

Effect of Potassium Humate and Micronic Sulfur on the Chemical Properties of Some Soils of Toshka, Egypt

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Authors' contributions

This work was carried out in collaboration between both authors. Authors AAAS and AAMA designed the research work and performed the experiment, analyzed the data and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI:10.9734/AJSSPN/2020/v6i230081

Editor(s):

(1) Dr. Tualar Simarmata, University of Padjadjaran Bandung, Indonesia.

Reviewers:

(1) Jayath P. Kirthisinghe, University of Peradeniya Peradeniya, Sri Lanka.

(2) Paul Kweku Tandoh, KNUST, Ghana.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/56120>

Received 10 March 2020

Accepted 14 May 2020

Published 05 June 2020

Original Research Article

ABSTRACT

Low soil organic matter, low nutrient availability and the higher soil pH (more than 8) are the major problem of agricultural practices in region of Toshka. An incubation trial at October 2019 was conducted to investigate the effect of potassium humate (KH) and micronic sulfur (MS) on some chemical properties of different soils (sandy clay soils, loamy sand and sandy soils). The used amendments (KH and MS) were added to the studied soil at 4 levels of each amendment i.e. 0.0, 0.25, 0.50 and 1.0%. A two way randomized completely block design and provided with three replications. Studied parameters were included soil pH, EC, exchange Na and the content of available - P and K. Results showed that, the MS application at 1% level caused a significant decrease in soil pH values compared with the KH application and control treatment. These reductions were more pronounced in case of soil B (loamy sand). Also, KH application gave an increase on exchange Na and available-K. While MS application was cause an increased in soil EC and available-P in the three soils under study. Moreover, the increases in the percentage of available – K with added of KH were higher than added of MS for soils under study. While the percentages of available-P with added of KH were higher than with added of MS for studied soils. It

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may be recommended to add KH and MS at a rate of 1% to improve the soil chemical properties. But the effect of application from MS has greater than KH to increase dissolved sodium salts on the form of sodium sulfate, which facilitates disposal during soil drainage.

Keywords: Potassium humate; micronic sulfur; available K and available P.

1. INTRODUCTION

The horizontal expansion in Egypt of agricultural soils depends on the cultivation and reclamation of new soils, especially in the Toshka region in the east of the Western Desert in Egypt. The majority of this soil is characterized by an alkaline pH and a decrease in the availability of macronutrients to the soil, which adversely affects plant growth. Phosphorus forms an insoluble compound with a cation such as calcium in alkaline soil conditions that reduce its availability in the soil [1]. The level of available-K in the soil has decreased due to the rapid development of agriculture and the application of unbalanced fertilizers [2]. Some amendments as potassium humate affect the availability of phosphorous and potassium [3]. The competitive adsorption between organic acids and phosphates, which prevents P adsorption on active soil surfaces and makes it more available [4]. It plays a key role in nutrient cycles (P, S, K) and increasing soil availability [5]. Potassium humate is one of material which improves soil properties and nutrient dynamics [6]. Available phosphorous in the soil is the remaining part of the precipitation and adsorption processes in the soil, and this phosphorus plays a major role in the soil by providing plants with phosphorous [7]. Sulfur is one of the good amendments that may affect the availability of phosphorous and potassium, as it is oxidized to sulfuric acid, which facilitates the elements in the soil. The rate of sulfur oxidation depends on several factors such as organic matter content, soil moisture content, microorganism's populations and temperature [8]. In addition, it improves some of the physical properties of soils. So, sulfur is available and less costly material for amending soils of Egypt. In the best of circumstances, S is oxidized to sulfuric acid within a few weeks by soil microorganisms [9]. This study was focused to evaluate the effect of potassium humate and micronic sulfur on the availability of potassium and phosphorus and other chemical properties of different soils. The application of 1% KH or MS is expected to improve some of the chemical properties of all types of soil under study, especially low soil PH, increased soil EC and exchange Na, availability of K and P.

2. MATERIALS AND METHODS

2.1 Soil Sampling

Three soil samples were collected from the upper layers (0- 20 cm) of three cultivated soils at different locations of Toshka, Aswan Governorate, Egypt (Table 1). The soil samples were air-dried then ground and sieved through a 2 mm sieve and characterized for their some chemical and physical properties according to procedure [10,11] and the obtained data are shown in Table 1.

2.2 Soil Amendments

Two soil amended materials were used in to study their effects on soil pH and EC and as well as the content of available P and K. These amendments were potassium humate (KH) and micronic sulphur (MS) was supported from Kafr El-Zayat Pesticides & Chemicals Co., Egypt (70% sulfur, 13% surfactant material and 17% inactive material). Some chemical characteristics of KH are shown in Table 2. Each used amendments was added to 400 g soil at four rates i.e., 0.0, 0.25, 0.5 and 1.0%. Some chemical and physical properties of KH and MS were determined according methods of AOAC [12].

2.3 Incubation Experiment

Three different soil samples (A, B and C) and the two soil amendments were used in this experiment. The studied factors represented 3 soils * 2 amendments (KH and MS) * 4 application rates of each amendment 0.0, 0.25, 0.5 and 1% * 3 replicates which laid out in completely randomized block design in three replicates by two-way ANOVA under laboratory conditions at Soil and Natural Resources Department, Faculty of Agriculture and Natural Resources, Aswan University Egypt. A 72 plastic pots with 10 cm of diameter and 8 cm depth were used in this study. These pots were divided into three main groups (24 pot/ main group) representing the used three soils. Each pot was filled with 400 g fine A, B and C soils. The pots of each main group were divided into two subgroups representing the used amendments

(potassium humate and micronic sulfur). Also, the pots of each subgroup were arranged in four sub subgroups (3 pot/sub subgroup) representing application rates of the used amendments (0, 0.25, 0.5 and 1%). Incubation period was 45 days. The moisture content of the incubated soil was adjusted every two days with distilled water up to the field capacity of each treatment. At the end of the incubation period, soil sample was taken from each treatment to air-dried, ground and sieved through on 2 mm sieve. The sieved soil was analysis for some soil chemical properties as soil pH, electrical

conductivity (EC), exchange-Na and the available P and K and calculated the percentage changes of some the studied properties according to the following equation:

$$\text{Percentage change} = \frac{[\text{reading at treatment} - \text{reading at control}]}{[\text{reading at control}]} \times 100$$

2.4 Statistical Analysis

Statistically analyzed of all data for soil chemical parameters were according to the method of

Table 1. Some physical and chemical properties of investigated soils

Soil parameters	Units	Soil, location		
		(A)	(B)	(C)
Location	North	23° 8`	22° 44`	23° 10`
	East	31° 35`	31° 27`	31° 35`
Sand	(%)	62.50	82.50	60.00
Silt		15.00	12.50	27.50
Clay		22.50	5.00	12.50
Textural Class		Sandy clay loam	Loamy sand	Sandy loam
Bulk density	gcm ⁻³	1.52	1.69	1.65
Field capacity	%	26.50	20.00	26.00
pH sus. (1:2.5)		8.42	8.75	7.93
EC extract (1:5)	dS m ⁻¹	3.41	0.27	3.06
Soluble cations				
Ca	meq L-1	12.00	1.10	17.6
Mg		5.00	0.60	9.00
Na		16.66	1.10	2.52
K		0.45	0.24	0.4
Soluble anions				
HCO ₃	meq L ⁻¹	0.80	1.00	0.20
Cl		8.80	1.20	2.60
SO ₄		24.51	0.84	26.72
Total CaCO ₃	%	11.81	15.45	18.00
CEC	C mol Kg ⁻¹ soil	21.78	8.58	9.56
Organic matter	%	0.12	0.12	0.50
Available P	mg kg ⁻¹ soil	44.80	4.90	19.70
Available K	mg kg ⁻¹ soil	327.65	121.24	228.45

Table 2. Determined properties of potassium humate used

Parameters	Unit	Value
pH (1:2.5 KH: water)		9.80
EC	dSm ⁻¹	0.28
OM	%	74.00
Total C	%	42.92
Total N	%	3.81
C/N ratio		11.27
Total P	mg kg ⁻¹	Nil
Total K	%	8.75

*pH was determined in solution

analysis for a variance for a split-plot design using the Info Stat computer software (Version, 2012). The differences among treatment means were compared by LSD.

3. RESULTS AND DISCUSSION

3.1 Soil pH

Results in Fig. 1 illustrated that the application of potassium humate (KH) and micronic sulfur (MS) to the used soils caused a significant decrease in soil pH. The decline in soil pH values increases with increasing application rates of amendments. Moreover, there were significant differences between the application rates of micronic sulfur (MS) compared to the application rates of potassium humate (KH) on the low incubated soil pH.

The significant decreases within soil pH of soil A, B and C as a result of MS are more than the KH application. These decrements rate in soil pH values of soil A, B and C after the addition of 1% MS were 7.80, 7.53 and 7.56 respectively while pH values were 8.44, 8.71 and 9.92 with the soils without added the amendments (control) of soils A, B and C respectively. Also, the decreasing in pH values of soils A, B and C after the addition of 1% KH were 8.31, 8.92 and 7.90 respectively. These decrements in soil pH as a result of MS application were a result of S oxidation to sulfuric acid and decomposition of KH to organic acids because the addition of MS and KH respectively by the soil microorganisms. These reductions in soil pH values were due to the presence of a sufficient number of microorganisms in the soils because that these soils were cultivated before experiment procedure or the used amendments were improve the environment for microbial growth in the soil. These results were supported by Badawy et al. [13]. Similar conclusions were reported by Hammad et al. [14] who found that elemental S is oxidized by microorganisms in soil to sulfuric acid which reduces soil pH.

3.2 Soil EC

Data in Fig. 2 showed that, there are significant increases of the applications rates of MS and KH of EC 1:2.5 soil: water extract of the three soils under study (A, B and C) at the end of the incubation period. Generally, increasing the applications rates of KH and MS led to a non-significant increase in the soil EC values in all investigated soils. In regard to the effect of application rates of MS was have a highest effect

on the increase soil EC compare with of the same application rates of KH for soil B. It may be due to that, sulfuric acid produced from S oxidation led to reduce the soil pH that due to dissolve some insoluble salts. While, the highest increase of soil EC was due to addition MS compare with KH for soil C at all addition levels.

The results in Fig. 2 showed that using 1% of KH resulted in an increases of EC values in soils A, B and C upto 3.57, 0.27 and 2.54 dSm^{-1} and these values with 1% of MS were 3.73, 1.55 and 2.53 dSm^{-1} compared with control treatment (without amendments) which was 3.22, 0.17 and 2.37 dSm^{-1} respectively. It was noteworthy that the soil which has high initial salinity such as soil A shows a minimum change in salt concentration. These results may be due to the low activity of microorganisms caused by the high salt concentration, followed by a low rate of KH and MS decomposition and oxidation of KH and MS respectively in highly saline soils. The acids produced from the oxidation of micronic sulfur and the decomposition of potassium humate led to the dissolution of some insoluble salts in the soil which lead to increasing values of soil EC. Similar conclusion was reported by Cottenie et al. [11]. In this respect, [15] reported that the EC values of soil extract were increased with increasing both level of S application and the incubation period. Similar results were reported by Atia [16] and Velarde et al. [17].

3.3 Exchange Na

The results in (Fig. 3a and b) showed that, the applications of potassium humate (KH) and micronic sulfur (MS) led to more significant increase the exchange sodium (EX Na) in the used soils (A, B and C) at end of the incubation period. Except the treatment of 1% MS which resulted in a high effect on increasing EX Na compare with application rates of MS for soils B and C. While, the highest increasing of EX Na was due to addition MS compared with KH for soil A at all addition reates.

Fig. 3b illustrated that the highest percentage changes of EX Na related to control treatment were 95.44, 166.51 and 324.14% with application rates 0.25, 0.5 and 1% of KH of soil B. While were 25.96, 52.39 and 120.50% with application rates 0.25, 0.5 and 1% from MS of soil B. These high changes in % of EX Na of soil B may be due to the increase in the activity of microorganisms due to a decrease the salts concentration in this soil before experiment procedure, as in Table 1,

followed by an increase in the rate of oxidation of MS and the decomposition of KH, which increases EX Na. Similar results found by El-Kholy et al. [18] on the effect the application of sulfur on Egyptian soils.

The results in Fig. 3a showed that by using 1% of KH increases of EX Na in soils A, B and C were 150.89, 18.62 and 37.97 and by using 1% of MS were 147.55, 9.68 and 24.56 compare with control treatment (without amendments) were 140.63, 4.39 and 20.27 respectively.

3.4 Available Potassium (K)

The results in (Figs. 4a and b) showed that available – K extracted from investigated soils treated with potassium humate (KH) and micronic sulfur (MS) application rates are progressively and significantly increased.

Moreover, the highest increases of available – K was found with the applications of potassium humate because its contain on potassium 8.75% as (Table 2).

The increases in the percentage changes (%) of available – K at the rate 1% of KH for soils A, B and C were 43.39, 109.53 and 61.22% respectively, while, the percentage changes of available – k at the rate 1% from MS were 8.17, 12.04 and 13.39% for soils A, B and C respectively, compared to the control treatment. This result was expected because it is known ordinary that the soil's content of high calcium carbonate as soils B and C relatively high content of K-bearing minerals in the primary form such as mica, orthoclase. In this respect, [16] studied the efficiency supplying of K in soils contains on calcium carbonate and found that

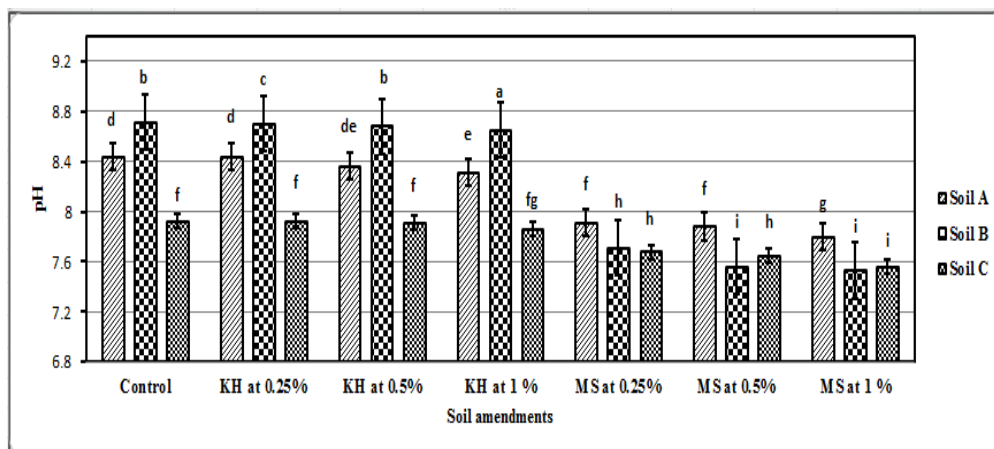


Fig. 1. Effect of soil amendments (KH and MS) at different rates on soil pH of the incubated soils

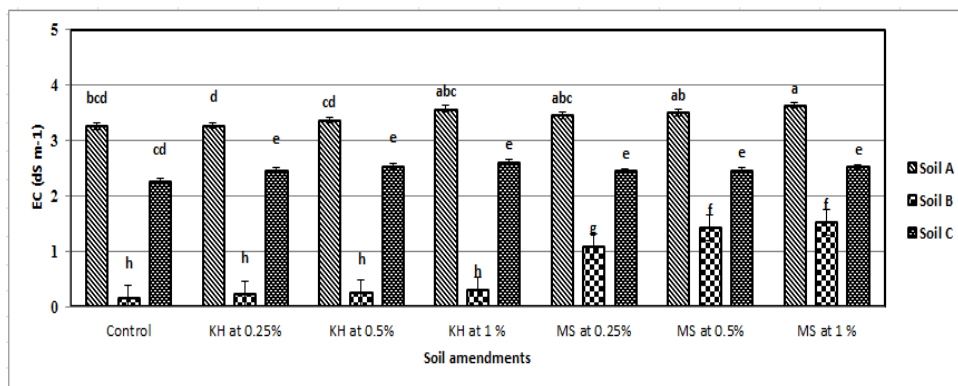


Fig. 2. Effect of soil amendments (KH and MS) at different rates on soil EC of the incubated soils

high amounts of K were obtained from the sandy calcareous soils. Similar conclusion reported by Eriksen [19] stated that sulfur application significantly increased exchangeable K in calcareous soil. They added that such effects may be due to the effect of transformation of S to

sulfuric acid and its substantial effect on dissolution of primary K bearing minerals. Additional conclusion was reported by El-Ghanam et al. [20] who found that sulfur application rates had significant effect on available K and P in the amended soils.

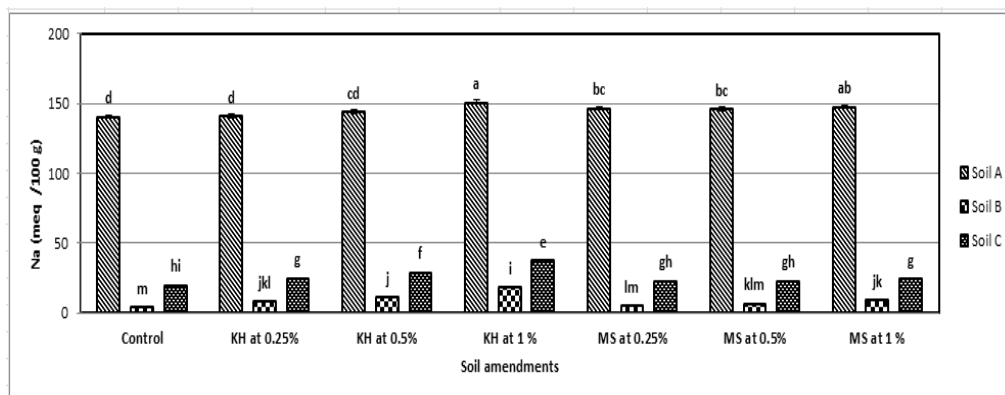


Fig. 3a. Effect of soil amendments (KH and MS) at different rates on exchange sodium (meq/100 g) of the incubated soils

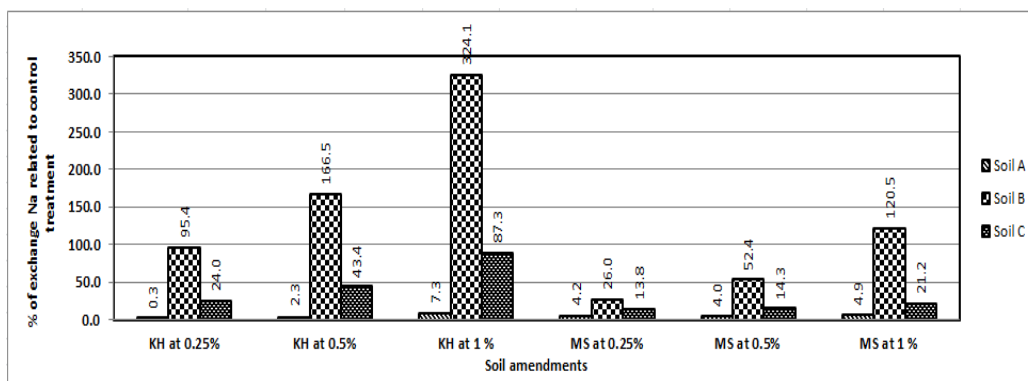


Fig. 3b. The percentage change of exchange Na related to control treatment

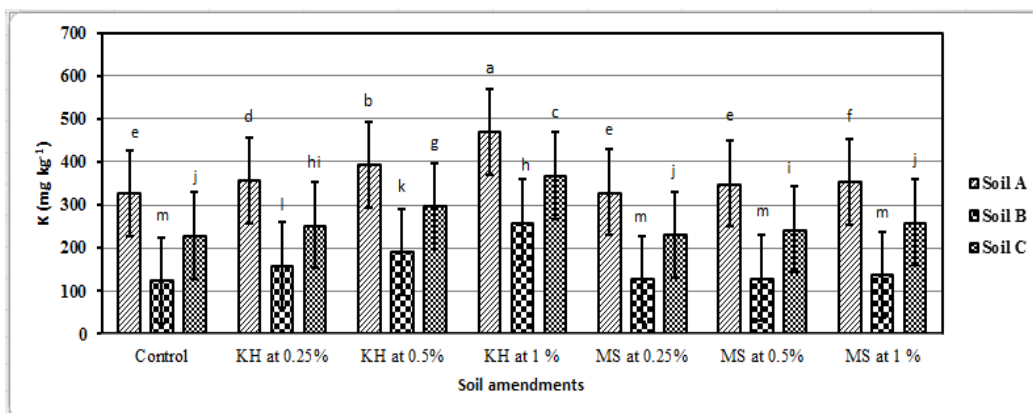


Fig. 4a. Effect of soil amendments (KH and MS) at different rates on available K (mg/100g soil) of the incubated soils

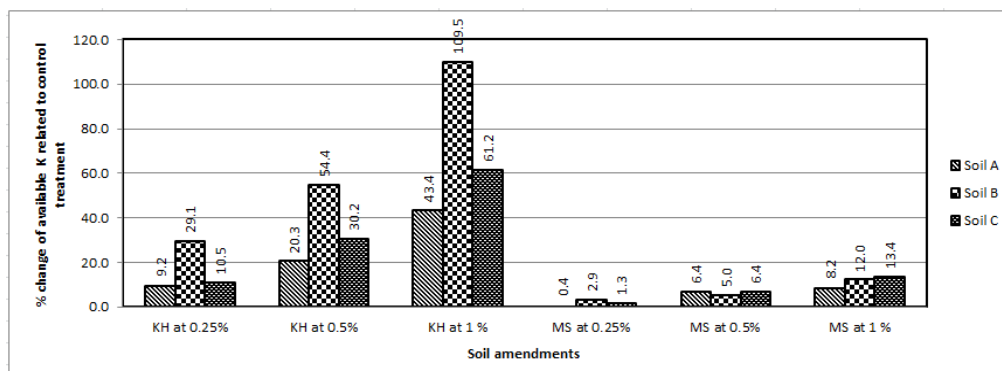


Fig. 4b. The percentage changes of available K related to control treatment

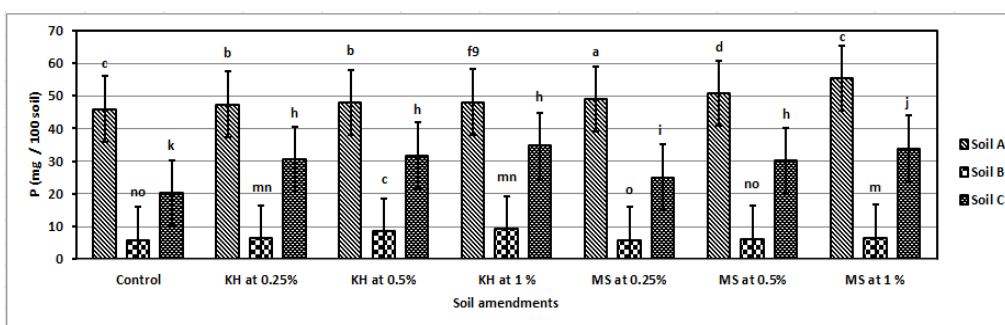


Fig. 5a. Effect of soil amendments (KH and MS) at different rates on available - P (mg / 100 g soil) of the incubated soils

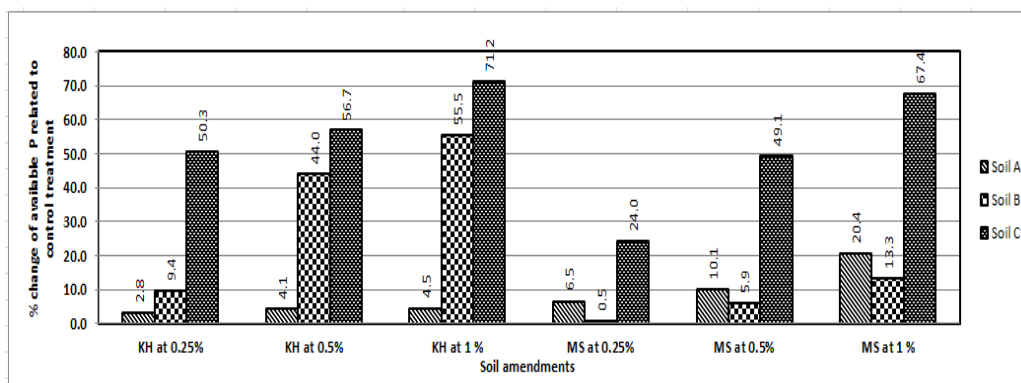


Fig. 5b. The percentage changes of available P related to control treatment

3.5 Available P

Results in (Figs. 5a and b) summarize the effect of different amendments and application rates of potassium humate (KH) and micronic sulfur (MS) on the availability of phosphorus in the investigated soils at the end of the incubation period. The amounts of NaHCO₃ extractable phosphorus increase with increasing KH and MS applications rates from 0 up to 1%. As there were

significant differences for the amendment and non-significant types of soil types used at the 5% level of significance. This may be due to the decrease in soil pH due to the decomposition of humate and the oxidation of S production of under the different application rates of KH and MS treatments. Organic acids and sulfuric acid produced from KH and MS respectively by soil microorganisms and consequently increases the available P.

The highest content of available P was 55.42 mg / 100 g soil with application rate 1% in soil A. Also, Data in Fig. 5b showed that the percentage of available P was increased with the addition of KH in soil B and C but was increased with the addition of MD in soil A. The percentage changes of available-P were ranged between 2.8 to 4.4%, 9.4 to 55.4% and 50.3 to 71.2% with the treatments of KH in soils A, B and C respectively. But these percentage changes of available-P was ranged between 6.4 to 20.6%, 0.5 to 13.2% and 24.0 to 67.4% with added of MS in soils A, B and C respectively. These increments in the percentage changes of available -P relative to soils B and C may be due to that part of the calcium ions combined with the insoluble phosphate anion interacts with sulfate ions resulting from sulfur oxidation or organic acids resulting from the decomposition of potassium humate, which frees part of the phosphorous. Similar results were obtained by Jalilehv and Sulfur [21] who found that, the availability of phosphate was higher in calcareous saline soil than the other calcareous soils. These results also revealed that the chemically available P was clearly increased by increasing S application rates may be due to the decrease in soil pH as aforementioned due to humate decomposition and S oxidation and the production of organic acids and sulfuric acid respectively, by soil microorganisms. The results in Fig. 5a. also show that the increase of KH and MS applications from 0.25% to 1% progressively increases the extractable – P for all soil samples at the end of incubation period. These results stand in a good agreement with that obtained by El-Kholy et al. [18] who found that the amount of P extracted increased progressively by increasing the application rates of sulfur. They added that the increased S rates resulted in increased levels of soluble SO_4^{2-} , followed by lower soil pH. This, in turn, would increase the extractability of P and its availability to plants. Similar finding was reported by Abdel-Fattah et al. [15] who found that the availability of P increased with increasing S application rates.

4. CONCLUSION

Application of micronic sulfur (MS) and potassium humate (KH) gave a different effect on chemical soil properties as soil pH, soil EC, exchange-Na and availability of K and P. The MS application lowered soil pH values compared to KH application. The MS and KH application rates caused in increasing exchange-Na and availability of K and P compare with control

treatments in different amounts for three different soil types. Furthermore, the percentage of recovery of available-K and P was higher with KH applications compared to MS applications. It could be recommended that the MS and KH applications caused the improvement of several soil properties. These results confirms that usage of 1% micronutrient sulfur (MS) and 1% potassium humate as ameliorant agent could recommend to improve the chemical properties of the soils.

ACKNOWLEDGEMENT

The authors would largely acknowledge my dear Professor El-Huseiny Abou-Hussein, for his support in all my research and the Faculty of Agriculture and Natural Resources, Aswan University, to provide its energies to complete this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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