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Application of potassium-rich processed dactte tuff as a fertilizer of slow and long-lasting effect

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A B S T R A C T

Together with the Institute of General and Inorganic Chemistry of NAS RA, the researchers of National Agrarian University of Armenia have developed the method of deriving a complex fertilizer of slow and long lasting effect from potassium-rich alumino-silicates (processed dacite tuff, PDT) containing potassium, calcium, magnesium, phosphorus and silicium, from which the nutrients pass into the soil solution gradually. Upon the field and vegetation experiments it has been stated that in case of using PDT with the amount equivalent to potassium, it provides higher yield in 10,0-15,3 % than it is in case of using potassium chloride.

It has been proved that PDT prevents the leaching of ammonium and nitrate ions from the soil, which is very important for the reduction of the nitrogen loss from the nitrogenous fertilizers and for the environmental protection; it also promotes the increase of phosphorus and potassium in the yield and enhances the crops drought-resistance.

Keywords: Dacite tuff, Efficiency, Nitrogen loss, Active phosphorus, Potassium, Yield capacity.

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Introduction

Among the mineral fertilizers used in the agricultural production the potassium fertilizers also make a certain amount. Potassium chloride is mainly used which is derived from Sylvinite. But the mentioned mineral variety is not found in many countries, also in the republic of Armenia.

Potassium chloride also contains 47 % chlorine, which has an adverse effect on the soil properties and also on the yield quality of some crops (potato, tobacco, grape vine, etc.)[1,2].

Alumino-silicates rich in potassium [3-6], as well as nano-modified natural zeolites [7] are of industrial importance for the enlargement of the varieties of potash fertilizers and the base of production raw material [1,4,5,8-10].

The researchers of the institute of general and inorganic chemistry at NAS, RA and those of ANAU have disclosed that it is possible to obtain potassium fertilizer out of the alumino-silicates which are rich in potassium, such as, for example, the dacite tuff, moreover, they have revealed that it is possible to realize this process through ecologically safe methods. The derived fertilizer is allowed to be used in organic agriculture as well. The fertilizer contains plants available potassium, as well as calcium, magnesium, phosphorus, silicium, which penetrate into the soil solution gradually and that is why they are considered to be fertilizers of slow and long-lasting effect [8]. It is also endowed with indirect positive influences, for example, it can absorb up to 500 %water and due to this property it temporarily absorbs the humidity from the environment, which the plants use gradually. It is obvious that it is particularly prioritized for the agriculture in dry conditions [9].The fertilizer is also able to absorb NH_4^+ and NO_3^- ions (up to 45-50 mg/eq), due to which the loss of nitrogen and other nutrients introduced into the soil is prevented [10]. Being endowed with the ability of absorbing the heavy metals in non-exchangeable way, the mentioned fertilizer can be used for the re-cultivation of the soils contaminated with heavy metals [11].The fertilizer promotes the strengthening of the plants root system resulting in the better/more efficient use of soil humidity and nutrients by the plants, it also contributes to the increase of plants available phosphorus and potassium, which takes place at the expense of the solubility increase of hardly soluble compounds and the opportunity to reduce the application dosages[12]of phosphorous and potassium fertilizers or to improve the plants nutrition with phosphorus, particularly in the soils poorly provided with phosphorus [13-15], appears.

The impact of the fertilizer maintains in the soil for several years, thus it is possible to apply it in the same place once in 3-5 years [16].

Objectives and methods

The objective of the research is to find out the agro-chemical characteristics of the fertilizer (dacite tuff) of slow and long-lasing influence containing potassium, calcium, magnesium, Silicium and phosphorus extracted from the potassium-rich alumino-silicates and its efficiency on the example of spring barley experiments comparing it with potassium chloride.

The field experiments have been conducted in dry steppe and steppe zones (non-irrigated) of RA in three repetitions, the size of an experimental bed is 50 m^2, they were implemented by the following scheme:

1. Without fertilization (control)
2. $N_{90}P_{90}$ (background)
3. background+K_{90}(KCl)
4. background +K_{90}(PDT)

NH_4NO_3, Ca $(H_2PO_4)_2 \cdot H_2O$, KCl and the processed dacite tuff have been used.

The vegetation experiments have been conducted in the ANAU greenhouse in four repetitions by the following scheme /the holding capacity of a vessel was 6,5 kg air-dry soil/:

1. Without fertilization (control)
2. N_2P_2 (background)
3. background+K_2(KCl)
4. background+K_1(PDT)
5. background+K_2(PDT)

In the experiments N_2 is equal to 0,2 g N per 1 kg soil, P_2–is equal to 0,2 g P_2O_5, K_1-is 0.1 g K_2O,K_2-is 0,2 g K_2Oper 1 kg soil. Ammonium saltpeter, double superphosphate, processed dacite tuff (PDT) and potassium chloride have been used. The processed dacite tuff has the following composition: K_2O-9,9 %, CaO-13,0 %, MgO-7,5 %, P_2O_5-0,18 %, Al_2O_3-7,5 %, SiO_2-47,1%, H_2O-9,4%.

Results and analyses

The field experiments were conducted in Arzakan community of Kotayk region in the forest brown and carbonated soils with almost neutral reaction and low humus content, which is weakly provided with nitrogen and phosphorus and well provided with potassium (table 1).The field experiments in Hatsashen community of Aragatsotn region were carried out in the brown carbonated soils which are poor in humus and poorly provided with nitrogen and averagely provided with phosphorus and potassium and in Artik province the experiments were implemented in the carbonated black soils, where the humus content makes 4,45 %, pH-7,1 and these soils are weakly provided with plants available nitrogen, phosphorus and potassium (Table 1).

In the field experiments the impact of the application of KCl and PDT on $N_{90}P_{90}$background is remarkable on the growth, yield capacity and chemical composition of the grain of the spring barley in all three sites; anyhow the influence rate depends on the variant of the fertilization.

Table 1. *Agro-chemical indicators of the experimental plots(plowing layer)*

Sampling site	Humus, %	pH	EC	$CaCO_3$ %	Physical clay, %	Available nutrients, mgin100 g soil		
						N	P_2O_5	K_20
Kotayk region Arzakan community	3,11	7,1	0,12	3,5	52,1	3,5	1,5	40,7
Aragatsotn re-gionHatsashen commu-nity	2,85	7,3	0,20	8,6	54,8	2,6	3,1	33,1
Shirak region Artik province	4,45	7,1	0,29	1,4	63,6	4,1	1,6	17,5

Table 2. *The impact of PDT and KCl on NPK content in the spring barley grain, % (2017)*

Variants	Arzakan community			Hatsashen community			Artik community		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1.	1,42	0,56	0,44	1,53	0,47	0,43	1,38	0,39	0,41
2.	1,73	0,72	0,40	1,79	0,58	0,41	1,80	0,59	0,37
3.	1,75	0,70	0,55	1,76	0,53	0,54	1,85	0,74	0,48
4.	1,81	0,87	0,67	1,79	0,87	0,70	1,87	0,90	0,67

Variants 1. without fertilization (control), 2. N90P90(background), 3. background +K90(KCl), 4. background+K90(PDT)

So, we can see that the plants growth, weight of the grains in an ear and the yield capacity is lower in control variant. Only in case of nitrogen and phosphorus application the yield has increased by 5,7-10,9 c/ha as compared to that of control variant, which is rather high in Artik province making10,9 c/ha (table 2), which is related to the relatively high precipitation rate and low soil fertility in the steppe zones, in conditions of which the fertilizers demonstrated rather high efficiency.

In case of using potassium chloride or PDT on the nitrogen-phosphorus background the highest grain yield/24,9-41,3 c/ha/ was obtained in the variant of $N_{90}P_{90}K_{90}$ (PDT), moreover this regularity stays stable independent of the soil provision with potassium. Thus, in the experimental variant of $N_{90}P_{90}K_{90}$ (PDT) the yield surplus against the variant of$N_{90}P_{90}$ (background) has made 4,5-7,8c/ha, and against the variant of background + K_{90} (KCl) it is3,3-4,1c/ha. We think that this regularity is related to the positive side effects of PDT: it promotes the strengthening of the plants root system, reduction of the water amount spent for getting a yield unit, more efficient accumulation of the moisture resulted from the precipitations, as well as it promotes the increase of the available phosphorus and potassium quantities in the soil [17].

The use of the fertilizer has also promoted the increase of the amounts of the main nutrients (NPK), which is more noticeable in case of using PDT (table 3).We think that it is connected with the improvement of plants nutrition particularly with phosphorus and potassium.

Table 3. *The impact of PDT and KCl on the growth and yield capacity of spring barley (average data for 2016-2017)*

Variants	Arzakan community			Hatsashen community			Artik community		
	Plants height, cm	Weight of grains in an ear, g.	Grain yield, c/ha	Plants height, cm	Weight of grains in an ear, g.	Grain yield, c/ha	Plants height, cm	Weight of grains in an ear, g.	Grain yield, c/ha
1.	43	0,65	15,2	37	0,51	14,5	49	0,81	22,6
2.	48	0,81	23,1	44	0,66	20,2	56	1,10	33,5
3.	49	0,83	24,0	43	0,70	21,6	58	1,18	37,2
4.	51	0,92	27,6	45	0,78	24,9	61	1,27	41,3

Variants: 1. Without fertilization (control), 2. N90P90(background), 3. background +K90(KCl), 4. background+K90(PDT)

The comparative efficiency of the processed dacite tuff (PDT) and potassium chloride has been studied also in the vegetation experiments. The soil (brown) was selected from Hatsashen community of Talin region. The mechanical composition of the soil was clay and sandy heavy, pH-was 7,3, carbonates made 8,6 %, the plants available nitrogen made 2,6 mg N, phosphorus content was 3,1 mg P_2O_5, potassium was 33,1 mg K_2O, in 100 g soil. According to these data the soil is poor in nitrogen and is averagely provided with phosphorus and potassium. The goal of the vegetation experiments has been to investigate the comparative impact of the processed dacite tuff (PDT) and potassium chloride on the mitigation of the loss of nitrogen forms (NH_4^+ and NO_3^-) from the soil and from the nitrogenous fertilizers inserted into the soil, as well as the comparative impact on the growth and yield capacity of spring barley (Table 4,5). It should be mentioned that in the production due to the reduction of nitrogen loss from nitrogenous fertilizers their application dates get restricted or nitrogenous fertilizers of long-lasting effect are used [18].In order to study the issue the vegetation vessels were periodically provided with excessive water amounts, so as the outflow in the filtrate occurred and where the content of NH_4^+ and NO_3^- (table 4) was determined. The results show, that up on the application of PDT, the loss of $NH_4^+$and NO_3^- ions from the soil is considerably mitigated. So, in the non-fertilized variant (control) the loss of nitrogen is minimal and this is related to the low content of NH_4^+ ևNO_3^-ions in the soil. While in N_2P_2variant, where $NH_4NO_3$was used as a nitrogenous fertilizer the nitrogen loss was rather high. Almost similar loss rate was observed when potassium chloride on the background of $N_2P_2$was used [variant $N_2P_2K_2$ (KCl)]. While in case of the use of PDT on the background of $N_2P_2$the nitrogen loss considerably decreased in all calculating periods (Table 4).As a result the plants growth and yield capacity have also changed (Table 5).According to the data of that table in the variant of $N_2P_2K_2$ (PDT) the grain yield has made 16,5 g, which is higher than the control one by 7,6 g (85,4 %), against the N_2P_2 variant it is higher by 3,0 g (22,2 %), and comparing to $N_2P_2K_2$ (KCl) variant by 1,9 g (13,0 %).Thus the highest yield was resulted in the variant where PDT was used on the background of N_2P_2 .

Table 4. *The impact of the processed dacite tuff (PDT) and KCl on the leaching mitigation of NH_4^+ (numerator) and NO_3^- (denominator) from the soil, mg/l (vegetation experiment, the crop is spring barley)*

Variant	Periods of Analyses				
	3-leaves-growth stage	5-6-leaves growth stage	Ear-formation stage of the growth	Milk maturation stage	The total during vegetation
1.	0,11 0,17	0,07 0,04	0,02 0,01	n/a n/a	0,20 0,22
2.	2,45 5,76	1,02 2,84	0,13 0,31	0,07 n/a	3,67 8,91
3.	2,40 5,79	1,16 2,67	0,10 0,28	0,08 n/a	3,74 8,74
4.	0,35 2,13	0,13 0,76	0,02 0,18	n/a n/a	0,50 3,07
5.	0,21 0,76	0,07 0,58	0,02 0,10	n/a n/a	0,30 1,44

Variants: 1.Without fertilization (control), 2. N_2P_2(background), 3background +K_2 (KCl), 4.background+K_1(PDT), 5. background+K_2(PDT)

Table 5. *The impact of the processed dacite tuff (PDT) and KCl on the plants growth and grain yield of spring barley (vegetation experiments, 2017)*

Variants	Plants height cm	The number of grains in an ear, n	The weight of grains in an ear, g	yield, g./ vessel	The weight of thousand grains, g.
1.	39	15,0	0,60	8,9	39,6
2.	47	21,4	0,90	13,5	42,0
3.	47	23,1	0,97	14,6	42,1
4.	48	22,9	0,97	14,5	42,3
5.	48	25,9	1,10	16,5	42,4

Variants: 1. Without fertilization (control), 2. N2P2(background), 3. background +K2 (KCl), 4. background+K1(PDT), 5. background+K2(PDT)

Conclusion

1. The fertilizer of slow and long-lasting effect (PDT) is recommended for the agricultural production, which is resulted through the physical-chemical treatment of potassium-rich alumino-silicates, by means of which the potassium, calcium, magnesium and phosphorus of the mineral turn into the plants available forms and penetrate into the soil solution gradually.
2. In dry steppe and steppe (non-irrigated) conditions of RA PDT provides grain yield surplus of spring barley equal to 3,3-(11,0-15,3%) c/ha as compared to that of potassium chloride in case when PDT is used on the nitrogen-phosphorus background.
3. Having a high absorption capacity (45-50 mg/eq)the fertilizer (PDT) considerably prevents nitrogen leaching from the nitrogenous fertilizers introduced into the soil, which, in vegetation experiments, has made 7,34-7,48 for NH_4^+ and for NO_3^- it has made 2,84-6,03against the variants of $N_2P_2$and $N_2P_2K_2$ (KCl).
4. In vegetation experiments when using PDT on the background of N_2P_2 the surplus of the grain yield ofspring barley makes 3.0 g. (22,2 %) against the N_2P_2variant and 1,9 g (13,0 %) against the $N_2P_2K_2$ (KCl) variant.

References

[1] A. Yagodin, Agro-chemistry. Manual for the students of higher education institution. Publishing house VO "Agro industry publishing house", Moscow, 1989 (in Russian).
[2] N.E. Vlasenko, Potato Fertilizer. M. “Agro industry publishing house”, 1987 (in Russian
[3] Ya.M. Ammosova, Silica in the agronomy system. Agrochemistry, 10 (1990) 103-108 (in Russian).
[4] Belyaev G. N., Khorenyan E. G., Bartikyan P. M. Efficiency of potassium fertilizers extracted from rhyolite-dacite tuffs of Armenia on sod-podzolic soils, Pochvovedenie, 8 (1994) 97-103 (in Russian).
[5] Loboda B. P, Application of Natural Fertilizers on the Basis of Free Silica of Khotynenskoye Zeolite Deposit in Agriculture, Moscow, 2009 (in Russian).
[6] A. N. Nurlybaev, Alkaline Rocks of Kazakhstan and Their Minerals, AN Kaz. SSR, Institute of Geological Sciences. 1973 (in Russian).
[7] G. Tsintskaladzea, L. Eprikashvilia, T. Urushadzeb, T. Kordzakhiaa, T. Sharashenidzea, M. Zautashvilia, M. Burjanadzea, Nanomodified natural zeolite as a fertilizer of prolonged activity, J. Annals of Agrarian Science, Vol.14, No.3 (2016) 163-168.
[8] Grigoryan G. O., Grigoryan K. G, Muradyan A. B, Kostanyan A. K, Bartikyan P. M. Methods

of obtaining hardly soluble fertilizers. Patent № 402 (RA) upon the request №000371 of Arm. ind. property, №2, 2006 (in Armenian).
[9] H.G. Ghazaryan, A.L. Mkrtchyan, G.G. Petrosyan, Climate changes and soil degradation process in Armenia, J. Annals of Agrarian Science, Vol.13 No.2 (2015) 34-38 (in Russian).
[10] S.K. Yeritsyan, R.R. Manukyan, L.S. Yeritsyan, A. Nelian, "Agro-Chemical Characteristics of Potassium-Rich Processed Dacite Tuff and Its Application as Potash Fertilizer" G.S. Davtyan Institute of Hydroponics problems NAS RA. Yerevan 2017 Proceedings of the 6-™ International Conference on "Modern Problems of Plants Soilless (Hydroponics) and Tissue in Vitro Cultures", Dedicated to the 70th Anniversary of the Institute, 2017, 38-45 (in Armenian).
[11] M.A. Galstyan, A.V. Shirinyan, S.S. Harutyunyan, S.J. Tamoyan, K.Sh. Sargsyan, Assessment and remediation of soils previously buried under mine tailings and contaminated with heavy metals, J. Annals of Agrarian Science, Vol.13 No.1 (2015) 46-53 (in Russian).
[12] K.F. Gladkova, The role of silicon in the plants phosphorous nutrition. Agro-chemistry, 3 (1982) 133-140 (in Russian).
[13] R.E.Yeleshev, A.L. Ivanov, S.K. Sadvakasov, Study of the influence of joint application of phosphorus silicon-containing fertilizers on the phosphate regime of the main soil types in Kazakhstan, Agro-chemistry, 1 (1990) 78-85 (in Russian).
[14] T.F. Urushadze, A.T. Tkhelidze, T.T. Urushadze, Agrochemical characterization of the main soil types of Georgia, J. Annals of Agrarian Science, Vol.12 No.4 (2014) 14-31
[15] T.F. Urushadze, T.O. Kvrivishvili, R.G. Kakhadze, Field school in soil science: Results and prospects, J. Annals of Agrarian Science, Vol.13 No.3 (2015) 51-54.
[16] S.K. Yeritsyan, N.V. Farsiyan, Influence of the consequences of fertilizers and ameliorants on winter wheat in conditions of the Askeran region of NKR / Bulletin of the Samara State Agricultural Academy, (2016) 28-32 (in Russian).
[17] A.V. Baranov, The influence of silicon on the growth, development and productivity of spring wheat under various conditions of mineral nutrition and water supply. Author's abstract. diss. Cand. Biol. Sciences. M., 2006 (in Russian).
[18] E. Gugava, A. Korokhashvili, Technologies for obtaining nitrogen fertilizers prolonged effect in wheat, J. Annals of Agrarian Science, Vol.16 No.1 (2018) 22-26.