Use of saponite-containing basaltic tuffs as a Mg-fertilizer in the cultivation of vegetable crops

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Abstract

Basaltic tuffs in the Republic of Belarus contain the clay mineral saponite, which can be used as an Mg source for crops. We applied a mixture of saponite-containing basaltic tuffs, containing 82 g MgO kg^{-1}, doses of 20 to 80 kg MgO ha^{-1} to improve the cultivation of blue fenugreek, dill, green beans and basil on a Eutric Retisol in a field trial. The yield of all crops increased significantly compared to complete mineral fertilization, so that the tuffs may be used as a natural soil amendment.

Zusammenfassung

Basaltische Tuffe in der Republik Belarus enthalten das Tonmineral Saponit, das als Mg-Quelle für Kulturpflanzen verwendet werden kann. Wir haben eine Mischung aus saponithaltigen basaltischen Tuffen, die 82 g MgO kg^{-1} enthalten, in den Dosen von 20 bis 80 kg MgO ha^{-1} beim Anbau von blauem Bockshornklee, Dill, grünen Bohnen und Basilikum auf einem Eutric Retisol in einem Feldversuch verwendet. Der Ertrag aller Kulturen stieg im Vergleich zur vollständigen Mineraldüngung deutlich an, so dass die Tuffs als natürliches Bodenverbesserungsmittel verwendet werden können.

Keywords: magnesium, blue fenugreek, dill, green beans, basil

1. Introduction

Saponite, $(Ca_{0.5}, Na)_{0.3} [(Mg, Fe)_3 (Si, Al)_4 O_{10}](OH)_2 \times 4H_2O$, is a clay mineral of the montmorillonite/smectite group.

It is present in basaltic tuffites and tuffs of Vendian (Neoproterozoic) age (Volyn series, Rataychitsa stage) in the southwest of the Republic of Belarus. Depending on their localization, the depth of stratified tuffs ranges from 40 to 1500 m. The saponite-containing tuffs (SCT) are a by-product of basalt exploration. Along with saponite, the basaltic tuffs are composed of analcime, hematite, hydromica, kaolinite, feldspars and quartz.

Apart from industrial applications (e. g., for Portland cement, ceramic products, glass) and for the removal of toxic metals and radionuclides, saponite-containing basaltic tuffs (SCT) are used in agriculture as an Mg source to improve the nutrition of agricultural crops (NUMIMOR, 2012; POZNYAK et al., 2012; SPIVAK et al., 2012; ŚRODOŃ et al., 2019; БОСАК et al., 2017).

The aim of the study was to test the agronomic effectiveness of SCT in the cultivation of selected vegetable crops. We hypothesize that the byproduct SCT has the potential of an effective and low-cost Mg source in plant production.

2. Material and methods

We carried out a field experiment on a Eutric Retisol (arenic) in the Republic of Belarus from 2014 to 2019. The Ap horizons on the experimental site were weakly acidic (pH (KCl) 5.5–5.7). Total contents of P_2O_5 (0.2 M HCl), K_2O (0.2 M HCl) and humus (0.4 n $K_2Cr_2O_7$) amounted to 135–145 mg kg^{-1}, 120–130 mg kg^{-1} and 22–24 g kg^{-1}, respectively. The contents of 1 M KCl-extractable Ca and Mg were 1061–1205 and 66–72 mg kg^{-1}.

We used a composite sample of SCTs from three locations (from the Pinsk, Ivanava and Malaryta district of the Brest region of the Republic of Belarus).

The composite sample contained 8.2 % MgO, 2.1 % K_2O, 0.16 % N, 0.23 % P_2O_5, 2.8 % Na_2O, 1.0 % CaO, 20.6 % FeO, 13.0 % Al_2O_3, 49.5 % SiO_2, 162.4 mg kg^{-1} Mn, 4.5 mg kg^{-1} Co, 35.4 mg kg^{-1} Zn, 51.7 mg kg^{-1} Cu and had a pH (KCl) of 8.2.

The field experiment included:

1) a control variant without fertilization,

2) a variant with NPK fertilization (carbamide, ammoniated superphosphate, KCl) during the pre-sow-

ing cultivation,

3) various doses of SCT (20, 40, 60 or 80 kg MgO ha^{-1}; Mg_{20}, Mg_{40}, Mg_{60}, Mg_{80}),

4) a variant with magnesium sulfate (Mg_8).

The size of saponite-containing basaltic tuffs particles did not exceed 5 mm (more than 75 % was less than 1 mm).

The cultures under investigation were green beans (*Phaseolus vulgaris* L.), basil (*Ocimum basilicum* L.), blue fenugreek (*Trigonella caerulea* (L.) Ser.) and dill (*Anethum graveolens* L.).

3. Results and discussion

Preplant application of saponite-containing basaltic tuffs in Mg doses of $Mg_{20–80}$ increased yield of

- green beans by 14.2–16.2 dt/ha,

- green mass of basil by 0.16–0.22 kg/m^2,

- green mass of blue fenugreek by 0.12–0.26 kg/m^2,

- green mass of dill by 0.14–0.18 kg/m^2,

with better agronomic efficiency in case of application of Mg_{40} (*Phaseolus vulgaris* L. and *Trigonella caerulea* (L.) Ser.) and Mg_{20} (*Ocimum basilicum* L. and *Anethum graveolens* L.) against the background of complete mineral fertilizing (tables 1 and 2).

Foliar treatment of the crops using magnesium sulfate (Mg_8) increased the yield of

- green beans by 14.1 dt/ha,

- green mass of basil, blue fenugreek and dill by 0.08–0.13 kg/m^2.

4. Conclusions

The experiments on a Eutric Retisol (arenic) showed that the best indicators of agronomic efficiency in the cultivation of blue fenugreek, dill, green beans and basil were achieved in case of preplans application of saponite-containing basaltic tuffs in Mg doses of Mg^{40} (leguminous crops) and Mg_{20} (green crops) against the background of complete mineral fertilizing.

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Table 1:. Influence of fertilizers on productivity of green beans and blue fenugreek

Green beans [dt/ha]			**Green mass of blue fenugreek [kg/m2]**		
variants	total yield	increased yield	variants	total yield	increased yield
Control	158.1	–	Control	1.18	–
$N_{50}P_{60}K_{120}$	251.7	–	$N_{40}P_{40}K_{70}$	1.52	–
NPK + Mg_{8}	265.8	14.1	NPK + Mg_{8}	1.60	0.08
NPK + Mg_{40}	265.9	14.2	NPK + Mg_{20}	1.64	0.12
NPK + Mg_{60}	267.9	16.2	NPK + Mg_{40}	1.73	0.21
NPK + Mg_{80}	267.1	15.4	NPK + Mg_{60}	1.78	0.26
CD_{05}	12.2		CD_{05}	0.07	

Table 2: Influence of fertilizers on productivity of dill and basil

Green mass of basil [kg/m^2]			**Green mass of dill [kg/m^2]**		
variants	total yield	increased yield	variants	total yield	increased yield
Control	2.06	–	Control	0.83	–
$N_{45}P_{60}K_{90}$	2.29	–	$N_{60}P_{50}K_{80}$	1.07	–
NPK + Mg_{8}	2.42	0.13	NPK + Mg_{8}	1.19	0.12
NPK + Mg_{20}	2.45	0.16	NPK + Mg_{20}	1.21	0.14
NPK + Mg_{40}	2.51	0.22	NPK + Mg_{40}	1.24	0.17
NPK + Mg_{60}	2.46	0.17	NPK + Mg_{60}	1.25	0.18
CD_{05}	0.12		CD_{05}	0.05	