolus vulgaris* plants grown on salt affected soil compared to untreated plants. These findings reveal the positive effects of potassium fulvate, which can be explained as mentioned by Omar et al. (2020) who reported that fulvic acid can be used as plant biostimulants to increase nutrients uptake, plant height and fresh weight due to its low molecular weight, high oxygen content and has many (-OH) and (-COOH) groups, which increases its exchange capacity.

As for Mo effect, these results may be explained by the fact that Mo is an essential component in two enzymes that convert nitrate into nitrite in plant tissue and then into ammonia before it is used to synthesize amino acids within the plant as well as plants also use molybdenum to convert inorganic phosphorus into organic forms in the plant.Also, Mo enzymes are involved in the synthesis of the phytohormones ABA and indole-3-acetic acid (IAA) (Kaiser et al. 2005). Spraying Mo as ammonium molybdate ($(NH_4)_6Mo_7O_{24}.4H_2O$) cause improve growth and yield quality of kidney bean plants due to its high contents from Mo and NH_4.Such results are supported by the findings of Brito et al. (2005) who stated that the molybdenum fertilization resulted in increases in the height of the snap bean plants. Also, Steiner and Zoz (2015) who reported that foliar application of Mo rates increased the concentrations of both total nitrogen and Mo in the leaf tissue of sunflower. Beside Rana et al.(2020) who stated that transition metal molybdenum in molybdate form is essential for plants as a number of enzymes use it to catalyze most important reactions in the nitrogen acclimatization, the synthesis of the phytohormone, degradation of the purine and the detoxification of the sulfite.

Conclusion

According to the obtained results, kidney bean ”Nebraska variety” plants treated with potassium fulvate (at a rate of 2 kg fed^{-1}) and potassium humate (at rate of 2 kg fed^{-1}) as a combined treatment and sprayed with molybdenum at a rate of 50 mgL^{-1} is the best treatment that could be recommended to enhance growth and seeds quality of kidney bean and obtain the highest yield. This study discovered that the soil addition of humic substances, *i.e.* potassium fulvate and potassium humate is useful for growing plants due to its high contents from HA, FA and K. Spraying Mo as ammonium molybdate ($(NH_4)_6Mo_7O_{24}.4H_2O$) cause improve plant growth due to its high contents from Mo and NH_4. It can be concluded that investigated treatments represent an attractive option for sustainable crop management programs.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest

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All authors of this study shared in all stages from the beginning with idea, design and experimental work up to interpretation of data and edit of manuscript for publication.

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