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The Effect of Organo-Mineral Fertilizers, Zeolite and Different Soil Tillage Methods on the Growth, Development and Yield Capacity of Winter Wheat in Conditions of Hrazdan Province

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ABSTRACT

Investigations carried out in 2017-2019 under dry agricultural conditions at the Hrazdan province of the Kotayk region have disclosed that out of the two tested soil cultivation variants (deep ploughing, single disk harrowing), soil loosening with the single disk harrowing is the most efficient variant for the winter wheat cultivated in the black soils, while out of the applied technologies (organo-mineral fertilizers and zeolite), that of the zeolite, manure and N_{30} applied on the background of $P_{90}K_{90}$ is the best variant. When applying this variant the soil agro-meliorative properties improve and 55.0 c/ha grain yield is harvested. Thus the mentioned variant is recommended for the introduction in the agricultural production.

Introduction

Winter wheat is rather sensitive towards the environmental conditions (humidity, air, nutritional elements, etc.). Unlike the other cereal crops, plants of the winter wheat usually have poorly developed root system in their early growing stage, meanwhile the intensive nutrition period of the plants is rather short (about 2 months). Thus, in order to get high and sustainable yield it is necessary to provide them with favorable air-water and nutritive environment from the very start of their growth and development.

The excess or shortage of any ecological phenomenon in the soil somehow retards the bio-chemical processes taking place in the plant parts, which has definitely an adverse effect on the plant growth, development, structural elements of yield, as well as on its quantity and quality (Galstyan, 2007, Galstyan, et al., 2018, Minyeev, 1980).

Multiple researchers both in our country and abroad (Galstyan, 2006, Gargus, et al., 1970) have proved that the mineral nutrients and environmental conditions have specific effects on the structural elements of the winter wheat yield. The authors mention, that by providing the plants with phosphorus and potassium from the very start of their growth the root formation intensity is improved, regular sprouting capacity and sugar content increase is promoted, which in its turn ensures high winter-resistance of the plants. Therefore, any study aimed at the creation of the medium needed for the development of the winter

wheat and at the provision of nutrients, is urgent and stems from the requirements of providing the population with safe agri-food system, which is stated by the agricultural development strategy of Armenia.

Materials and methods

The studies were carried out throughout 2016-2019, in conditions of Alapars community of the Hrazdan province in Kotayk region. In all mentioned research years the field experiments were carried out in common lime-free (delimed) black soils, which are characteristic to Hrazdan province. Winter cereal crops (mainly winter wheat) are cultivated in such soil types, where the humus content in the arable layers makes 5.8 %, the environmental reaction is close to neutral (PH 6.9-7.1), the content of easily hydrolyzed nitrogen makes 4.39 mg, that of the phosphorus-6.5 mg, while the exchangeable potassium makes 38 mg in 100 g soil. The soils of the experimental plot are averagely provided with humus, poorly provided with nitrogen, while they are rich in phosphorus and potassium (Melkonyan, et al., 2004).

The aim of the research is to study the effect of organo-mineral fertilizers, zeolite and different ways of soil cultivation on the growth, development and yield capacity of the cultivated winter wheat variety "Bezostaya-1" for the first time in the region and to identify the best variant for fertilization, soil tillage and the resulted yield in order to introduce it to the agricultural production.

The field experiments were set up with three repetitions; each experimental bed was 100 m^2. The following experimental variants were used for our investigations: 1. control (without fertilization), 2. $P_{90}K_{90}$-background, 3. background + manure 15 t/ha, 4. background + manure 15 t/ha + zeolite 2 t/ha, 5. background + manure 10 t/ha + N_{30} + zeolite 2 t/ha, 6. $P_{60}K_{60}$ + N_{90} + zeolite 2 t/ha.

The mentioned fertilization variants were applied upon different soil tillage methods, i.e. deep plowing (22 cm-26 cm) and single loosening (disk harrowing 10 cm-12 cm).

Winter wheat sowing, its further cultivation and harvesting activities were implemented in consistent with the agricultural rules accepted in the region.

Phosphoric and potash fertilizers, as well as the full doses of manure and zeolite were introduced in autumn during various ways of soil tillage, while in the 5th and 6th variant the nitrogenous fertilizer was introduced in spring through nutritive form. The soil agro-chemical and agro-physical indicators have been determined through universal methods introduced in the methodical manual on agri-chemistry analyses published under the editorship of B.A. Yagodin (Vadyunina&Korchagina, 1986, Yagodin, et al., 1989). The amount of winter wheat yield has been determined through the comprehensive yield calculation method during the harvesting period. The data on crop productivity have been subjected to mathematical analyses upon the identification of the experimental error (E_X, %) and the least significant difference ($LSD_{0.95}$ g) through the method of dispersion analysis (Dospekhov, 1973).

Results and discussions

The studies have disclosed that phosphoric and potash fertilizers and the doses of the manure with combination of zeolite and nitrogenous fertilizer applied on the background of the abovementioned fertilizers, as well as mineral fertilizers used in the region have demonstrated certain effect on the growth, development and structural elements of the winter wheat yield and its quantity.

According to the three-year average data (Table 1) when using manure with the dose of 15 t/ha on the background of phosphoric and potash fertilizers, the plants height amounts to 104.5 cm in case of common ploughing, while in case of disk harrowing it makes 109 cm; the number of spiciferous stems and ear length are 360 n and 5.7 cm; 390 n and 6.2 cm respectively in case of common plowing and disk harrowing (per one meter square). At the same time, the table data show that when adding zeolite with 2.0 t/ha dose and then N_{30} kg/ha to the 15 t/ha manure on the background of PK, the plants grow up more intensively than those in the former variant; they become of darker green color with higher plants (5-8 cm) both in case of common ploughing and disk harrowing, the number of spiciferous stems per a meter square grows up by 26 n-60 n and the length of an ear/spike increases by 0.9 cm-1.6 cm against the same indicators observed in the control variant.

This circumstance is accounted for the fact that soil zeolite creates more favorable air-water conditions for the regular growth and development of the plants, while the availability of the nitrogen in the soil apparently promotes the development of the plants vegetative mass.

The mechanical analysis of the sample batches have revealed that the application of manure, manure and zeolite, as well as manure, zeolite and nitrogenous fertilizers on the background of phosphorous and potash fertilizers has had particular effect on the structural elements of the winter wheat yield. In all years of field experiments the application of the mentioned fertilizers, as well as individual and combined application of zeolite increased the grain weight in an ear of winter wheat and the weight of 1000 grains in general.

Table 1. The effect of organo-mineral fertilizers, zeolite and different soil tillage methods on the growth, development and structural elements of winter wheat yield (average for 2017-2019)*

n/n	Variants	Soil tillage methods	Spiciferous stems		Spike/Ear length, cm	Average weight of grains in an ear	Weight of 1000 grains, g	Average grain yield, c/ha	Average straw yield, c/ha
			number n/m²	height cm					
1.	Control (without fertilization)	common	340	93.5	4.9	0.40	38.0	20.1	36.2
		disking	346	96.5	5.2	0.45	38.8	22.4	39.0
2.	$P_{90}K_{90}$-background	common	351	98.0	5.3	0.50	39.8	26.0	39.3
		disking	359	99.5	5.6	0.53	41.0	28.5	46.4
3.	Background+ manure 15t/ha	common	360	104.5	5.7	0.58	45.0	47.2	65.8
		disking	390	109.0	6.2	0.63	46.0	49.4	70.5
4.	Background+manure 15t/ha+zeolite 2t/ha	common	386	109.5	6.5	0.68	47.2	48.9	71.0
		disking	423	112.0	7.0	0.69	47.6	51.6	79.6
5.	Background + manure 10t/ha+ N_{30}+ zeolite 2 t/ha	common	386	115.0	6.9	0.70	47.9	51.7	79.0
		disking	450	118.5	8.1	0.71	50.0	54.8	89.0
6.	Background + N_{90}	common	422	107.5	7.6	0.68	47.6	48.6	73.6
		disking	428	112.0	7.8	0.69	48.4	50.8	75.0

*Composed by the authors.

For example, if in the control variant (without fertilization) upon the common ploughing the weight of the grains per an ear has made 0.40 g, the weight of 1000 grains - 38.0 g and all in all 20.1 c grain yield, 36.2 c straw yield per hectare has been received, and in the background variant the mentioned indicators have made 0.50 g, 39.8 g, 26.0 c grain and 39.3 c straw yield respectively, then by applying 15 t/ha manure on the same background the weight of grains in an ear has exceeded that of the background by 0.8 g amounting to 0.58 g, the weight of 1000 grains to 45 g and as a result the grain yield has made 47.2 c and the straw yield - 65.8 c.

The increase in the mentioned indices is more obvious when the manure used on the background was supplemented in one case with 2.0 t/ha zeolite and in another case with nitrogenous fertilizer (per N_{30} active agent) combined with the same dose of zeolite. Against the variant of background + 15 t/ha manure, in the mentioned variants the grain weight in an ear has increased by 16.6 % and 21.1 % respectively, the mass of 1000 grains - by 4.85 % -6.4 %, the grain yield has increased by 34.9 %-54.0 % and the straw yield - by 16.7 %-51.2 %.

It is noteworthy, that though the application of organic fertilizer together with nitrogenous one on the background of phosphorous and potash fertilizers has had a positive effect in different soil tillage conditions (common ploughing and disk harrowing), it influences differently the winter wheat growth, development, its yield structural elements and yield capacity everywhere. The mentioned ameliorants have always provided higher results in case of disk harrowing than those provided in case of common ploughing. Thus, in the background variant, if in case of common ploughing the wheat yield has made 26.0 c/ha, in case of disk harrowing it has made 28.5 c/ha. Almost the same regularity for yield production discrepancy has been recorded in the other fertilization variants as well; everywhere disk harrowing soil tillage method with the same fertilization technology has provided higher yield than only the method of common ploughing. So, if by applying 15 t/ha manure on the PK background in conditions of common ploughing 47.2 c/ha grain yield and 65.8 c/ha straw yield has been harvested, then the same fertilization technology in conditions of single disk harrowing has provided 49.4 c wheat grain yield and 70.5 c straw yield

per hectare. Similar regularities in yield capacity increase have been observed also in the other fertilization variants, i.e. different technologies used with equal doses under the conditions of disk harrowing have provided higher grain yield for winter wheat by 2.5-3.1 centners and straw yield - by 71 %-100 % as compared to the same indices provided under the conditions of traditional (common) ploughing (Table 2).

Such a discrepancy caused by different soil tillage methods is accounted for the fact that the soil compaction resulted from the ongoing soil tillage process by means of heavy equipment causes decrease in the water permeability and in such soils the plant roots are unevenly settled into the soil profile or don't get extended deeper at all, therefore, in case of traditional/common ploughing unfavorable conditions are created for the plants root system and the plants of winter wheat demonstrate lower growth and development as compared to those recorded in case of disk harrowing tillage; as a result they provide lower grain and straw yield amount. According to the results of the researches conducted by different researchers the roots of winter wheat plants hardly penetrate through the monolithic black soil layers in case of compaction with 1.42 g/cm^3 bulk density, while in case of compaction with 1.50 g/cm^3 bulk density they fail to penetrate at all (Hayrapetyan&Shirinyan, 2003).

The authors have disclosed that when the soil compaction increases by 0.1 g/cm^3 the overall crop yield decreases by 6 %-8 %, the cereal crops yield - by 2 c/ha -10 c/ha, that of the potato - by 15 c/ha -25 c/ha, etc.

During our investigations (in the control variant) in case of common ploughing the soil compaction rate was 1.43 g/cm^3 and in case of only disk harrowing it was 1.39 g/cm^3 due to which, according to the three-year average data, in case of traditional ploughing the winter wheat plants (control variant) have provided 11.4 % lower grain yield than in case of disk harrowing tillage. The same regularity holds true for all variants of fertilization technologies: in case of applying single disk harrowing tillage method the yield surplus of winter wheat grain has made 2.5 c/ha-3.1 c/ha, and that of the straw yied - 7.1 c/ha-10.0 c/ha against the same indicators identified in case of traditional or common ploughing.

Table 2. The effect of organo-mineral fertilizers, zeolite and different soil tillage methods on the winter wheat yield per years*

n/n	Variants	Soil tillage method	Grain yield per years, c/ha			Average grain yield, c/ha	Surplus	
			2017	2018	2019		c/ha	%
1	Control (without fertilization)	common	19.6	21.4	19.3	20.1	-	-
		disking	23.2	22.4	21.6	22.4	2.3	11.4
2	$P_{90}K_{90}$-background	common	25.0	27.0	26.0	26.0	4.9	23.2
		disking	27.5	28.5	29.5	28.5	6.1	27.2
3	Background + manure 15 t/ha	common	47.4	46.9	47.3	47.2	123.7	65.8
		disking	48.9	49.9	49.2	49.4	120.5	70.5
4	Background + manure15t/ha + zeolite 2 t/ha	common	50.2	48.5	49.1	48.9	131.8	71.0
		disking	52.6	50.6	51.6	51.6	130.4	79.6
5	Background + manure 10 t/ha+ zeolite 2t/ha + N_{30}	common	52.0	51.3	51.8	51.7	145.0	79.0
		disking	54.2	54.6	55.6	54.8	143.3	89.0
6	Background + N_{90}	common	47.9	48.6	49.3	48.6	27.5	130.3
		disking	50.8	50.2	51.4	50.8	28.4	126.8
	E_X, %		0.7	1.1	0.9			
	$LSD_{0.95}$, g		1.2	1.5	1.4			

*Composed by the authors.

Conclusion

Being a natural and pure mineral raw material, zeolite absorbs the excessive moisture from the soil in dry agricultural conditions and retains it for a while due to its absorption capacity, and during the vegetation period it transfers the retained moisture to the soil environment, hence, creating favorable conditions for the plants regular growth and development and promoting considerable increase in the crops yield capacity.

In order to provide high and sustainable winter wheat yield cultivated in dry agricultural conditions on the black soils of the Hrazdan province at the Kotayk region it is recommended to reclaim the soil through the single loosening method (down to 10-12 cm depth), which in contrast to deep or common ploughing (22 cm-26 cm), creates more favorable conditions for the improvement of agro-meliorative properties in the soil and for the increase of soil fertility.

When organizing fertilization activities for the winter wheat, during the application of disk harrowing method it is necessary to introduce zeolite (2 t/ha) in the soil together with phosphoric and potash fertilizers in autumn ($P_{90}K_{90}$), while in spring it should be treated with nitrogenous fertilizer (N_{30}) in nutritional form. As a result 55.0 c/ha grain yield is produced. Thus, this methodology is recommended for the introduction in the agricultural production.

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