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Reducing Import of Potash Fertilizer in Egypt by Using Glauconite Deposits as an Indigenous Alternative Source of Potassium

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Abstract

Egypt is an agrarian economy and as such requires fertile soils for attaining and maintaining the self-sufficiency in food production. Potassium fertilizers are playing an important role in plant production. There is practically no production of K in the country. Egypt is dependent on imports to meet its annual requirements of K. In order to reduce the dependence on imported K, glauconite as à K mineral, has been identified as an indigenous alternative source of K. In Egypt, huge resources of glauconite are found in many localities in the Western Desert, New valley Governorate. Pot experiment was carried out in Soil Sci. Dept., Faculty of Agric., Minia Univ., Alminia, Egypt. To evaluate the glauconite as a natural alternative source for potassium. Gluaconite deposits were collected from Al-Bahria Oasis, New valley, Egypt. In this experiment, corn grains were planted to study the effect of glauconite on growth, water use, and N, P and K uptake. Glauconite was applied to the sandy soil at six rates (0, 5, 10, 15, 20, and 25 Mgha^{-1}), Additional treatment was involved in this experiment including the recommended K fertilizer for comparison. In general, treating the sandy soil with the different application rates of glauconite increased the vegetative growth parameters (plant height, fresh and dry weights), water use efficiency and uptake of N, P, and K by corn plant grown in the treated sandy soil, compared with the untreated control. The increase in almost the studied parameters, was proportional to the increase in the application rate of glauconite up to 15 Mgha^{-1}. It could be concluded that it is possible using the glauconite at application rate of 15 Mgha^{-1} as an alternative source of potassium in sandy soils in Egypt. Glauconite application in the field is economic as well as eco-friendly as there is no losses of nutrients from this mineral and its price is cheaper than the imported potash.

Keywords: Sandy soil; Glauconite; Potasstum; Corn; Potash import

Introduction

Egypt is dependent on imports of potash fertilizers to meet its annual requirements. In order to reduce the dependence on imported potash fertilizers, Glauconite (à potash mineral) has been identified as an indigenous alternative source of potash [1]. Glauconite is a naturally occurring mineral mined from ocean sedimentary rock known as "greensand". It is often an olive-green colored sandstone rock found in layers in many sedimentary rock formations. The major chemical description of glauconite is $((K, Na)(Fe^{+3}, Al, Mg)_2(Si, Al)_4O_{10}(OH)_2)$. Greensand deposits are found all over the world. The pH of the glauconite varies from slightly acidic to slightly alkaline depending on the source and has little effect of soils [2]. Glauconite is the name given to a group of naturally occurring iron potassium phyllosilicat mineral (mica group), green in color, very low weathering resistance and very friable composed of pellets or grains [3].

In Egypt, according to the thickness of the overlying glauconite sediments varies from up to 25 m in the Western and Eastern Wadis areas to less than 1 m in the high central area, El-Gideda mine of Bahria Oasis [4]. Glauconites occur in the Western Desert associated with phosphorites and iron ores [1]. Bambalov and Sokolov suggested that the glauconite is an improving agent for accelerated cultivation of soils with low fertility and damage in Belarus, United Arab Emirates and Egypt. Petkova et al., Pishmanov and Petkova reported that Lucerne and Wheat can be grown on glauconite-phosphorite substrate without any addition of mineral fertilizers. Many agronomic studies discussed the potential of glauconite as soil additive that gradually release potassium essential for plant growth [5-12]. Glauconite ores can be used instead of K_2SO_4 fertilizer and a base of ecological agriculture because they are not only an alternative of mineral fertilizers but they also can increase soil fertility [13]. The main objective of the present study was to evaluate the impact of the glauconite on growth and water use by corn plants.

Material and Methods

Soil

The soil used in this study was sandy loam in texture and was collected from the newly reclaimed desert land at the Western district of the Nile Valley, West of Samalout, El-Minia Governorate, Egypt. Some analytical data of the studied soil are given in Table 1.

Glauconite deposits

The tested fine glauconite in the current study was collected from Al-Bahria Oasis, New Valley governorate, Egypt and thoroughly mixed. A representative sample was taken and analyzed for the particle size distribution, pH, EC, P, K, Fe, Mn, Zn and Cu. Some analytical data of the tested glauconite are presented in Table 2.

Set up of the pot experiment

The fine glauconite. was applied to the sandy soil at seven rates {0, 5, 10, 15, 20, and 25 Mgha^{-1}, as well as (0+375 kg K_2SO_4.ha^{-1}) for the comparison}. Each treatment was replicated 3 times. Three kg of the air dried treated soil were placed in a plastic pot (14 cm diameter and 20 cm depth). Five grains of corn (Zea mayz) were planted in each pot on 26 July 2014. The corn plants in each pot were thinned and fertilized with N and P at the equivalent rates of 250 kg N and 155 kg P_2O_5.ha^{-1}

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Soil properties		**Value**
Particle size distribution (%)	Coarse sand	41.80
	Fine sand	30.08
	Silt	10.20
	Clay	17.92
Texture		**Sandy loam**
pH (1:2.5)		7.74
CaCO$_3$, gkg^{-1}		128.00
OM, gkg^{-1}		1.50
EC, dSm^{-1} (soil paste extract)		2.73
Soluble cations, mmol / l:		
Na$^+$		3.10
K$^+$		1.10
Ca^{2+}		1.05
Mg^{2+}		0.85
Soluble anions, mmol / l:		
Cl -		4.10
HCO $_{-3}$		0.80
CO $_{2-3}$		
SO $_{2-4}$		1.05
Available P, ppm		16.00
Available K, ppm		237.90
Available Fe, ppm		2.20
Available Mn, ppm		0.50
Available Zn, ppm		0.30
Available Cu, ppm		0.10

Table 1: Some analytical data of the studied soil.

Glauconite properties		**value**
Particle size distribution (%)	Coarse sand	1.05
	Fine sand	1.02
	Silt	7.24
	Clay	90.69
pH (1:2.5)		6.10
Organic Carbon, gkg^{-1}		3.20
EC, dSm^{-1} (soil paste)		17.06
P, ppm		7.00
K$_2$O %		6.20
Fe, ppm		9.80
Mn, ppm		3.10
Zn, ppm		3.00
Cu, ppm		0.50

Table 2: Some analytical data of the tested fine glauconite.

The corn plants were irrigated whenever required every seven days with an amount of water to compensate the loss in moisture which was maintained at the field capacity. At 60 days from the corn planting, the plant height (cm) and water consumptive use by the corn plants (l/pot) were recorded. The corn plants were cut at 2 cm from the soil surface and the fresh weight of the corn shoots (g/pot) was dried at 65°C and the dry weight of the corn shoots (g/pot) was recorded by weighing. Also, the water use efficiency by the corn plants was calculated. The oven dried corn shoots were grinded in a plant mill, passed through a 0.5 mm screen mesh, and a representative sample was taken and analyzed for the total nitrogen, total phosphorus, and total potassium. Analyses of soil, glauconite, and plant tissues were determined according to the standard methods [14-16]. All recorded data were subjected to statistical analysis of variance procedures. Treatments means were compared using the L.S.D. according to Gomez and Gomez in 1984.

Results and Discussion

Effect of applying fine glauconite (FG) to the sandy soil on some vegetative growth parameters and water use by corn plants

Data given in Table 3 reveal that, treating the sandy soil with different application rates of FG generally increased the vegetative growth parameters i.e., plant height, fresh and dry weights of corn plant, compared with the untreated control. The increase in almost all the studied plant growth parameters was proportional to the increase in the application rate of FG up to 15 Mgha^{-1}. However, the plants treated with FG at 20 up to 25 Mgha^{-1}, showed a decrease in terms of their vegetative growth parameters. It appears from the abovementioned results that, application of FG to the sandy soil improved the corn vegetative growth parameters, suggesting the proper increase in the grain and stover yield.

The improvement in growth parameters of corn plants grown in the treated soil with FG may be attributed to the change in soil structure and water regime subsequently, water available to plants was increased also, to the effect of FG as a source of nutrients (Table 2) and that reflected on enhancing soil fertility. However, the decrease in growth parameters of corn plants at 20 or 25 Mgha^{-1} rates, compared to 15 Mgha^{-1}, may be attributed to the negative effect of salts that added to soil with these higher rates of application (EC=17.06 dSm^{-1} for FG). It is clearly shown from Table 3 that the amount of water consumed by the corn plants grown in the FG treated soil were slightly affected, compared with the untreated control. On the other hand, as the water use efficiency refer to the amount of dry plant materials produced by each unit of water, and as the dry matter yield of the corn shoots grown in the treated soil with FG was much higher than the untreated one (Table 3), it could be seen that the water use efficiency was also increased. The highest value of the water use efficiency by the corn plants (1.87 g/L) was obtained with FG application rate of 15 Mgha^{-1} compared with (1.39 g/L) with the control. The increase in water use efficiency due to treating with FG could be attributed to the effect of FG on increasing soil water holding capacity and decreasing water evaporation from soil surface, hence, increasing water available for plants. The increase in water available with improving soil structure helped in improving the plant environment and subsequently producing more plant materials. The improvement in water use efficiency by corn plants implies that application of the tested FG to the sandy soil can rationalize the irrigation water required for growth. Similar observations were corroborated by a number of workers e.g. Prokoshev et al., Mazumder et al., Rao et al., Petkova et al., Akhtar and Jenkinsm, Eid and Morsy.

Nitrogen, phosphorus and potassium concentration and uptake by corn plants grown in the sandy soil

The effectiveness of glauconite as a source of K was assessed by determining the K content and uptake by plants. Data dealing with the effect of the tested FG on concentration and uptake of N, P, and K by corn plants are presented in (Table 4). Careful examination of the data presented in (Table 4) show that the concentration of N in corn shoots was decreased due to the application of FG. The concentration of P displayed no effect, while the K concentration was increased compared to the untreated control. The decrease in N concentration may be due to the dilution effect, as the dry matter was increased with no accompanied increase on N content in soil. The increase in K concentration may be due to the high K content of the added FG (Available K=846 ppm). The highest values of K concentration in the corn plants (3.7%) were obtained when 10 of FG was applied to soil. As can be seen from Table

Fine glauconite treatments (Mgha^{-1})	Plant height, cm	Fresh weight, g/pot	Dry weight, g/pot	Water use	
				Water consumption, L/pot	Water use efficiency, g/L
0	73.8	23.9	7.10	5.1	1.39
5	85.5	31.2	7.91	5.2	1.52
10	86.4	36.0	8.24	5.2	1.58
15	94.0	49. 4	9.92	5.3	1.87
20	91.0	47.8	9.12	5.2	1.75
25	85.0	37.4	8.31	5.2	1.60
R (K)**	88.6	44.2	9.21	5.0	1.84
L.S.D (P< 0.05)	6.86	10.25	1.62	n.s	0.25

* Each value in the table is the mean of three replicates.
** Recommended application of K as K_2SO_4 = 375 kgha^{-1}

Table 3: Effect of fine glauconite on some vegetative growth parameters and water use by corn plants*.

Fine glauconite treatments, Mgha^{-1}	N		P		K|	
	Concentration (%)	Uptake, mg/pot	Concentration (%)	Uptake, mg/pot	Concentration (%)	Uptake, mg/pot
0	*2.47*	*175*	*0.14*	*9.9*	*3.02*	214
5	*2.35*	*187*	*0.13*	*10.2*	*3.40*	268
10	*2.40*	*197*	*0.14*	*11.5*	*3.50*	288
15	*2.25*	*223*	*0.14*	*13.8*	*3.51*	348
20	*2.30*	*209.*	*0.13*	*11.8*	*3.65*	332
25	*2.40*	*199*	*0.14*	*11.6*	*3.70*	307
*R (k)***	*2.30*	*212*	*0.14*	*12.8*	*4.15*	381
L.S.D (P<0.05)	*0.32*	*24.18*	*n.s*	*2.32*	*0.38*	54.33

**Each value in the table is the mean of three replicates.*
*** Recommended value for K as K_2SO_4 = 375 Kgha^{-1}*

Table 4: Effect of using fine glauconite on some nutrient's concentration and uptake in corn plants*.

4, increasing FG rate from 0 to 15 Mgha^{-1} increased N and P uptake by corn plants, compared to the untreated soil. By contrast, as the tested FG rate increased from 15 to 25 Mgha^{-1}, the N and P uptake were gradually decreased. However, K uptake was increased with increasing FG up to 25 Mgha^{-1}. The increase in N, P, and K uptake by the corn plants could be attributed to the increase in nutrients concentration in soil by glauconite application.

Generally, the increase in nutrients uptake may be due to one or more of the following reasons:

1. Presence of high amount of P and K nutrients in soil treated with FG compared with the untreated soil (Tables 1 and 2). This demonstrates that glauconite treatments could provide sufficient K for plants.
2. Plants grown in treated soil gave higher dry weight compared with plants grown in the untreated soil (Table 3).
3. The increase in ion mobility due to the increase in the available water in the studied treated soil.
4. Improvements in soil structure which reflected in increasing water holding capacity and decreasing nutrients losses by leaching.

The comparison between using FG and the recommended amount of K as seen in Tables 3 and 4 indicate that application of FG at the application rate of 15 Mgha^{-1} was more beneficial in enhancing plant growth and water use efficiency than the treatment with the recommended K fertilizer. The same trend was true with the uptake of the tested nutrients, except K. Positive response in plant growth parameters with the increase in the FG application rate, it is expected that uptake of N and P must follow the same trend. The recorded improvements in plant growth, water use efficiency and uptake of N and P by the corn plants may be due to the increase in the amount of available P, K, Fe, Mn, Zn and Cu. Also, to the low release of K from glauconite which lead to a decrease in its leaching compared with the readily soluble and leachable K_2SO_4 fertilizer. This study yielded, identical results to that obtained by Petkova et al. Akhtar and Jenkins, Heckman, Heckman and Tedrow, Eid and Morsy simultaneously.

Conclusion

It could be concluded that it is possible using fine glauconite at application rate of 15 Mgha^{-1} as an alternative and sufficient source of potassium in sandy soils of Egypt. For using fine glauconite as a natural source of potassium nutriment, on a large scale, some future studies, probably with field experiments, are still needed. These studies should include the economic aspects of the application of glauconite.

References

1. Baioumy HM (2007) Iron-phosphorus relationship in the iron and phosphorite ores of Egypt. Chemie der Erde –Geoch mistry 67: 229-239.
2. Abduelgawad G, Page AL, Lund L (1975) Chemical weathering of glauconite. Soil Sci Soc Am J 39: 567-571.
3. Odin G, Letolle R (1980) Glauconitization and phosphatization environments: A tentive comparison. SEPM Special Publication 29: 227-237.

4. El-Aref MM, Elsharkawi MA, Khalil MA (1999) The geology and genesis of stratabound to straitform Cretaceous-Eocene iron ore deposits of El Bahariya Region, Western Desert, Egypt. In GAW 4th International conference on Geol Arab World (GAW4) pp: 450-475.
5. Prokoshev V, Gosudareva Z, Chekin S, Voznesenskaya T (1992) On the problem of the utilization of glauconite sands of the Egorievsk deposit of phosphorites as potassium-phosphorus fertilizers. Agrokhimiya 5: 31-38.
6. Mazumder AK, Sharma T, Rao T (1993) Extraction of potassium from glauconitic sandstone by the roast-leach method. Int J Miner Process 38: 111-123.
7. Rao C, Rao A, Bansal S (1996) Potassium supply and management through non-conventional sources for optimizing K nutrition and crop production. Fertiliser News 41: 33-40.
8. Nosko B (1998) A good use of local resources is the guarantee of an increase in soil fertility in modern practice in the Ukraine. Visnik Agrarnoi Nauki Kiev, Ukraine 11: 5-10.
9. Akhtar M, Jenkins D (1999) Mineralogical charaterization of glauconite sandstone from Chichali formation of Surghar range. Pak J Sci Ind Res 42: 215-219.
10. Griffioen J (2001) Potassium adsorption ratios as an indicator for the fate of agricultural potassium in groundwater. J Hydrol 254: 244-254.
11. Vasiljev AA, Kozhemyakin VS (2007) Glauconites are effective natural mineral fertilizers at potato growing. Potato growing in Russia: Actual problems of science and practice. Materials of the international congress Potato, Moscow, Russia. pp: 158-162.
12. Morsy M, Darwich O, Eldawwy N (2016) Evaluation of glauconite deposits as an amendment for sandy soils, I – Preliminary studies. Minia J of Agric Res & Develop Egypt 36: 343-355.
13. Eid MA (2012) Success usage for the glauconite ores as a natural Egyptian potassium fertilizer source. Egypt J Soil Sci 53: 75-88.
14. Elmer H Wirth (1950) Soil and plant analysis. Inter Science Publisher, New York, USA. pp: 42-110.
15. Page AL, Miller RH, Keeny DR (1982) Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. (2nd edn). American Society of Agronomy. Inc. Soil Sci. Society of American, Inc. publisher, Madison, Wisconsin, USA.
16. Petkova D, Donov D, Stojchev D, Angelov G, Rajchev T, et al. (1998) Nutrient uptake by glauconit-phophorite rock material. Soil Science Agro-chemistry and Ecology 33: 15-17.