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The Influence of Tillage Methods on the Agrophysical and Agrochemical Properties of Soils on the Example of Yernjatap Village

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ABSTRACT

The research was carried out in the administrative area of Yernjatap settlement, Aragatsotn marz, Aparan region, RA. This was at an altitude of 1850 m above sea level. Soil studies were conducted on about 1 hectare of arable land. The area is located in the steppe land zone. It was planned to investigate the shallow tillage (disking) in preventing degradation processes and increasing the efficiency of cultivated land in the investigated land area. For this purpose, field and laboratory analyses were carried out to study the soil quality characteristics. Soil sections were placed at the experimental sites. The percentage of humus content, mechanical composition, amount of water-soluble salts, soil reaction (pH), and provision of macronutrients in the soil samples were given according to the depth of each soil section. As a result of using traditional and shallow soil tillage methods, the agrophysical and agrochemical properties of the studied soils were revealed.

Introduction

Degradation of cultivated land has become a serious problem from the point of view of the ecological safety of human society and the biosphere. This threatens not only the reduction of total land areas but also decreases productivity of a unit of land (Avagyan, et al., 2020; Markosyan, et al., 2023; Markosyan, 2015).

The traditional method of soil cultivation is used in agriculture throughout the territory of RA. Traditional intensive agriculture requires powerful agricultural machinery with high productivity and huge energy and labor resources. Meanwhile, due to economic-ecological challenges in the modern world, agriculture requires updated and more effective approaches.

Literature confirms that soils undergo mechanization, lose their agrophysical properties, and become unstructured under traditional cultivation. Therefore shallow tillage technology should be introduced and applied to traditional soil cultivation methods. The main and decisive link of this innovation is the cultivation of soil without turning. This is based on the principle of reducing the cultivated layer capacity and reducing the number of cultivations.

Based on international experience, minimal tillage technology restores properties lost due to intensive tillage in a relatively short period. At the same time, this technology contributes to increasing work productivity, efficiency, and the rational use of arable land. Minimal or shallow tillage of the soil provides an additional 30-50 mm of moisture accumulation and preservation. This protects the soil from wind and sun exposure during drought, and from water erosion and salinization in case of heavy rainfall and over-humidity (Adam, et al., 2023; Wang, et al., 2007; Teodor Rusu, et al., 2009).

This research revealed the influence of traditional and shallow cultivation methods on soil agrophysical properties and organic matter reserves. This was done on the arable lands of Yernjatap settlement, Aragatsotn region to determine the effectiveness of shallow tillage (disking) in preventing degradation processes and increasing soil efficiency. To clarify the mentioned issues, the results of field and laboratory research conducted in 2022-2023 in the arable lands of the Yernjatap settlement, Aparan region of the Aragatsotn marz were analyzed and compared.

Materials and methods

The test sites with a total area of 1 ha were located in the administrative area of the Yernjatap settlement of the Aragatsotn marz. It is located at an altitude of about 1850 meters above sea level at the southeastern foot of Aragats mountain, in the Aparan region, Aragatsotn marz, RA. The area's natural landscapes are black soils, where typical steppe vegetation grows. Agricultural land in the Yernjatap settlement is 1660.27 ha, of which the area of arable land for operational purposes is 583.00 ha (Yernjatap Community Development Plan (2017-2021) 2017; Soil Atlas of the Republic of Armenia (1990).

Cultivation of arable land here is carried out mainly by traditional tillage methods, which violate cultivation rules: longitudinal plowing of land on steep slopes, or deep plowing of land.

Based on this circumstance, to determine the effectiveness of cultivation methods in the arable lands of the settlement's administrative area, the method of disking was studied as an experimental option. Winter wheat cultivation methods were studied. The cultivation depth was 10-12 cm, and the conventional cultivation method with a depth of 20-22 cm was used as a control.

The size of each tillage variant tested was 225 m^2 (15m x 15m), and the experiments were set up with 3 replications (Table 1).

Soil sampling and preparation for analysis. Soil sampling and laboratory research were conducted to evaluate the impact of traditional and shallow tillage methods on agrophysical and agrochemical properties, as well as to determine the effectiveness of the implemented measures. According to the experimental sites, soil samples were collected from 0-20 cm and 20-40 cm depths, respectively, using a sampling auger.

The soil samples were taken to ANAU, an organic agriculture laboratory. The initial sample was mixed well, spread on a flat surface, divided into grids, and individual checkerboard grids were selected to obtain an average sample.

Crushed air-dried soil was sifted through a 2 mm sieve after being crushed in a glass sieve. An analytical sample was selected from the shredded average sample, and stored in labeled containers, to be used for further analysis.

Table 1. Scheme for field experiments*

I replication		**II replication**		**III replication**	
Conventional tillage 20-22 cm, (control)	Disking (10-12 cm)	Conventional tillage 20-22 cm, (control)	Disking (10-12 cm)	Conventional tillage 20-22 cm, (control)	Disking (10-12 cm)

*Composed by the authors.

To measure pH and electrical conductivity in soil samples, and to determine the amount of dissolved salts, a pH meter and an EC meter were used.

Also, humus content, mechanical composition, and easily hydrolyzable N content were determined by Turin and M. Kononova's method, the content of mobile by Machigin›s method, and the content of K by Maslova's method (Hayrapetyan, 2000; Farisyan, et al., 2020).

Results and discussions

It is evident from field studies, monitoring, and conversations with farmers that the majority of arable land in the settlement has been unused for a long time, resulting in some of it being trampled and turned into degraded, unstructured, and nutrient-deficient soils, especially adjacent areas.

The lack of irrigation water in the settlement makes it impossible to cultivate, which results in low profitability for agricultural holdings. The development of degradation in the area and the insufficient agrophysical and agrochemical properties of the land have also been contributed by the position and degree of slope. This has been contributed by surface flows, lack of flow buffer layers, non-use of soil protection sowing methods, constant operating winds, and of course traditional cultivation methods (Avagyan, et al., 2020).

Results of soil chemical analysis of the experimental area. Data on soil mechanical composition and humus content are given in Table 2. The taken soil samples were characterized as soils with a heavy clay-sand mechanical composition (the amount of physical clay was 47.9-56.1%) (Table 2).

However, in the disking version, the amount of physical clay is higher (by 2.4-7.1 %) compared to the control (up 20-22 cm), which is due to shallow cultivation, when the soil layer is turned over and does not mix with the lower layers, as well as the soil with a greater amount of plant residue on the surface. In the disking version, compared to the control (height 20-22 cm), there is an increase in the number of water-resistant aggregates by about 2.4-9.2 %.

The soil samples taken were characterized by medium (0-20 cm) humus availability, on which disking tillage, according to 2 years' data, did not have a significant impact (Table 2).

Figure presents the results of the soil water extract analysis. According to the sampling depths in the two experimental years, the soil samples analysed according to the cultivation methods have a similar pH, which is within the limits of neutral, and the amount of dissolved salts is low.

A comparison of the research results shows that disking as a shallow tillage method did not have a significant effect on soil pH, electrical conductivity, and the amount of dissolved salts (Figure). Data on macronutrient content in soil samples are given in Table 3.

Table 2. Humus content and mechanical composition of the investigated soil samples, 2022-2023*

Variants for field experiments	Depth, cm	Humus content, %		Physical clay content < 0.01mm, %		Water-resistant aggregates content > 0.25 mm, %	
		2022	2023	2022	2023	2022	2023
Conventional tillage 20-22 cm, (control)	0-10	4.06	4.06	48.2	47.9	44.1	43.9
	10-20	4.00	4.01	49.1	49.0	44.8	44.7
Disking (10-12 cm)	0-10	4.05	4.10	51.4	50.3	46.6	47.4
	10-20	4.03	4.11	55.9	56.1	51.3	53.9

*Composed by the authors.

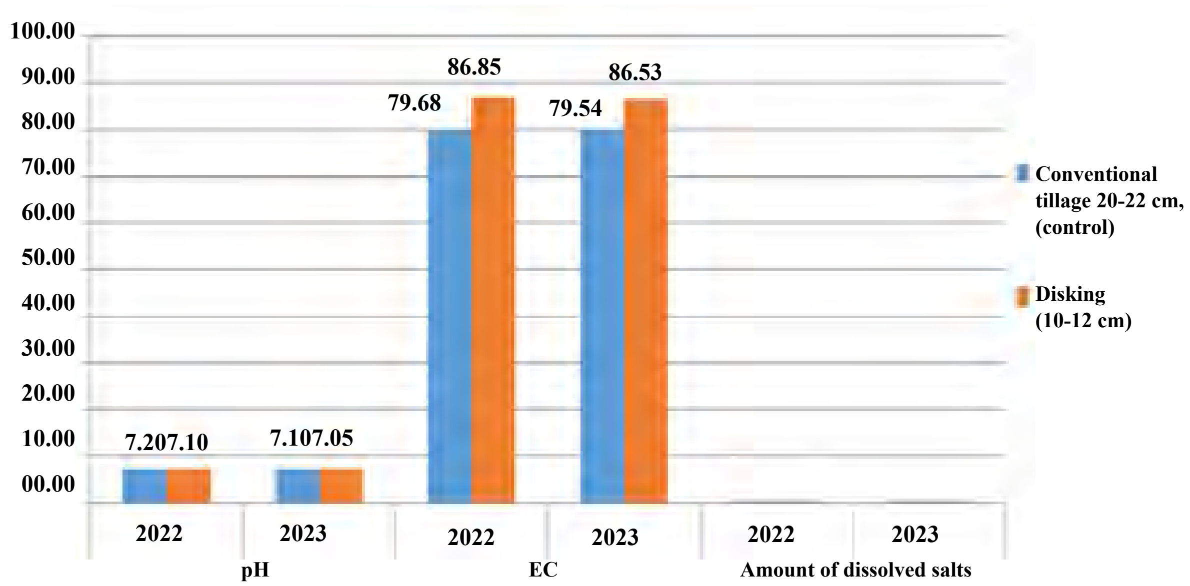

Figure. Results of the analysis of soil water extract.

Table 3. The results of mobile nutrients in soil samples (mg/100g of soil) according to the depth of the soil layer, 2022-2023*

Variants for field experiments	Depth, cm	*N*		*P₂O₅*		*K₂O*	
		2022	2023	2022	2023	2022	2023
Conventional tillage 20-22 cm, (control)	0-20	5.57	5.64	2.01	2.00	31.37	31.40
	20-40	4.18	4.00	2.00	1.98	28.55	28.63
Content according to norms, RA		Medium		Low		Medium	
Disking (10-12 cm)	0-20	5.71	6.08	2.72	3.81	36.78	42.51
	20-40	4.47	4.98	1.99	2.76	31.08	35.18
Content according to norms, RA		Medium and high		Low and medium		High and medium	

*Composed by the authors.

According to the norms adopted in RA, N is medium, K is medium, and P is low in soil samples from the control variant. In the case of disking, soil samples are provided with medium and high N, high and medium K, and low and medium with P.

There was a relatively higher accumulation of macronutrients in the root layers of the soil due to disking technology, shallow soil cultivation, and the presence of plant residues (Table 3).

Conclusion

Initial results from field and laboratory studies prove that the use of traditional cultivation technology in the arable land of the administrative area of Yernjatap settlement causes many negative phenomena: degradation of soil structural features, acceleration of the decomposition of organic matter and humus, destruction and dusting of the arable layer structure, loss of moisture and nitrogen, etc. Meanwhile, under shallow tillage, agrophysical and agrochemical characteristics become favorable for the growth and development of field crops. This leads to the formation of a possible high yield.

Therefore, the modern agricultural system should focus not only on obtaining a properly planned harvest, but also on ensuring a balance between humus and mineral nutrients in the soil, environmental protection, and neutral soil degradation.

References

1. Adam, B, Abdulai, A. (2023). Minimum tillage as climate-smart agriculture practice and its impact on food and nutrition security. PLoS ONE, 18(12). e0287441. https://doi.org/10.1371/journal. pone.0287441.
2. Avagyan, M., Markosyan, A. (2020). Features of degradation of mountain black soils under modern land use conditions. Gavar State University Collection of Scientific Articles 8, 60-66 (in Armenian).
3. Farisyan, N.V., Yeritsyan, L.S. (2020). Soil analysis. Methodical manual for laboratory-practical training. Shushi. Shushi Technological University Foundation, 32 (in Armenian).
4. Hayrapetyan, E.M. (2000). Soil science, Yerevan, Astghik publication, 456.
5. Markosyan, A.O. (2015). Efficiency of the complex soil protection measures on eroded and erosion dangerous agrolandscapes of mountain-steppe belt of the Republic of Armenia. Abstract, ANAU, Yerevan, 46.
6. Markosyan, A.O., Baghdasaryan, S.K., Daveyan, S.H., Vahanyan S.S. (2023). Impact of human activity and climate change on farming culture. Shirak M. Nalbandyan State University Scientific Bulletin, 2, 88-97. http://dx.doi.org/10.54151/27382559-23.2pa-88.
7. Soil Atlas of the Republic of Armenia. (1990). Research Institute of Soil Science and Agrochemistry, Yerevan, 64.
8. Teodor, R., Petru, G., Ileana, B., Paula, I.M., Adrian, I.P., Doina, C., Doru, I. M. et.al. (2009). Implications of minimum tillage systems on sustainability of agricultural production and soil conservation. Journal of Food, Agriculture & Environment 7 (2), 335-338.
9. Yernjatap community development plan (2017-2021). (2017). 27.
10. Wang, Y., Li, Z., Han, B., Shi, Z., Ning, T., Jiang, X., Zheng, Y., Bai, M., Zhao, J. (2007). Effects of conservation tillage on soil microbial biomass and activity. Acta Ecol. Sin., 27, 3384–3390.

Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

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