



## Soil Science and Agricultural Engineering

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## EFFECT OF SOME SOIL AMENDMENTS ON YIELD AND NUTRIENT UPTAKE BY MAIZE PLANTS GROWN ON SANDY SOILS

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Received: 31/05/2021; Accepted: 24/06/2021

**ABSTRACT:** A field experiment was carried out during 2018 growing season in Ismailia Governorate, Egypt. The experiment aimed to study the effect of different sources from sediment *i.e.*, Nasser Lake (NLS) and El Shabab Canal (ECS) solely or in combination with natural fertilizers *i.e.*, rock phosphate (RP) and potassium feldspar (KF) + vermicompost (Ver) on availability of P and K, yield and nutrient uptake by maize plants under sandy soil conditions. Application of Nasser Lake sediment mixed with RP+ KF in the presence of Ver. gave the highest values of stover, grains, ear yield, biological yield and N,P and K-uptake by maize plants compared to different treatments. The application of nature fertilizers *i.e.*, RP, KF and RP+ KF to Nasser Lake sediment and El Shabab Canal sediment increased available P and K in soil after harvest as compared to the untreated ones under application of vermicompost.

**Key words:** Sediment, K-feldspar, rock phosphate, vermicompost, maize.

### INTRODUCTION

Nasser Lake is the major freshwater body supplying Egypt with water used for domestic, agricultural, and industrial use, particularly as drinking water in addition to generating electricity and furthermore fish production and leisure activities (ElKobtan *et al.*, 2016). However, the deposited material in Nasser Lake has resulted in delta formation and affects the useful life of the reservoir (life storage). Increasing pressure from population growth and poverty in Egypt necessitate the importance of searching any development opportunity to decrease poverty (El-Kobtan, 2007). This research project is directed towards carrying out a preliminary technical and economical investigation for the suitability of using Nasser Lake sediment in amendment of agricultural land. Using sediment in agriculture has a great potential to meet the needs of organic matter and nutrient in soil. The organic matter in the applied sediment enhances the soil's structure by reducing plasticity, bulk density, improving granulation, increasing porosity and water-holding capacity (Merwad, 2009). In addition, sediment provides nutrient,

increasing cation exchange capacity. Certain trace elements are essential in plant nutrition (micronutrients). Trace element uptake by roots depends on both soil and plant factors (e.g., source and chemical form of elements in soil, pH value, organic matter, plant species, and plant age). However, plants growing in a polluted environment can accumulate trace elements at high concentrations causing a serious risk to human health when plant base food-stuffs are consumed (Mikkelsen, 2008) and have heightened public concern. Soil conditioning means improving the soil physical conditions, particularly for agricultural and forestry purposes by using small amounts of synthetic or natural product in order to optimize the effect of air, water and heat movement (Merwad, 2017). Conditioning sandy soils became a necessity to increase agricultural production and to overcome the deficiency in food requirements (Zhang *et al.*, 2020). Several materials (natural and synthetic) were used to improve properties of soils in Egypt. The addition of Nile mud was one of the techniques that based on using natural materials to improve sandy soil properties in Egypt (Merwad, 2017).

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The addition of bentonite, used as soil conditioner, can promote sandy soil macro-aggregate formation, moisture content retention and increase soil nutrient concentrations. However, there is limited knowledge about how bentonite influences soil microbial communities and interconnections among community members associated with crops, such as maize in continuous production on sandy soils (**Zhang *et al.*, 2020**). Application of the organic matter to the sandy soils has the same effect as application of the Nile mud. It improves the physical properties and decreases the loss of applied water and nutrients. However, organic matter is usually decomposed and has to be added frequently (**El-Nahas *et al.*, 2019**).

Vermicompost is described as an excellent soil amendment and a bio-control agent which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. Vermicompost is “ideal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment (**Joshi *et al.*, 2014 and 2015**). Vermicompost has higher nutritional value than traditional composts. This is due to increased rate of mineralization and degree of humification by the action of earthworms” (**Dastmozd *et al.*, 2015**). Vermicompost has high porosity, aeration, drainage, and water-holding capacity. Nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost (**Papathanasiou *et al.*, 2012**). The application of vermicompost gave the highest marketable yield of tomato (**Mathivanan *et al.*, 2013**), yield of lettuce (**Sandoval *et al.*, 2015**) and net yield of *Amaranthus* species (**Uma and Malathi 2009**). “All the growth, yield and quality parameters in vermicompost treatments varied significantly from control though differences within various vermicompost treatments were not found to be significant” (**Joshi *et al.*, 2015**).

Potassium is one of the essential nutrients for plant growth. Potassium in a given soil is a reflection of the parent material of the soil (**El-Nahas *et al.*, 2019**). To increase the efficiency of fertilizers used in crop production, it is important to understand the relationships between soil nutrient reserves, soil texture and root growth. As a major constituent within all living cells, potassium is an essential nutrient and is required in large amounts by plants as its

content in plant biomass is the second after nitrogen (**Römheld and Kirkby, 2010**).

Soil potassium content is a limiting factor for wheat growth, as it is one of the most important major elements for plant growth. Optimizing the use of K fertilization using natural amendments is growing up in parallel with accelerating increase in fertilizer prices. Feldspars are main source for K and are in many sedimentary rocks (**Wahba and Darwish, 2008; Hemasheene *et al.*, 2017**). Phosphate solubilizing microorganisms (PSM) have attracted the researchers to exploit their potential to utilize phosphate reserves in semiarid regions and to enhance the crop yields (**Khan *et al.*, 2018**). Phosphate solubilizing microorganisms have established their role for optimum growth of plants under nutrient imbalance conditions. Phosphate solubilizers are economical, ecofriendly and have greater agronomic utility to compensate the expensive inorganic sources of P fertilizers (**Gurdeep and Sudhakara, 2015**). Silicate dissolving bacteria (SDB) are an aerobic which play a significant role in maintaining soil fertility by solubilizing in soluble K (**Setiawati and Mutmainnah, 2016**).

The main objective of this research activity is to study the efficiency of sediment combined with rock phosphate and potassium feldspar with or without vermicompost on soil properties, availability nutrient, yield and nutrient uptake of maize and wheat plants under sandy soil conditions.

## MATERIALS AND METHODS

A field experiment was carried out during 2018 growing season in Ismailia Governorate, Egypt, to study the effect of different sources from sediment (Nasser Lake and El Shabab Canal) add solely or in combination with natural fertilizers *i.e.*, rock phosphate (RP) + potassium feldspar (KF) with or without vermicompost (Ver) on nutrient availability, yield and nutrient uptake of maize plants under sandy soil conditions.

Soil samples for the experiment was collected from the surface layers (0-30 cm). The soil was air dried, crushed, sieved to pass through 2 mm plastic screen, thoroughly mixed and stored in plastic bags, for analysis and experimental work. Table 1 shows physical and chemical properties of the soils as determined according to **Piper (1950), Black *et al.* (1965) and Jackson (1973)**.

Table 1. Some physical and chemical properties of the investigated soil and sediment

Characteristic	Soil	Nasser Lake Sediment	El Shabab Canal Sediment
<b>Soil particle distribution</b>			
Sand ,%	93.5	12.6	11.5
Silt,%	4.8	30.2	33.7
Clay,%	1.7	57.2	54.8
Textural class	Sand	Clay	Clay
Field capacity (FC),%	8.7	26.3	22.5
CaCO <sub>3</sub> , (g kg <sup>-1</sup> )	6.1	9.5	7.2
Organic matter,(g kg <sup>-1</sup> )	4.8	12.3	11.5
pH (1: 2.5 suspension in soil and sediment)	7.95	8.01	7.98
EC, (dSm <sup>-1</sup> ) in soil water extract 1:1 and Sediment paste extract	0.60	2.60	2.43
<b>Soluble cations and anions, (mmolc L<sup>-1</sup>)</b>			
Ca <sup>++</sup>	1.67	5.31	4.87
Mg <sup>++</sup>	0.99	5.12	4.78
Na <sup>+</sup>	2.20	3.14	3.05
K <sup>+</sup>	1.14	12.43	11.6
CO <sub>3</sub> <sup>=</sup>	-	-	-
HCO <sub>3</sub> <sup>-</sup>	2.36	9.18	8.54
Cl <sup>-</sup>	2.02	5.67	5.71
SO <sub>4</sub> <sup>=</sup>	1.62	11.15	10.05
<b>Available nutrient , (mg kg<sup>-1</sup>soil )</b>			
N	17.92	45.98	30.20
P	5.43	26.76	19.37
K	60.5	489	352

The experiment was conducted in a complete randomized block design with three replicates. The plot area was 21 m<sup>2</sup> (3 × 7 m), each plot had five rows 60 cm apart and 7 m long. The sediment sampled collected from specific location of Nasser Lake (Aswan Government) and El Shabab Canal which contains high amount of nutrients, organic matter and low concentration of available heavy metals. Before planting, the sediment was dried, grinded and mixed with the surface soil of 15 cm near the top at a rate of 30 Mg ha<sup>-1</sup>. Some characteristics of sediment are shown in Table 2. Potassium feldspar (94 g K kg<sup>-1</sup>) treatments were thoroughly mixed with the soil at a rate of 95 kg K ha<sup>-1</sup>. Rock phosphate (15 g P kg<sup>-1</sup>) was added

at a rate of 30 kg P ha<sup>-1</sup>. Also, the treatments of vermicompost (Ver) were mixed with the soil at a rate of 2.5 Mg ha<sup>-1</sup>. Some characteristics of vermicompost are shown in Table 3. The K-feldspar inoculated with silicate dissolving bacteria, "SDB", (*Bacillus circullans*) in a concentration of (10<sup>10</sup> cells ml<sup>-1</sup>) at rate of 20 ml kg<sup>-1</sup> K- feldspar; mixed with soil before planting and irrigated (Badr *et al.*, 2006). Also, addition *Bacillus megatherium* as activity in phosphorus dissolving bacteria (PDB) in the soil a rate of 2 ml kg<sup>-1</sup> rock phosphate. SDB and PDB were obtained from the Soil Microbiology Unit; Soil, Water and Environments Research Institute of the Agriculture Research Center, Giza, Egypt.

Table 2. Some characteristics of vermicompost

Characteristic	Value
EC, dSm <sup>-1</sup>	2.32
pH	7.65
Organic matter, ( gkg <sup>-1</sup> )	490
Total nutrients ( gkg <sup>-1</sup> )	
N	26.0
P	7.52
K	15.6
C/N ratio	10.93

pH in Vermicompost -water suspension 1: 10; EC in Vermicompost water extract 1: 10

Table 3. Stover and grains yield of maize plants (Mg ha<sup>-1</sup>) as affected by sediment, nature fertilizers and vermicompost under sandy soil conditions.

Sediment source (A)	Nature fertilizer (B)	Stover yield			Grain yield		
		Vermicompost (C)					
		Without	With	Mean	Without	With	Mean
Untreated	Without	8.56	9.02	8.79	3.02	3.23	3.13
	RP	9.32	9.50	9.41	3.52	3.68	3.60
	KF	9.62	9.87	9.75	3.59	3.75	3.67
	RP+ KF	10.2	10.33	10.27	3.82	4.29	4.06
	Mean	9.43	9.68	9.56	3.49	3.74	3.62
NLS	Without	12.33	12.59	12.46	6.20	6.53	6.37
	RP	13.20	13.60	13.40	6.68	6.97	6.83
	KF	14.02	14.47	14.25	7.12	7.36	7.24
	RP+ KF	14.95	16.37	15.66	7.68	8.45	8.07
	Mean	13.63	14.26	13.94	6.92	7.33	7.13
ECS	Without	10.49	10.65	10.57	4.33	4.50	4.42
	RP	11.25	11.47	11.36	4.62	4.70	4.66
	KF	11.52	11.73	11.63	5.32	5.48	5.40
	RP+ KF	11.98	12.02	12.00	5.67	5.92	5.80
	Mean	11.31	11.47	11.39	4.99	5.15	5.07
<b>Mean of B</b>							
	Without	10.46	10.75	10.61	4.52	4.75	4.64
	RP	11.26	11.52	11.39	4.94	5.12	5.03
	KF	11.72	12.02	11.88	5.34	5.53	5.44
	RP+ KF	12.38	12.91	12.64	5.72	6.22	5.98
<b>Mean of Ver (C)</b>		11.45	11.80	11.63	5.13	5.41	5.27
LSD <sub>0.05</sub>	A		0.09			0.05	
	B		0.12			0.04	
	AB		0.07			0.06	
	C		0.03			0.04	
	AC		0.04			0.03	
	BC		0.04			0.03	
	ABC		0.06			0.02	

NLS: Nasser Lake Sediment; ECS: El Shabab Canal Sediment; RP: Rock phosphate ; KF: Potassium feldspar; Ver: Vermicompost

The experiment was cultivated with maize (*Zea mays* L., cv. 2031 hybrid). Mineral nitrogen was added to all plots as ammonium sulphate (205 g N kg<sup>-1</sup>) at the rate of 250 kg N ha<sup>-1</sup> soil at three equal splits, 15 day after planting (DAP) and the second and third doses were added at tillering (45 DAP) and booting (75 DAP) stages, respectively. At harvest, plant samples were separated into stover and grains, dried at 70°C, ground and digested with concentrated mixture of H<sub>2</sub>SO<sub>4</sub>/HClO<sub>4</sub> for chemical analysis (Chapman and Pratt 1961).

In the end of experiment, Soil samples (0-30 cm) were collected from different locations of the experimental site to determine available P and K according to methods devised by Jackson (1973), Piper (1950) and Black (1968).

All of the obtained data such were statistically analyzed (LSD at 0.05) according to the method described by (Russell, 1991). Significant statistical differences among means were compared at P≤0.05 by Duncan's multiple range test. The analysis was implemented statistically by MSTAT C computer software, version 6.303 (Berkeley, CA, USA).

## RESULTS AND DISCUSSION

### Stover, Ear and Grains Yield of Maize Plants (Mg ha<sup>-1</sup>) as Affected by Sediment, Natural Fertilizers and Vermicompost under Sandy Soil Conditions

The data are given in Tables 3 and 4 show the effect of applying sediment, natural fertilizers and vermicompost on stover, grains, ear and biological yield of maize plants (Mg ha<sup>-1</sup>) grown on sandy soil. Application of various sediment *i.e.* NLS and ECS combined with natural fertilizers *i.e.* RP or KF or RP+ KF in the presence of Ver gave increases in stover and grains dry weight of maize plants compared to untreated plants. Application of NLS mixed with RP+ KF in the presence Ver. gave the highest values of stover, grains, ear and biological yield of maize plants compared to different treatments. These results are similar to those of Guo *et al.* (2019) and El-Nahas *et al.* (2019) who mentioned that the highest straw and grain dry weight of wheat were obtained under application of K-sulphate combined with sulphur in the presences of SDB, while the lowest ones were obtained with

untreated soils in absence of soil amendments and SDB.

Regarding the impact of sediment source addition, data indicate that the application of individual NLS or combination with natural fertilizers and Ver gave the higher values of stover and grains yield of maize than ECS application (Zhang *et al.*, 2020). Similar results were obtained by Singh *et al.* (2019) who reported that the application of FYM combined with potassium fertilizers gave the highest values of straw and grain yield of wheat plants in alluvial soil.

As for the average effect of natural fertilizers addition, the data show that using RP+ KF combined with different sediment in the presences of Ver. gave higher values than RP or KF application. This finding stands in well agreement with those of Swetha *et al.* (2017).

Results show that the addition of Ver. increased grains yield compared to the untreated ones. These increases represent 5, 4, 4 and 9% in the case of different for untreated, RP, KF and RP+KF, respectively. These results are in agreement with those of Bader (2006) who found that the application of biofertilization as SDB on plants increased growth parameters and yield. Application of K-feldspar combined with chicken manure in the presence of SDB gave the highest values of dry matter yield of wheat (Merwad, 2017 and El-Nahas *et al.*, 2019). Potassium solubilizing bacteria is an aerobic bacteria which plays a significant role in maintaining soil structure by their contribution in the formation and stabilization of water-stable soil aggregates (Khan *et al.*, 2018; Voelkner *et al.*, 2017; Etesami *et al.*, 2017; Guo *et al.*, 2019).

### Phosphorus and Potassium Uptake (kg ha<sup>-1</sup>) of Maize Plants as Affected by Sediment, Natural Fertilizers and Vermicompost under Sandy Soil Conditions

The data are given in Tables 4 and 5 show the effect of applied sediment sources, natural fertilizers and Ver on P and K-uptake by maize plants grown on sandy soil. Application of various sediment combined with RP or KF as well as RP+KF in the presence of Ver gave increases in P and K-uptake by stover and grains of maize plants as compared to untreated plants.

**Table 4.** Ear yield and biological yield of maize plants ( $\text{Mg ha}^{-1}$ ) as affected by sediment, nature fertilizers and vermicompost under sandy soil conditions

Sediment source (A)	Nature fertilizer (B)	Ear yield			Biological yield		
		Vermicompost (C)					
		Without	With	Mean	Without	With	Mean
Untreated	Without	4.98	5.23	5.11	11.58	12.25	11.92
	RP	5.62	5.92	5.77	12.84	13.18	13.01
	KF	6.01	6.35	6.18	13.21	13.62	13.42
	RP+ KF	6.44	6.53	6.49	14.02	14.62	14.32
	Mean	5.76	6.01	5.89	12.91	13.42	13.17
NLS	Without	8.75	7.95	8.35	18.53	19.12	18.83
	RP	8.45	8.90	8.68	19.88	20.57	20.23
	KF	9.23	9.54	9.39	21.14	21.83	21.49
	RP+ KF	10.25	10.62	10.44	22.63	24.82	23.73
	Mean	9.17	9.25	9.21	20.55	21.59	21.07
ECS	Without	6.76	6.95	6.86	14.82	15.15	14.99
	RP	7.02	7.25	7.14	15.87	16.17	16.02
	KF	7.62	7.87	7.75	16.84	17.21	17.03
	RP+ KF	8.03	8.48	8.26	17.65	17.94	17.80
	Mean	7.35	7.64	7.50	16.30	16.62	16.46
<b>Mean of B</b>							
	Without	6.83	6.71	6.77	14.98	15.51	15.25
	RP	7.03	7.36	7.20	16.20	16.64	16.42
	KF	7.62	7.92	7.77	17.06	17.55	17.31
	RP+ KF	8.24	8.54	8.40	18.10	19.13	18.62
<b>Mean of Ver (C)</b>		7.43	7.63	7.54	16.59	17.21	16.90
<b>LSD</b> <sub>0.05</sub>	A		0.02			0.03	
	B		0.05			0.12	
	AB		0.04			0.09	
	C		0.10			0.08	
	AC		0.09			0.08	
	BC		0.05			0.04	
	ABC		0.11			0.03	

See footnote of Table 3.

Table 5. P-uptake (kg ha<sup>-1</sup>) of maize plants as affected by sediment, nature fertilizers and vermicompost under sandy soil conditions.

Sediment source (A)	Nature fertilizer (B)	Stover			Grain		
		Vermicompost (C)					
		Without	With	Mean	Without	With	Mean
Untreated	Without	9.42	11.73	10.57	3.93	5.17	4.55
	RP	20.50	22.80	21.65	8.80	10.30	9.55
	KF	14.43	15.79	15.11	6.46	7.50	6.98
	RP+ KF	26.52	29.96	28.24	11.08	12.87	11.97
	Mean	17.72	20.07	18.94	7.57	8.96	8.26
NLS	Without	32.06	36.51	34.28	17.36	18.94	18.15
	RP	46.20	51.68	48.94	24.72	27.18	25.95
	KF	40.66	46.30	43.48	21.36	24.29	22.82
	RP+ KF	67.28	85.12	76.20	36.10	49.86	42.98
	Mean	46.55	54.90	50.72	24.89	30.06	27.48
ECS	Without	15.74	18.11	16.92	7.36	8.55	7.96
	RP	29.25	33.26	31.26	12.47	14.10	13.29
	KF	26.50	28.15	27.32	13.30	15.89	14.60
	RP+ KF	47.92	57.70	52.81	23.81	29.60	26.71
	Mean	29.85	34.30	32.07	14.23	17.03	15.64
<b>Mean of B</b>							
	Without	19.07	22.12	20.59	9.55	10.89	10.22
	RP	31.98	35.91	33.95	15.33	17.19	16.26
	KF	27.20	30.08	28.64	13.71	15.89	14.80
	RP+ KF	47.24	57.59	52.42	23.66	30.78	27.22
<b>Mean of Ver (C)</b>		31.37	36.43	33.90	15.56	18.69	17.13
<b>LSD<sub>0.05</sub></b>	A		0.23			0.14	
	B		0.45			0.13	
	AB		0.59			0.23	
	C		0.54			0.17	
	AC		0.72			0.14	
	BC		0.98			0.13	
	ABC		0.78			0.12	

See footnote of Table 3.

Similar results were obtained by **Ortas (2018)** who reported that the addition of K- fertilizer increased straw and grain K- uptake of maize plants. The highest P and K-uptake of maize were obtained under application of NLS combined with RP+KF in the presences of Ver, while the lowest ones were obtained with untreated soils in absence of natural fertilizers and Ver. The application of organic fertilizers in the soil helps in increasing the fertility of the soil as physical condition including its water holding capacity. Organic manures, which were perhaps the main sources of plant nutrients in traditional agriculture, receive less emphasis with the advent of high analysis chemical fertilizers (**Rossini *et al.*, 2018; Singh *et al.*, 2019; Kavinder *et al.*, 2019 and Zhang *et al.*, 2020**). The highest straw and grains P, K-uptake were obtained with K- sulphate or K-feldspar plus sulphur in the presence of SDB (**El-Nahas *et al.*, 2019**).

Regarding the impact of sediment sources addition, data indicate that the application of individual NLS or combination with natural fertilizers and Ver. gave the highest values of stover and grain P and K-uptake than ECS. Similar results were obtained by **Singh *et al.* (2019)** who found the nutrient contents as N, P and K in grain and straw of wheat enhanced significantly with the application of FYM at a rate of 10 Mg ha<sup>-1</sup> and K-sulphate.

Regarding the mean impact of sediment sources addition, the data show that using NLS with Ver. under different natural fertilizes gave highest values than those under ECS. Treatments under NLS gave higher values of grain P and K -uptake than those under NLS. These increases represent 128, 95, 56 and 61% of P-uptake for the treatments of without, RP, KF and RP+KF respectively, while the increases represent 51, 56, 44 and 54% of K-uptake for the same treatments, respectively. Similar results were obtained by **Ortas (2018), Jamal and Fawad (2018) and El-Akhdar *et al.* (2018)**. Application of K-feldspar combined with chicken manure in the presence of SDB gave the highest K-uptake of wheat (**Merwad, 2017**).

As for the average effect of natural fertilizers addition, the data show that using RP+ KF combined with different sediment sources in the presence of Ver gave highest values of P and K-

uptake than individual RP or KF application. This finding stands in well agreement with those of **Abdel-Salam and Shams (2012), Swetha *et al.* (2017) and Singh *et al.* (2019)**.

Data also showed that the application of Ver. to NLS or ECS increased stover and grain K-uptake of maize compared to the untreated ones under application of different natural fertilizers (Table 6). These increases represent 15, 13 and 17% of stover for the treatments of untreated, NLS and ECS, respectively and 20, 24 and 20% of grains for the same treatments, respectively. These results are in agreement with those of **Sheng and Huang (2002), Zhao *et al.* (2017) and El-Nahas *et al.* (2019)**. This increasing was due to the fact that SDB releases organic acids which solubilize the insoluble rock K materials (**Abou-El-Seoud and Abdel-Megeed, 2012**). Similarly, **Badr *et al.* (2006)** found that potassium uptake improved markedly with inoculation of bacteria in the tested soils compared to corresponding controls. Silicate Dissolving Bacteria play an important role in the formation of humus in the soil, the cycling of other minerals tied up in organic matter (**Dawwam *et al.*, 2013; Magare *et al.*, 2018**). The application of 50% K-sulphate + 50% K- feldspar combined with SDB gave the greatest values of K-uptake stover and seeds of maize plants (**Merwad, 2016**). **Abd El-Hakeem and Fekry (2014)** stated that the application of potassium sulphate plus K- feldspar with SDB increased K-uptake of tuber potato. **Badr *et al.* (2006)** found that K-uptake of sorghum plants inoculated with silicate dissolving bacteria and supplied with minerals (feldspar and rock phosphate) increased by 48%, 65% and 58% for clay, sandy and calcareous soil, respectively, compared to the plants supplied with minerals alone. **Hellal *et al.* (2009)** reported that the application of organic amendments with feldspar gave the highest values of K-uptake by faba bean plants. Application of K-sulphate plus K-feldspar with SDF increased quality potato tubers, total yield and NPK uptake in tubers and shoots by potato plants (**Labib *et al.*, 2012**). Potassium solubilizing bacteria is an aerobic bacteria which plays a significant role in maintaining soil structure by their contribution in the formation and stabilization of water-stable soil aggregates (**Etesami *et al.*, 2017; Voelkner *et al.*, 2017**).



Table 6. Potassium uptake ( $\text{kg ha}^{-1}$ ) of maize plants as affected by sediment, nature fertilizers and vermicompost under sandy soil conditions

Sediment source (A)	Nature fertilizer (B)	Stover			Grain		
		Vermicompost (C)					
		Without	With	Mean	Without	With	Mean
Untreated	Without	70.19	89.30	79.75	26.58	32.95	29.76
	RP	96	117	106	37.31	46.00	41.66
	KF	131	144	137	50.26	57.38	53.82
	RP+ KF	165	181	173	63.03	76.36	69.70
	Mean	116	133	124	44.30	53.17	48.74
NLS	Without	143	159	151	72.54	84.89	78.72
	RP	178	215	197	90.85	112	101
	KF	245	287	266	126	147	137
	RP+ KF	302	396	349	157	214	186
	Mean	217	264	241	112	139	126
ECS	Without	107	128	117	48.06	56.25	52.16
	RP	143	166	155	59.14	70.50	64.82
	KF	188	211	199	89.38	101.38	95.38
	RP+ KF	222	264	243	106	137	121
	Mean	165	192	178	75.65	91.28	83.34
<b>Mean of B</b>							
	Without	107	125	116	49.06	58.03	53.55
	RP	139	166	153	62.43	76.17	69.16
	KF	188	214	201	88.55	101.92	95.40
	RP+ KF	230	280	255	109	142	109
<b>Mean of Ver (C)</b>		166	196	181	77.26	94.53	81.78
<b>LSD</b> <sub>0.05</sub>	A		1.23			1.18	
	B		1.04			1.12	
	AB		1.02			1.07	
	C		1.05			1.02	
	AC		0.98			1.03	
	BC		0.75			0.89	
	ABC		1.01			0.67	

See footnote of Table 3.

### Available Phosphorus and Potassium ( $\text{mg kg}^{-1}$ ) as Affected By Sediment, Natural Fertilizers and Vermicompost under Sandy Soil Conditions

Under investigation, the values of available phosphorus and potassium ( $\text{mg kg}^{-1}$ ) as affected by the application of different sediment sources (NLS and ECS) and natural fertilizers (RP or KF and RP+KF) in the presences of Ver are illustrated in Fig. 1. The treatments of NLS combined with RP+KF with Ver gave the highest values of available P and K (28.98 and 145  $\text{mg kg}^{-1}$ , respectively), while the lowest ones (13.75 and 78.09  $\text{mg kg}^{-1}$ , respectively) were found with untreated soil. These results are in agreement with those obtained by **Mahmoud and Ibrahim (2012)**, **Merwad (2017)**, **Merwad and Khalil (2018)**, **Guo *et al.* (2019)** and **Zhang *et al.* (2020)** who indicated that the highest values of available potassium occurred with K- sulphate treatments followed by K-feldspar and without application of potassium fertilizers. **Wahba and Darwish (2008)** found that the addition of both compost and feldspar individually or together increased available potassium in sandy and calcareous soils compared to control.

Data showed that the application of nature fertilizers *i.e.*, RP, KF and RP+ KF to NLS and ECS increased available P and K in sandy soil compared to the untreated ones under application Ver. These increases represent 14, 10 and 10%, respectively of available P for the treatments of LNS and 16, 8 and 20%, respectively for ECS treatments, while the increases represent 3, 7 and 16 % of available K for the same treatments of NLS, respectively and 11, 22 and 29%, respectively for ECS. These results are in agreement with those of **El-Akhdar *et al.* (2018)**. The promotive effect of different natural fertilizers on available phosphorus and potassium in sandy soil may follow the order: RP+KS> KS> RP> without under the application of NLS and ECS in the presence or absence of Ver. The favourable effect of different sediment with natural fertilizers on nutrient content is mainly due to the positive effect of this material on increasing the available moisture content and hence increasing the availability of nutrients in the soil solution (**Adnan *et al.*, 2016**; **Setiawati and**

**Mutmainnah, 2016**). Soil amendments are soil improving agents. The application of such amendments *i.e.* sediment could improve the retentive capacity of sandy soil for water and fertilization nutrients and also may help in improving the unfavorable structure and in increasing nutrients availability in soil (**Tian *et al.*, 2017**; **Voelkner, 2017 and Singh *et al.*, 2019 and Barczak *et al.*, 2019**).

As a general result, the available phosphorus and potassium was clearly increased after harvest at all treatments of any sediment sources application and natural fertilizers with vermicompost. These increases may be due the microbial activity which has the ability to affect soil reaction in the soil microenvironment leading to solubilizing mineral potassium and phosphorus. This finding is in agreement with that obtained by **Hemasheenee *et al.*, 2017**; **Kavinder *et al.*, 2019**; **Hellal *et al.* (2009)** and **Badr *et al.* (2006)** who found that the available potassium was remarkably increased after 150 days at harvest stage. The increased in the available potassium level after harvest may be due to the mineralization of organic amendments and solubilizing action of certain organic acids produced during manure decomposition as well as the significant effect of microbial activities and role of SDB. The highest values of release potassium was consistent up the end of composting process (feldspar +compost + SDB) after 90 days of incubation. Natural bentonite is mainly composed of 2:1 clay mineral montmorillonite (**Benkhelifa *et al.*, 2008**), which has a high cation exchange capacity (CEC) and water holding capability (**Dastmozd *et al.*, 2015**; **Mishra *et al.*, 2001**). Incorporation of bentonite in soil can improve the overall agronomic quality of sandy soils (**Khan *et al.*, 2018**) by increasing soil water retention capacity (**Suzuki *et al.*, 2007**; **Lazányi, 2005**), soil aggregate stability (**Khan *et al.*, 2018 and Suzuki *et al.*, 2007**) and CEC (**Churchman *et al.*, 2014**).

### Conclusion

There were positive significant effects of different sources from sediment (Nasser Lake and El Shabab Canal) and natural fertilizers *i.e.*, rock phosphate and potassium feldspar with or without vermicompost on availability of P and K, yield and nutrient uptake by maize plants

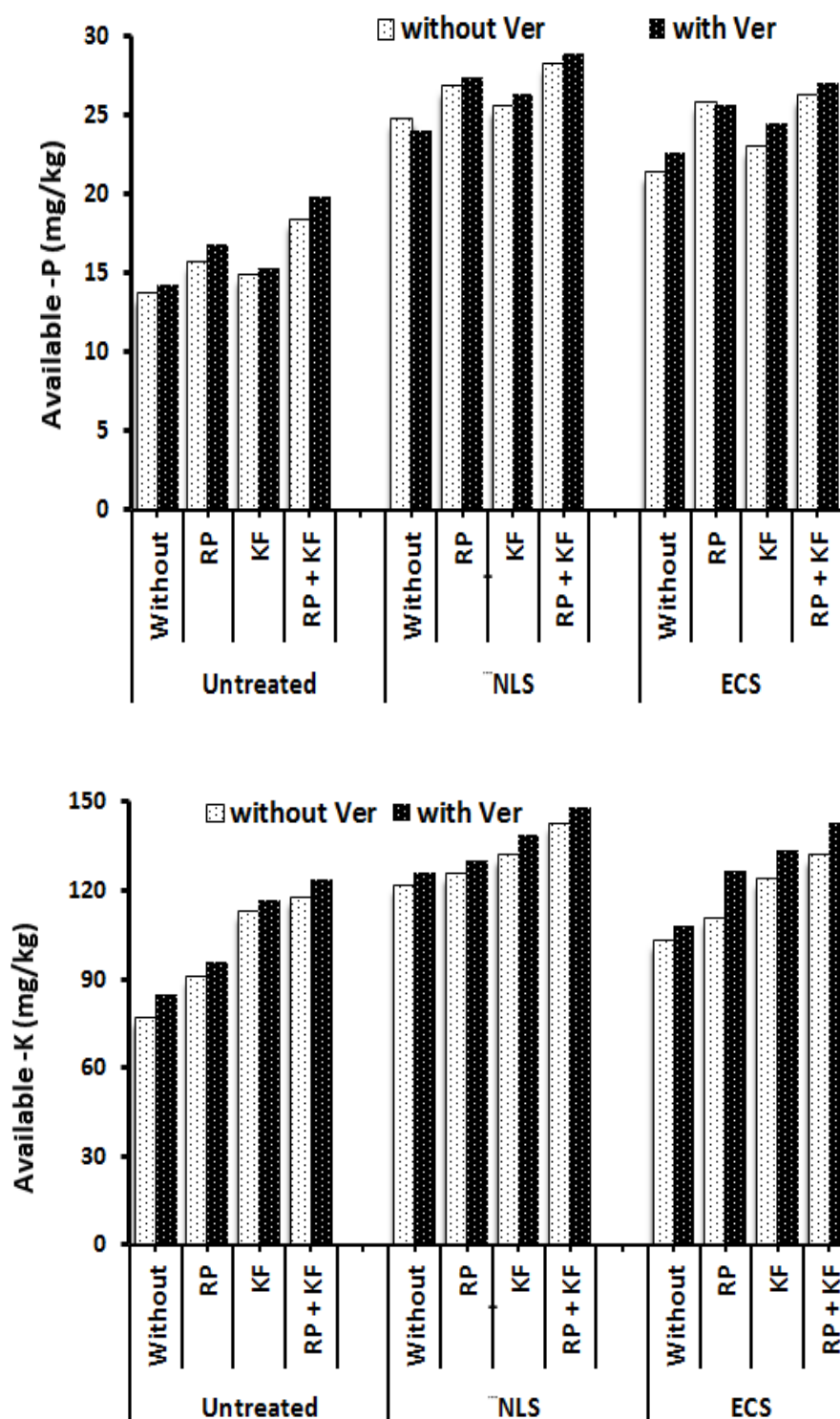


Fig. 1. Available phosphorus and potassium ( $\text{mg kg}^{-1}$ ) as affected by different sediment sources, nature fertilizers and vermicompost in sandy soil conditions

under sandy soil conditions. The application of nature fertilizers *i.e.*, RP, KF and RP+ KF to NLS and ECS in the presence of vermicompost increased yield and NPK-uptake by maize plants and available P and K in the soil after harvest as compared to the untreated ones. From economic point of view, this approach of using different sources of sediment and the naturally deposited materials (Rock phosphate and K-feldspar) instead of chemical fertilizers or combination with them will be very beneficial for the farmers who subsidize the costs of chemical fertilizers.

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## تأثير بعض مصلحات التربة على المحصول والعناصر الممتصة بواسطة نباتات الذرة النامية في الأراضي الرملية

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أجريت تجربة حقلية في موسم الزراعة 2018م في محافظة الإسماعيلية، مصر. تهدف التجربة لدراسة مصادر مختلفة من الرواسب (بحيرة ناصر- ترعة الشباب) منفرداً أو مخلوطة مع الأسمدة الطبيعية مثل صخر الفوسفات و الفلسبار البوتاسي في وجود الفيرمي كمبوست على المحصول والعناصر الممتصة بواسطة نباتات الذرة تحت ظروف الأراضي الرملية وكذلك على تيسر الفوسفور والبوتاسيوم بالتربة بعد الحصاد. إضافة راسب بحيرة ناصر مخلوطة مع صخر الفوسفات والفلسبار البوتاسي في وجود الفيرمي كمبوست أعطت أعلى قيم في محصول الكيزان والحطب والحبوب والمحصول البيولوجي وكذلك النيتروجين والفوسفور والبوتاسيوم الممتص بواسطة نباتات الذرة مقارنة بالمعاملات الأخرى. إضافة الأسمدة الطبيعية مثل صخر الفوسفات أو الفلسبار البوتاسي أو صخر الفوسفات+ الفلسبار البوتاسي في وجود الفيرمي كمبوست أدت لزيادة الفوسفور والبوتاسيوم الميسر في الأرض الرملية مقارنة بغير المعاملة (الكنترول).

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