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Aftereffect of Fertilizers and Ameliorants on the Reclamation of Some Agro-Physical and Agro-Chemical Indicators in Soil

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ABSTRACT

The forest brown soils of the Artsakh Republic are often distinguished by the less favorable agro-physical and agro-chemical properties, including low fertility. It is possible to reclaim these soils by means of appropriate fertilizers.

According to our observations the processed dacite tuff (PDT) is among these fertilizers, which is fabricated out of the potassium-rich dacite tuffs through thermo-chemical method.

According to the experimental data, in case of applying PDT or “MM” bio-fertilizer in $N_{90}P_{90}K_{90}$ fertilization system the soil water absorption capacity has increased by 5.7%-15.5 %, water permeability by 16.2%-20.6 % and the absorption capacity for NH_4^+ - ion by 14.9%-16.3 % as compared to the same properties of $N_{90}P_{90}K_{90}$(KCI) variant.

In case of applying processed dacite tuff or “MM” bio-fertilizer on its background, the content of mobile nitrogen has increased by 65.4%-96.1 % against the control variant and by 38.7%-64.5 % against the $N_{90}P_{90}K_{90}$(KCI) variant. This difference for the mobile phosphorus has made 126.9%-161.5% and 90.3%-119.3 %, for the potassium- 49.5%-62.8 %. The use of gypsum hasn't influenced the abovementioned indicators.

Due to the aftereffect in the fertilization variants of $N_{90}P_{90}K_{90}$(PDT) and $N_{90}P_{90}K_{90}$(PDT)+MM the yield surplus has made 37.4%-43.6 % against the control variant and 17.1%-24.3 % against the $N_{90}P_{90}K_{90}$(KCI) variant. The use of gypsum hasn't provided any yield surplus.

Introduction

Application of fertilizers is an indispensable measure (Gulyan, Adamyan, Melkumyan, 2011, Mineev, 2004) for the increase of soil fertility and crops yield capacity. It is related not only to the lack of the plants available nutrients in the soil but also to the reclamation need for some soil agro-physical and agro-chemical properties (Hakobyan, 2010, Atlas of soils of the RA, 1990, Vadyunina, Korchagina, 1986). Some fertilizers are also endowed with considerably high aftereffect, which is particularly characteristic to the organic fertilizers, since their organic substances promote the reclamation of soil properties. Moreover, their effect lasts more than 3-4 years. Thus, such fertilizers can be used in one and the same place once in 3-4 years (Mineev, 2004, Myazin, Lutsenko, 2002).

The forest brown soils of the Artsakh Republic are often distinguished by the less favorable agro-physical and agro-chemical properties, including insufficient water permeability, low water absorption and retention capacities, the property of solidification and encrustation when dried out, as well as by low fertility rate. In such soil conditions the plants suffer from water and nutrients shortage during the vegetation period (Gulyan, Adamyan, Melkumyan, 2011, Hakobyan, 2010, Vadyunina, Korchagina, 1986).

It is very vital that due to the fertilizer's aftereffect its nutrients become available gradually. In this respect the processed dacite tuff (PDT) stands apart, which is endowed with the above mentioned properties, due to which it becomes possible to reduce the application of phosphorus and potassium containing fertilizers. Possessing a positive side effect PDT partially increases the plants drought-hardiness and mitigates the nitrogen loss (Yeritsyan, Farsiyan, 2016, Loboda, 2009).

Materials and methods

The aim of this work is to study the effect and aftereffect of the fertilizers on the soil properties, as well as on the growth and yield capacity of potato and winter wheat, since it is known that the use of these fertilizers and ameliorants is very important for the improvement of the above mentioned properties.

The field studies and fertilization experiments have been carried out in the arable forest brown soils of the Askeran district at NKR.

Based on the soil map of the republic, land areas were selected on the basis of field surveys, 6 soil segments were dug out, described, then soil samples were taken from the genetic horizons and their agro-physical and agro-chemical properties were examined (Atlas of soils of the RA, Yerevan, 1990, Vadyunina, Korchagina, 1986) .

Results and discussions

The results of the soil samples' analyses testify that the land areas significantly differ from each other by their agro-physical and agro-chemical properties. There is also a difference between the various depths (table 1,2) of the same segment. The soil specific and volumetric (dimensional) weights are relatively lower in segment 1 and then in those of 3 and 5. Besides, this regularity is also observed in the top soil and partially in sub-soil layers. We think that this is related to the high humus content in the soil and its mechanical composition. While in the 2nd, 4th and 6th segments of the soil its specific and volumetric weights are relatively higher, which is more vivid in the sub-soil layers. According to our observations this is accounted for the relatively lower humus content in the soil, mechanical composition and the same plowing depth for many years as a result of which a solid layer appears in the sub-soil layer.

Based on the "marginal numbers" stated for the soils specific and volumetric weights the 2nd, 4th and 6th segments of the soil are considered to be strongly solidified, thus less favorable for the plants growth and yield capacity, so they need to be reclaimed (Vadyunina, Korchagina, 1986).

The data on the soils porosity and water permeability show that the porosity in the segments 1, 2, 3 and 5 is equal or exceeds 50 %, thus they are favorable for the plants growth. The data of the same table testify that the water permeability in the segments 1 and 3 is assessed as "good", while those of the segments 2, 4, 5 and 6- as "satisfactory". Thus, the property of water permeability in those soil segments needs to be reclaimed, which is possible to implement through the use of organic fertilizers and ameliorants. As to the soils water retention capacity (moisture capacity), it turns out that there is a slight difference between the individual soil samples.

Table 1 The agro-physical properties of the experimental plots

The soil segment and the experimental number	Sample taking depth, cm	Specific weight, g/cm³	Volumetric weight, g/cm³	Porosity %	Water permeability mm/hour	Water retention capacity, %	Hygroscopic moisture, %
Segment №1 Experiment № 1	0-19	2.31	1.05	54.6	75	32.6	7.7
	19-44	2.46	1.27	48.4	58	26.8,	7.1
Segment №2 Experiment № 2	0-22	2.42	1.21	50.0	66	31.0	7.2
	22-49	2.48	1.35	45.6	58	27.8	7.5
Segment №3	0-17	2.29	1.08	52.8	80	31.9	6.3
	17-38	2,41	1,20	50,4	62	31,2	5,1
Segment №4	0-24	2.38	1.29	45.8	63	31.3	4.8
	24-37	2.37	1.51	36.3	57	29.0	4.0
Segment №5	0-29	2.31	1.03	55.4	69	35.4	7.9
	29-49	2.35	1.09	53.6	69	34.7	7.1
Segment №6	0-21	2.51	1.28	49.0	61	30.3	5.4
	21-49	2.72	1.51	44.5	45	23.5	6.3

The data on the agro-chemical characteristics (table 2) of the experimental plots testify that the selected land areas considerably differ from each other by the mentioned indicators, which is particularly true for the content of mobile nutrients. This is, probably, related to the terms of soil formation and to the human agricultural activities. In this regard it should be mentioned that as a result of ongoing cultivation (irrigation, fertilization, crop rotation) of the RA semi-desert brown soils, they have been turned into irrigated meadow brown soils, which are endowed with much higher fertility and yield capacity (Atlas of soils of the RA, 1990).

Table 2 The agro-chemical properties of the experimental plots (at the start of the experiment)

Sample taking place, experiment	Sample taking depth, cm	Humus, %	pH in the water extract	Water – soluble salts content,%	Carbonates, ($CaCO_3$), %	The absorbed Ca^{2+}+Mg^{2+} mg/eq in100g soil	Physical clay, %	Available nutrients mg in 100g soil		
								N	P_2O_5	K_2O
Experiment № 1	0-19	4.29	7.1	0.116	3.60	34.8	58.9	4.5	3.80	55.10
Segment № 1	19-44	3.71	7.3	0.091	4.70	31.6	56.6	3.6	3.10	48.60
Experiment №2	0-22	3.18	6.86	0.108	0.12	29.6	61.2	4.57	0.78	45.55
Segment 2	22-49	2.06	6.95	0.081	1.21	27.1	60.4	2.81	0.49	39.50
Segment №3	0-17	4.18	7.0	0.078	2.14	38.9	49.39	2.91	2.70	48.61
	17-38	3.19	7.1	0.047	4.07	31.6	47.24	1.75	1.65	35.62
Segment №4	0-24	3.12	7.3	0.055	4.06	31.5	59.66	2.13	0.92	38.25
	24-37	0.78	7.4	0.036	5.95	27.4	65.22	1.36	0.43	35.41
Segment №5	0-29	5.12	6.9	0.094	1.52	40.8	49.88	4.18	4.36	62.15
	29-46	3.44	7.2	0.042	1.68	38.5	44.99	4.03	3.29	47.83
Segment №6	0-21	3.06	7.1	0.041	4.84	28.4	73.07	2.15	0.81	34.17
	21-49	1.46	7.4	0.037	6.93	23.6	67.85	1.37	0.39	33.58

The land areas are poorly provided with the available nitrogen content everywhere. The 2nd, 3rd, 4th and 6th segments of the soil areas are poorly provided with phosphorus and only the 1st and 5th soil segments are averagely provided with it (table 2). The plants available potassium content is compatible with the standard one except for the 6th segment soil which is averagely provided with potassium.

Taking into account the vitality of the effect and aftereffect of the fertilizers and ameliorants' application on the reclamation of the soil agro-physical and agro-chemical properties we have studies their impact on the changes of the mentioned properties (table 3). The data of the table show that the use of the gypsum or bentonite on the background of the main mineral fertilizers (NPK) has had an insignificant aftereffect on the soil agro-physical or agro-chemical properties, while it is remarkable, when in the fertilization system PDT or "MM" bio-fertilizer has been used. "MM" bio-fertilizer was produced in the RA institute of bio-chemistry upon the supervision of H. Sargsyan. It contains strains of 8-10 microorganisms. There are about 9-10 billion bacteria in 1 g fertilizer. It is used by soaking the seeds before their sowing watering the soil through top/foliar nutrition.

So, in the potato fertilization variants-($N_{90}P_{90}K_{90}$(KCI), $N_{90}P_{90}K_{90}$(KCI))+bentonite, $N_{90}P_{90}K_{90}$(KCI)+gypsum) - the pH fluctuated within the range of 7.10%-7.20 %, the content of soluble salts was 0.076%-0.101 %, water absorption capacity was 31.7%-35.7%, water permeability was 68-71 mm/hour, the absorption capacity due to the NH_4 was 28.9 mg/eq - 30.0 mg/eq in 100 grams soil. The data of those indicators are rather close to those of the variant without fertilization. Nevertheless, when the potassium chloride was displaced by PDT in the $N_{90}P_{90}K_{90}$ system, or the "MM" bio-fertilizer was applied the above mentioned indicators grew up, evidencing the reclamation of some soil properties.

The aftereffect of the fertilizers' application is more vivid upon the content of the available nutrients in the soil. So, the available amounts of nitrogen, phosphorus and potassium are lower in the control (non-fertilized) variants which are followed by the 2nd control variant, as well as by the 4th and 5th variants. While when the potassium chloride was displaced by PDT or the "MM" bio-fertilizer was introduced, out of the mobile nutrients the nitrogen content increased by 65.4%-96.1 % against the control variant and by 38.7%-64.5% against the variant of $N_{90}P_{90}K_{90}$(KCI). The mentioned difference for the phosphorus makes 126.9%-161.5% and 90.3-119.3%, for the potassium it is 49.5%-62.8% and 31.6%-43.3 % respectively. We think that the increase of the available phosphorus and potassium amounts in the soil is particularly related to the positive side effect of PDT, which promotes the gradual increase of the mentioned elements in the soil, which is also proved for other silicon containing fertilizers (Ammosova, et al, 1990, Baranov, 2006, Gladkova, 1982, Yeleshev, et al, 1990).

As to the changes of the soil properties in the industrial sowings (segment 3, 4, 5, 6), it turns out that the content of their available nutrients has decreased throughout time, which is probably related to the unifold /single/ fertilization (only nitrogen) system (tables 2, 3).

The aftereffect of the fertilizers is vivid on the growth and yield capacity of the winter wheat (table 4). According to the table data the size of the aftereffect depends on the fertilization system. It has lower indices in the fertilization system where as a potash fertilizer potassium chloride and then on this background bentonite or gypsum has been used. In the mentioned variants the plants height, grain yield, weight of thousand grains, as well as the content of NPK are lower. Anyhow, the highest yield has been received when the processed dacite tuff (PDT) or "MM" bio-humus on its background or $N_{90}P_{90}K_{90}$ (KCI) with manure has been used. In the mentioned variants the plant growth has improved as well: the weight of 1000 grains and the content of nitrogen, phosphorus and potassium have increased.

Table 3 The aftereffect of fertilizers and ameliorants on some indicators of the soil agro-physical and agro-chemical properties in the layers of 0cm-20 cm depth

Variants		pH	Soluble salts, %	Water absorption capacity, %	Water permeability, mm/hour	(NH4) absorption capacity, mg/eq in100 gram soil	Available nutrients, mg, in 100 gram soil		
							N	P_2O_5	K_2O
Before fertilization of the main crop		6.91	0.101	31.2	66	29.3	3.8	0.51	43.4
1.	Without fertilization (control 1)	6.97	0.078	31.0	65	29.5	2.6	0.26	38.4
2.	N_{90} P_{90} K_{90} (KCl) (control 2)	7.14	0.081	31.7	68	28.9	3.1	0.31	43.6
3.	N_{90} P_{90} K_{90} (PDT) 600 kg/ha	7.18	0.121	33.5	79	33.6	4.3	0.59	57.4
4.	$N_{90}P_{90}K_{90}$(KCl) + bentonite 300kg/ha	7.20	0.101	35.1	71	30.0	3.6	0.47	43.0
5.	$N_{90}P_{90}K_{90}$(KCl) + gypsum 300 kg/ha	7.10	0.076	31.9	71	27.8	3.5	0.40	43.2
6.	$N_{90}P_{90}K_{90}$ (PDT) 600kg/ha +MM	7.01	0.119	36.6	82	33.2	5.1	0.68	62.5
Segment №3		7.0	0.056	34.6	75.	25.4	1.81	2.06	44.32
		7.2	0.038	28.5	61	21.6	1.13	0.79	33.64
Segment №4		7.2	0.041	29.3	55	28.3	0.86	0.42	37.13
		7.4	0.029	21.6	49	29.5	0.28	0.35	31.15
Segment №5		7.0	0.096	34.4	72	25.7	4.52	4.48	65.71
		7.2	0.057	34.2	70	21.2	4.50	3.08	62.24
Segment №6		7.0	0.035	27.6	51	30.4	0.98	0.36	34.08
		7.5	0.031	24.1	40	24.3	0.43	0.17	30.39

Table 4 The aftereffect of fertilizers and ameliorants on the growth and yield capacity of the winter wheat (average data for 3 years)

№	Variants	Plants height, cm	Grain yield, c/ha	Yield surplus, c/ha	Grain weight, g	Content in a grain, %		
						N	P_2O_5	K_2O
1.	Without fertilization (control-1)	72	25.9	-	43.3	1.78	0.69	0.53
2.	$N_{90}P_{90}K_{90}$ (control-2)	78	30.4	4.5	43.7	1.80	0.81	0.65
3.	$N_{90}P_{90}K_{90}$ (PDT) 600 kg/ha	81	35.6	9.7	44.3	1.90	0.93	0.77
4.	$N_{90}P_{90}K_{90}$(KCI) + bentonite 300kg/ha	78	32.8	6.9	43.7	1.96	0.78	0.61
5.	$N_{90}P_{90}K_{90}$(KCI)+ gypsum 300kg/ha	76	30.6	4.7	43.6	1.79	0.68	0.45
6.	$N_{90}P_{90}K_{90}$(KCI) + manure 30t/ha	87	37.2	11.3	44.8	2.08	0.97	0.73
7.	$N_{90}P_{90}K_{90}$ (PDT) 600 kg/ha+ "MM"	86	37.8	11.9	44.8	2.15	0.93	0.85

Notification: In the experiments Sx%=1.3 % and $LSD_{0.5}$=1.2 c/ha has been calculated through the dispersion analysis method accepted in the RA.

Conclusion

Thus, it can be concluded that the forest brown soils of Askeran district at NKR are often distinguished by less favorable agro-physical and agro-chemical properties: insufficient water permeability, low water absorption and retention capacity, solidification and encrustation properties when dried out, as well as by low fertility.

The investigated land areas are poorly provided with available nitrogen in 100 %, poorly provided with phosphorus in 80 %, whereas no land areas with poorly provided potassium have been observed.

In case of using processed dacite tuff or the "MM" fertilizer on this background in the fertilization system, the content of the mobile nitrogen has increased by 65.4%-96.1 % against the control variant and by 38.7%-64.5 % against the $N_{90}P_{90}K_{90}$(KCI). For the mobile phosphorus this difference is between 126.9%-161.5% and 90.3%-119.3 % and for the potassium it has made 49.5%-62.8 %. The use of gypsum hasn't influenced the mentioned indices.

Due to the aftereffect in the fertilization variants of $N_{90}P_{90}K_{90}$(PDT) and $N_{90}P_{90}K_{90}$(PDT)+MM the surplus of the winter wheat yield has made 37.4%-43.6 % as compared to that of the control variant and 17.1%-24.3 % against the $N_{90}P_{90}K_{90}$(KCI) variant. The application of gypsum hasn't provided any yield surplus.

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