Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2025, Vol. 9 (4), 454-474
https://doi.org/10.29329/ijiaar.2025.1375.13

Original article

Evaluation of Some Properties of Artvin/Yusufeli/Erenköy Soils and Farm Fertiliziers Used in the Region by Laboratory and Greenhouse Experiments

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Abstract

Sustainable crop production depends on proper soil management and nutrient supplementation. This study assessed the physical and chemical properties of soils in Erenköy village, Yusufeli district, Artvin province, characterized commonly used animal manures, and evaluated their effects on plant growth under controlled greenhouse conditions. Soil samples from 26 locations were analyzed for pH, electrical conductivity (EC), organic matter, lime content, macro- and micronutrients. Eight manure samples including fermented and unfermented cattle and goat manures were analyzed for pH, EC, organic matter, moisture, and nutrient composition. A greenhouse experiment was conducted with rye (*Secale cereale* L., Aslım-95) using a completely randomized design. Fermented cattle and goat manures were applied at 5% (w/w) to 200 g soil pots in triplicate, and plant growth, dry weight, and total nitrogen content were recorded after 21 days. Soils were slightly to moderately alkaline (average pH 8.11), very slightly saline (EC 0.38 dS m^{-1}), moderately calcareous, and exhibited very high organic matter. Mg, K, total nitrogen, and inorganic N (NH_4^+, NO_3^-) were high, Ca and P sufficient, and Na within normal range. Micronutrients Mn, Fe, and Cu were adequate, while Zn was elevated. Soil textures were mainly sandy loam and sandy clay loam. Manures were moderately alkaline, slightly to moderately saline, high in organic matter (40–84%), low in moisture (~4.5%), rich in K, Ca, and Mg, deficient in P, and elevated in Mn, Fe, Cu, and Zn. Application of fermented manures significantly increased plant nitrogen content and dry weight compared to control ($p<0.001$), with average dry weights of 1.66 g/pot (control), 1.51 g/pot (goat manure), and 1.61 g/pot (cattle manure). The results highlight the potential of fermented animal manures to enhance soil fertility and sustainable crop production in the region.

Keywords: Soil analysis, Plant analysis, Farmyard manure analysis, Soil fertility.

Received: 20 October 2025 * **Accepted:** 05 December 2025 * **DOI:** https://doi.org/10.29329/ijiaar.2025.1375.13

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INTRODUCTION

Although the beginning of agriculture is not known exactly, the stage in which cultivated plants began to be grown during the development period of humanity is the starting point of agriculture. This period corresponds to several thousand years before the birth of Jesus. Until the beginning of agriculture, people provided the food they needed entirely by hunting and continued their lives as nomads in the form of tribes. Over time, the settlement of people led to the formation of families, clans and villages, which led to the development of food supply skills, and these skills were called agriculture. According to mythology, King Augeas, who is known for his farm with 3000 oxen, did not clean the farm with a pile of manure for 30 years, and Odysseus left his father's house where he created a pile of manure for 20 years, and Hercules, whom he agreed to give 10% of the cattle at the end of the work, passed the Alpheus River through the farm and accumulated the manure in a field near the farm with water, and Odysseus' father used the manure that he kept for 20 years and on which his dog slept in the vineyard. The mention of manure shows that it was collected and stored in a certain way and leads to the understanding that farm manure was used in agriculture in the IX century BC. Xenophon, who lived between 434 and 355 B.C., observed that agricultural soils were destroyed due to the lack of knowledge of how to fertilize the field with farm manure, and that there was nothing better than farm manure. Between 372 and 287 B.C., the philosopher Theophrastus suggested that shallow (poor) soils should be fertilized regularly and rich soils should be fertilized with farm manure from time to time, and that bedding should be used on farms to protect urea and solid feces in animal feces and to increase the humus value of manure, and this situation continues to be valid today. In addition, this thinker stated that plants that require and consume high levels of nutrients require the same amount of water. The vegetable gardens and olive groves around Athens were fed by the city's sewage streams using a canal system. After the data obtained from this canal system, the sewage residues were sold to the farmers, and the farmers fertilized their olive groves and orchards with water containing dissolved farm manure (Tisdale and Nelson 1982).

The importance of applying plant nutrients to the soil at the appropriate time and dose in order to ensure effective crop production or to secure production is more understood today. Growers strive to prevent nutrient deficiencies as well as to implement cultural measures developed to catch the genetic limits of cultivated plants in terms of yield. Fertilizers, which have been used to increase plant yield and quality since the existence of agriculture, and the increase in food demands in proportion to the rapidly developing population, combined with the emerging global environmental problems, are an indication that effective and sustainable strategies are needed more than ever. The number of people in the world who have problems with adequate food supply has decreased from 18.6% in the 1990s to 11% in 2015 and beyond. This problem is becoming inextricable with the increasing socioeconomic imbalance between countries and global climate change. Due to its impact on economic and environmental variables, food security affects more than just the resources needed by rapidly growing populations. In addition, the use of mineral fertilization in agricultural applications has increased worldwide in recent years, despite the rapid decrease in arable land assets and the widespread environmental problems that arise as a result. Therefore, the development of sustainable yet cost-effective alternative measures has become increasingly necessary, and researchers have focused their attention on microbiology and fertilizer use to find new methods (El-Samnoudi, et al. 2019; Liu, et al. 2017; Ren., et al. 2019).

In our country, except for some regions, the use of chemical fertilizers is not applied intensively and consciously. In regions where fertilizer use is intense, it cannot make a healthy fertilization with the logic that the more products we use, the more products we get. Even under these conditions, fertilizer consumption in our country lags behind the consumption of many European countries (Eyüpoğlu, 2002). Today, waste composts with a wide C/N ratio, such as plant and animal product wastes, sewage sludge, farm fertilizers, wood shavings, bed straw and household wastes, are used as organic plant nutrients to improve the chemical, biological and physical properties of the soil in relation to the organic matter content of the soil (Debosz et al., 2002). Organic fertilizers are an important component of environmentally friendly/organic farming practices and can provide essential nutrients to plants and increase productivity. They can be applied alone or mixed with inorganic fertilizers (Berner et al., 2008; Zhang, 2016). Organic matter plays an active role in agricultural production in many ways with its ability to improve the physical properties of soils, the plant nutrients it contains (chemical properties) and soil micro-organisms (soil biological properties) and its ability to improve soil properties (Yetkin 2010). In addition, it acts as a repository and creates a source for plant nutrients, especially nitrogen, phosphorus and sulfur, which are released as a result of the decomposition of organic matter through microorganisms and the enzymes they secrete and contain the chemical properties of the soil (Tamer and Namlı 2018; Ergene 1995). While the organic matter content is around 1-2% in the part of the agricultural land corresponding to about half of the agricultural land in our country; Our soils, which are at the ideal level and contain more organic matter, are 6% (Taban et al. 2013). Considering the nutrient content of the agricultural lands in our country, the amount of nitrogen is also scarce at the same rate, which is directly related to the organic matter scarcity of the soils at a level of more than 75% of the soils. Although soils are rich in phosphorus, due to the fact that phosphorus is immobile in the soil and forms insoluble compounds with cations in the soil solution, phosphorus useful for plants is almost non-existent in 75%, while it is abundant in 14% and in 80%, potassium suitable for plants is high or very high, and in 1.3% it is scarce (Yetgin 2010).

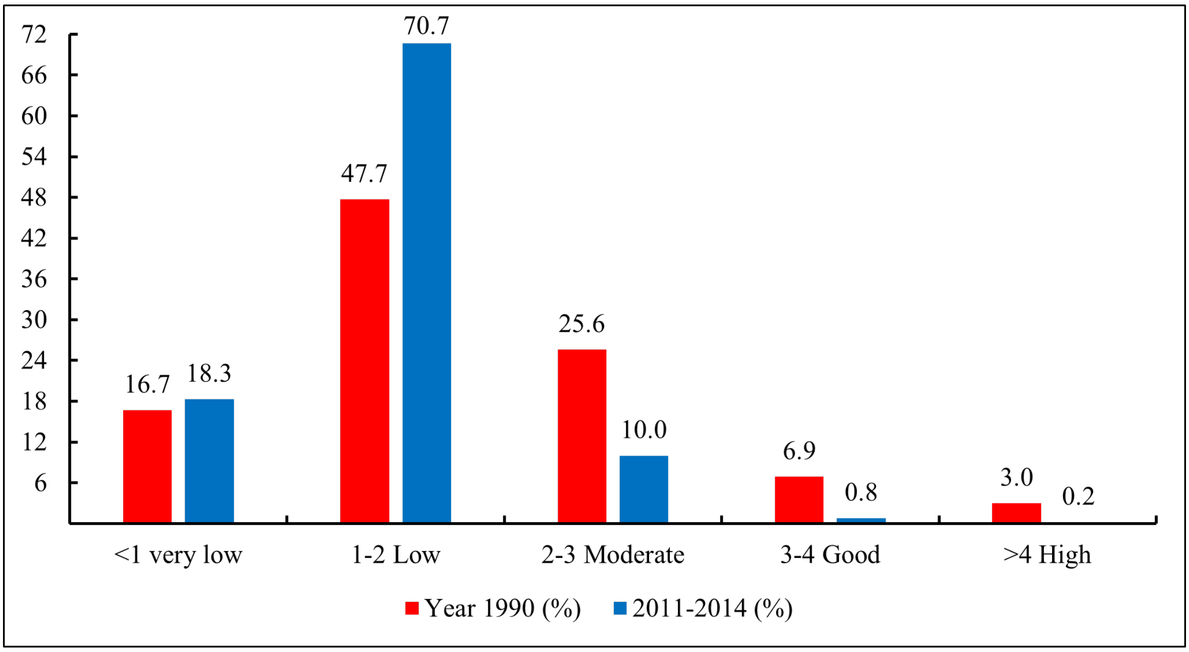

Figure 1. Organic Matter Amounts of Turkish Soils (Gezgin., 2018).

When we look at the distribution of organic matter in the soils of our country, 79.1% of the soils of the Black Sea region and the soils of the Southeastern Anatolia region are below 3%. The organic matter contents of the soils of the other region are located between the two regions mentioned (Gezgin 2018; Fig.1). Important fertilizers that are the source of plant nutrition; farm manure, green manures, urban waste fertilizers, composts, other organic fertilizers, meat combination wastes, guanas, commercial organic fertilizers (Yetgin 2010). Aşık and Katkat (2018) expressed their views on the effects of organic matter on soil properties as "the main sources of organic matter are the wastes of cattle, sheep and poultry". Farm manure, animals; It includes urine, solid feces, bedding materials, and is abundant as a by-product in livestock facilities. Average in farm manure; It contains 75% water, 17% organic matter, 6% inorganic matter (Yetgin 2010). Since the organic materials used are the main source of many plant nutrients, the interest in the use of organic materials in agricultural production has increased in recent years. Although the presence of plant nutrients varies according to different organic substances, soil organic matter provides 90-99% of total soil nitrogen, 33-37% of soil phosphorus and 70-80% of sulfur in soils if artificial fertilizers are not added from outside. In addition; Soil organic matter also contains other different plant nutrients such as potassium, manganese, boron, copper, zinc, molybdenum. Plant nutrients in organic matter become available to plants gradually depending on the rate of decomposition and decomposition of organic matter, and these nutrients can be taken by plants in a process covering 3-5 years (Sağlam, 2012). In this study conducted by Bayu et al. (2006), 4 doses of farm manure (THA-1) and 3 doses of inorganic fertilizer were applied to sorghum plants in 3 repetitions according to the random full blocks trial design in a semi-arid region for 6 years, and their effect on plant growth and quality and soil chemical properties was investigated. According to the findings, the application of farm manure and inorganic fertilizer plays an important role in plant development and yield. They determined that the application of farm manure and inorganic fertilizer combinations increased dry matter production and grain yield after flowering, while farm manure application increased grain protein yield, grain protein concentration and total nitrogen (N) uptake. Beşirli et al. (2010) investigated the effect of common vetch green manure on the physical and chemical structure of the soil and its effect on nutrient content by applying seaweed extract, bioenzyme, farm manure, chicken manure, sheep manure and commercial fertilizer according to the coincidence blocks trial design in Yalova. According to the findings, the effect of soil saturation with water was sheep manure, cattle manure, NPK and chicken manure applications from large to small, respectively, and it was determined that farm manures increased the P_2O_5 and K_2O contents of the soils. Yıldız et al. (2012) conducted a study on the grain yield of two types of bread wheat as East 88 and Kirik of mineral NP, Bio, Bio SR, leonardite, organic fertilizer and farm manure and non-chemical weed control between 2006-09 according to the coincidence blocks pattern. According to the findings, the highest grain yield was obtained from the application of mineral NP. Farm manure provided the highest grain yield among organic fertilizers, followed by organic fertilizer. They determined that farm manure can be used in dry conditions to increase soil fertility and grain yield of wheat. Mordoğan et al. (2013) applied 0, 75, 150 and 225 kg of farm manure per tree and investigated the effect on the nutrient content of the olive plant grown in sandy-loamy soils. According to the findings, they determined that the Fe and Zn contents were not affected and significantly affected the content of other macro and micronutrient elements. Aksu (2017) experimented with coincidence blocks at Adnan Menderes University Faculty of Agriculture Research and Application farm in 2014.

MATERIALS and METHODS

In the study, 4 fermented and 2 unfermented cattle manure, 1 fermented bovine-ovine manure and 1 fermented ovine manure were used. While planning this research study, our first objective was to ensure the fermentation of the farm manures in question together with the fertilizer owners under farm conditions and to investigate the effect of the compost fertilizer to be obtained on plant growth. On this occasion, it is to lead the farm owners to use their existing fertilizers by composting. However, due to the covid19 epidemic, the pandemic process, limited communications and, more importantly, travel restrictions to Yusufeli/Erenköy, unfortunately, this project could not be realized due to intercity travel in farm and field conditions. In order to investigate whether the sampled farm manures will have an effect on soil properties by only drying and grinding them in conditions where they are not composted in their current state, a greenhouse pot trial, which is a macrobiological method, was established and its effect on plant growth was examined. Of course, if the possibilities allow, in the future, with a different research study, the farm fertilizers in question will be projected for compost fertilizer production, suggestions will be made to the farmers in this sense and a vision will be gained with model compost mechanisms. Yusufeli district is located in the southwest of Artvin city center. Erenköy, with its vineyards, hamlets, plateaus and mountains, is located on an extremely rugged terrain with a very scattered and wide geography (Fig.1). Within the boundaries of the village, there are many landforms such as mountains, hills, streams, forests, plateaus, hamlets and vineyards. (İşçioğlu, 2019; Anonim 2020).

Fig.1 General view of the study area (Erenköy Village) The location information of the sampling points was determined by the GPS Global Positioning System system (Table 1 and Figure 2).

Table 2. Soil sampling points and some their characteristics.

Soil Samples	Latitude	Longitude	Altitude	Sampling Place
1	40°53’59.70” N	41°50’40.13” E	1.455 m	Cami Locality
2	40°54’00.19” N	41°50’41.27” E	1.457 m	Cami Locality
3	40°53’59.77” N	41°50’41.06” E	1.458 m	Cami Locality
4	40°53’50.54” N	41°50’33.74” E	1.481 m	Kıvrakgil Locality
5	40°53’59.68” N	41°50’40.81” E	1.458 m	Cami Locality
6	40°54’03.35” N	41°50’43.27” E	1.456 m	Cami Locality
7	40°54’00.62” N	41°50’41.46” E	1.456 m	Cami Locality
8	40°54’00.64” N	41°50’43.8” E	1.466 m	Cami Locality
9	40°54’00.81” N	41°50’40.85” E	1.454 m	Cami Locality
10	40°53’48.82 N	41°5024.11” E	1.497 m	Hacıgil Locality
11	40°53’50.34” N	41°50’24.37 E	1.495 m	Hacıgil Locality
12	40°53’93” N	41°49’53.68” E	1.759 m	Plateau
13	40°53’29.11” N	41°48’07.01” E	1.512 m	Hamlet
14	40°53’ 57.18” N	41°50’40.25” E	1.467 m	Kahramangil Locality
15	40°53’59.59” N	41°50’33.78” E	1.449 m	Orta Locality.
16	40°53’45.95” N	41°50’32.26” E	1.511 m	Kıvrakgil Locality
17	40°54’03.44” N	41°50’42.88” E	1.454 m	Cami Locality.00
18	40°53’05.47” N	41°49’50.86” E	1.778 m	Plateau
19	40°53’59.75” N	41°50’30.44” E	1.4577 m	Orta Locality
20	40°52’45” N	41°49’53” E	1.847 m	Plateau
21	40°53’67.63” N	41°50’39.15” E	1.461 m	Kahramangil Locality
22	40°53’50.50” N	41°50’24.01” E	1.497 m	Hacıgilin Locality
23	40°53’22.27” N	41°50’02.76” E	1.673 m	Plateau
24	40°53’49.95” N	41°50’32.12” E	1.483 m	Kıvrakgil Locality
25	40°53’59.06” N	41°50’30.60” E	1.457 m	Orta Locality
26	40°53’29.05” N	41°48’06.44” E	1.508 m	Hamlet

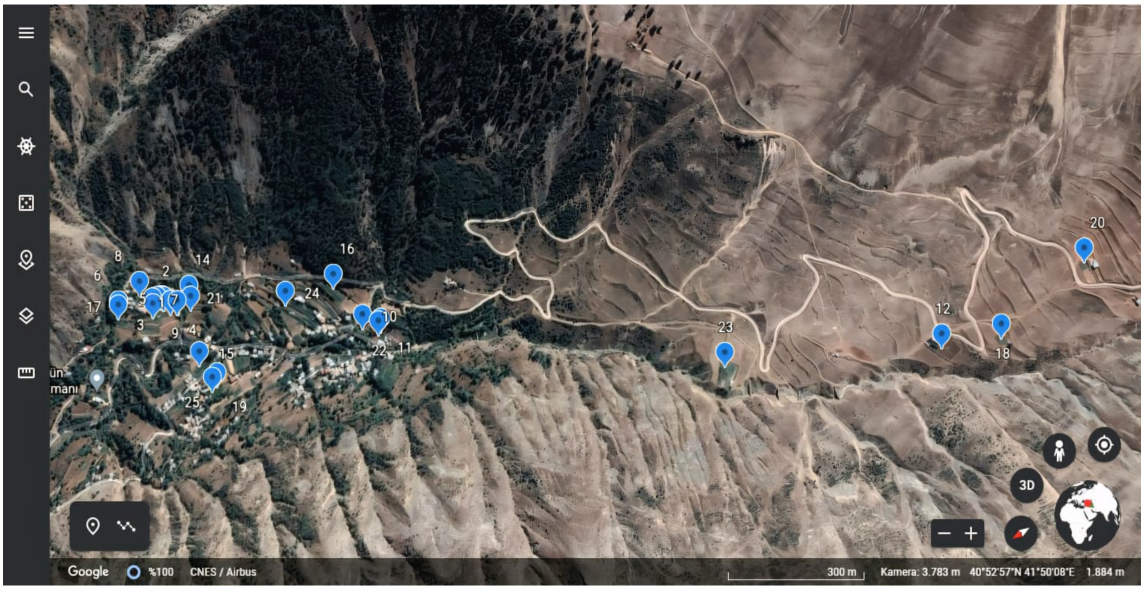

Figure 2. Soil sampling points from satellite image

In the study, 4 fermented and 2 unfermented cattle manure, 1 fermented bovine and ovine manure mixture and 1 fermented ovine manure were used. Fertilizer samples taken from at least 30 places from different depths of the fermented (burnt) manure pile for an average of one year in storage areas that are not exposed to sunlight and rain water, well ventilated, under constant temperature and with sufficient humidity level were collected and mixed on a hard and clean surface. A sample of 1 kg was taken from the mixture obtained and stored in plastic containers. For soil and fertilizer samples and plant samples obtained as a result of greenhouse trials, drying, grinding, screening and burning processes were carried out sequentially (Kacar and İnal, 2010). In the greenhouse-pot trial (Fig. 3), Aslım-95 variety of rye plant was grown for 21 days with 200 g of soil 1 control, 1 ovine manure, 1 cattle manure application with 5% fertilizer application on a weight basis. At the end of the experiment, its effects on plant growth and nutrition were determined by both morphological observations and post-harvest mineral content (total N) analysis. After 21 days, the rye plants, which were separated from the soil by washing with high-pressure water (Figure 3), were dried and ground in a drying cabinet set at 70 °C for at least 48 hours until they reached a constant weight (Kacar and İnal, 2010).

Figure 3. In the potted experiment, rye plants are washed out of the soil.

Texture analysis of soil samples: Determined according to the Bouyoucos (1951) hydrometer method and the texture class according to the Soil Survey Manual (1951); pH and EC: pH with glass electrodes in a soil-water (1:2.5) mixture and lime with EC meter: determined by Scheibler calcimeter (Nelson, 1982); Organic matter (OM): By the Walkley-Black method (Walkley and Black, 1934), according to the method of P: Olsen et al. (1954), which is available for the plant, total N (Bremner 1965) and available NH_4 and NO_3 (Bremner And Mulvaney 1982) the cations that are extracted with changeable K, Ca, Mg: 1.0 ammonium acetate and passed into solution were determined by potassium AAS (Kacar, 2012). Plant available Fe, Zn, Mn and Cu: Soil samples were determined in AAS after being extracted with a solution containing DTPA + $CaCl_2$ + TEA (pH = 7.3) (Lindsay and Norvell 1969). The results were compared and interpreted with the standard values used in the evaluation of soil analyses (Alparslan et al, 1998; FAO 1990; Tovep 1991). The data obtained as a result of soil and plant analysis were determined by correlation analysis in the SPSS-16 package program. Correlation analysis was performed between the nutrient content of plant leaf samples and soil properties, and statistically significant values were interpreted according to Düzgüneş et al. (1987).

Data was processed using SAS volume 25. ANOVA was performed to assess treatment effects, with mean comparisons conducted using the Least Significant Difference (LSD) test. Soil, manure, and plant results were interpreted using established critical concentration values from literature.

RESULTS and DISCUSSION

Soil analysis results were compared with reference values (Lindsay and Norwell 1969; FAO 1990; Tovep 1991; Sun et al. 1998) and the texture, pH, lime content, electrical conductivity (EC), organic matter content, useful phosphorus and changeable calcium, magnesium, potassium, useful micronutrient elements Mn, Zn, Fe and Cu, KDK and total nitrogen classes of the soils of the region subject to the study were determined. Texture class of soil samples; According to the data in Table 2, 13 of the soil samples are sandy-clayey-loam, 12 are sandy-loam and 1 is loamy texture. The proportional distribution of the texture classes of the soil samples is 3.85% loam, 50% sandy-clayey-loam and 46.15% sandy-loam.

Table 2. Texture analysis results, texture classes and moisture contents and soil samples,

Soil Samples	Clay (%)	Silt (%)	Sand (%)	Class	Moisture content (%)
1	19.13	26.86	54.01	Sandy Clay-Loam	3.31
2	19.19	25.01	55.80	Sandy Loam	3.95
3	19.40	22.31	58.29	Sandy Loam	3.09
4	12.75	18.60	68.66	Sandy Loam	3.31
5	20.06	25.99	53.95	Sandy Clay-Loam	3.31
6	25.12	18.07	56.80	Sandy Clay-Loam	2.46
7	19.03	28.93	52.04	Sandy Loam	3.09
8	21.17	18.21	60.62	Sandy Clay-Loam	2.88
9	19.05	20.33	60.62	Sandy Loam	2.88
10	21.04	20.39	58.57	Sandy Clay-Loam	2.25
11	17.14	40.47	42.39	Loamy	2.25
12	27.14	22.84	50.02	Sandy Clay-Loam	3.52
13	15.19	22.42	62.40	Sandy Loam	3.31
14	25.53	26.93	47.53	Sandy Clay-Loam	2.88
15	19.08	24.52	56.41	Sandy Loam	2.67
16	17.24	18.40	64.36	Sandy Loam	2.88
17	19.32	26.82	53.86	Sandy Loam	2.67
18	30.14	21.66	48.19	Sandy Clay-Loam	2.67
19	11.01	36.79	52.20	Sandy Loam	2.88
20	11.09	26.49	62.41	Sandy Loam	3.09

As can be seen from the examination of Table 3; The average pH value of the soil samples is moderately alkaline with a pH of 8.11. In other words, the pH levels of the soil samples are 15% mildly alkaline and 84% moderately alkaline. The electrical conductivity (salt content) of the soils is 0.20-0.54 dSm^{-1}, 11 of which are slightly saline and 15 of which are moderately saline, with an average level of 0.38 medium saline. The proportional distribution of salt content of soils is 42% lightly saline and 57% moderately saline. Soil samples have a lime content of 0.38-12.81, of which 2 are slightly calcareous, 17 are medium calcareous and 7 are calcareous. The average lime content of the soil samples was 7.31 and medium calcareous. Organic matter contents of soil samples; It has an organic matter content between 3.41-12.91%, 2 of which are low, 4 of which are high, 19 of which are very much and 1 of which is sufficient, and the average organic matter content of the soils is 5%. The contents of the CRA are between 10.30-23.75 cmol kg-1, 13 of them are between 15.02-22.25 cmol kg-1, 12 of them are between 14.38-23.75 cmol kg-1 and 1 of them is 15.50 cmol kg^{-1}.

Table 3. Results and evaluation of chemical analysis of soil samples.

Soil Samples	pH	Comment	EC dSm^{-1}	Comment	Lime (%)	Comment	Organic Matter	Comment	CEC cmol kg^{-1}
1	7.77	Slightly alkaline	0.43	Very low salt	3.87	Limy	5.00	Very high	18.33
2	7.78	Slightly alkaline	0.52	Very low salt	4.06	Limy	6.07	Very high	17.22
3	7.92	Moderate alkaline	0.46	Very low salt	12.11	Moderate	5.74	Very high	16.77
4	7.78	Slightly alkaline	0.31	Very low salt	7.86	Moderate	4.61	Very high	16.85
5	7.88	Slightly alkaline	0.44	Very low salt	11.73	Moderate	5.94	Very high	15.02
6	7.96	Moderate alkaline	0.54	Very low salt	9.00	Moderate	5.54	Very high	19.93
7	8.14	Moderate alkaline	0.40	Very low salt	12.49	Moderate	5.11	Very high	15.55
8	8.19	Moderate alkaline	0.38	Very low salt	10.53	Moderate	4.78	Very high	16.87
9	8.13	Moderate alkaline	0.44	Very low salt	11.54	Moderate	5.18	Very high	19.23
10	8.18	Moderate alkaline	0.29	Very low salt	10.02	Moderate	3.41	High	15.27
11	8.23	Moderate alkaline	0.30	Very low salt	8.94	Moderate	3.75	High	15.50
12	8.16	Moderate alkaline	0.32	Very low salt	3.93	Limy	4.67	Very high	15.36
13	8.09	Moderate alkaline	0.45	Very low salt	7.10	Moderate	5.67	Very high	20.10
14	8.25	Moderate alkaline	0.20	Very low salt	3.42	Limy	1.91	Low	15.01
15	8.14	Moderate alkaline	0.32	Very low salt	12.18	Moderate	3.96	High	14.38
16	8.16	Moderate alkaline	0.20	Very low salt	7.80	Moderate	1.37	Low	10.30
17	8.06	Moderate alkaline	0.41	Very low salt	0.38	Low	12.91	Very high	16.19
18	7.93	Moderate alkaline	0.49	Very low salt	3.68	Limy	5.81	Very high	16.75
19	8.22	Moderate alkaline	0.32	Very low salt	12.81	Moderate	3.97	High	14.17
20	8.10	Moderate alkaline	0.39	Very low salt	5.07	Moderate	5.53	Very high	23.75
21	8.20	Moderate alkaline	0.31	Very low salt	4.38	Limy	5.07	Very high	18.07

Total N and inorganic nitrogen (NH_4 and NO_3) from the macro element contents of the soil samples were determined by the Kjeldal method, P molybdophosphoric blue color method, and the results are given in Table 4. Of the 26 soil samples, 1 is too little, 1 is too little, 5 is sufficient, 10 is too much, and 9 is too much. The average total N content of soil samples is at the level of 0.26 and above and is between 0.01-0.50. 3.85% of the soil samples contain very little, 3.85% less, 19.23% sufficient, 38.46% excess and 34.62% too much nitrogen. Inorganic nitrogen levels range from NH_4 7 to 98.7 mgkg-1 and average to 63.40 mgkg-1 or more. NO_3 ranges from 52.50 to 1.306 mgkg-1 and is at an average level of 259.64 mgkg-1 and more. Phosphorus contents of soil samples useful for the plant; It varies in the range of 9.76-38.21 mgkg-1, 14 of which contain excess and 12 contain sufficient phosphorus. The average soil samples were 24.50 mgkg-1 and contained sufficient phosphorus.

Table 4. Macro Element Analysis Results and Evaluation of Soil Samples.

Soil samples	N (%)	NH_4 (mgkg^{-1})	NO_3 (mgkg^{-1})	Comment	P (mgkg^{-1})	Comment	P (kgda^{-1})	Comment
1	0.01	7.00	124.60	Very low	28.46	High	12.43	Sufficient
2	0.14	63.70	172.20	Sufficient	19.51	Sufficient	8.52	Sufficient
3	0.09	48.30	151.20	Low	33.74	High	14.73	Sufficient
4	0.18	92.40	488.60	High	9.76	Sufficient	4.26	Low
5	0.25	82.60	541.80	High	19.92	Sufficient	8.70	Sufficient
6	0.28	93.10	508.20	High	30.08	High	13.14	Sufficient
7	0.25	95.20	626.50	High	37.81	High	16.51	Sufficient
8	0.11	69.30	165.90	Sufficient	38.21	High	16.69	Sufficient
9	0.16	72.10	329.00	Sufficient	26.83	High	11.72	Sufficient
10	0.23	86.80	476.00	High	25.21	High	11.01	Sufficient
11	0.18	90.30	662.20	High	21.55	Sufficient	9.41	Sufficient
12	0.21	95.90	508.90	High	29.27	High	12.78	Sufficient
13	0.16	75.60	360.50	Sufficient	27.64	High	12.07	Sufficient
14	0.18	89.60	532.00	High	21.14	Sufficient	9.23	Sufficient
15	0.28	86.10	683.20	High	30.90	High	13.49	Sufficient
16	0.46	100.10	755.30	Very high	13.42	Sufficient	5.86	Low
17	0.12	62.30	286.30	Sufficient	28.46	High	12.43	Sufficient
18	0.42	98.70	758.80	Very high	16.67	Sufficient	7.28	Low
19	0.32	85.40	507.50	High	15.04	Sufficient	6.57	Low
20	0.36	100.80	803.60	Very high	28.05	High	12.25	Sufficient
21	0.39	104.30	762.30	Very high	30.90	High	13.49	Sufficient
22	0.35	105.70	774.20	Very high	13.01	Sufficient	5.68	Low
23	0.33	105.00	1306.20	Very high	22.36	Sufficient	9.76	Sufficient
24	0.44	100.80	786.80	Very high	19.51	Sufficient	8.52	Sufficient
25	0.36	102.20	760.20	Very high	26.42	High	11.54	Sufficient
26	0.50	91.70	774.90	Very high	23.17	Sufficient	10.12	Sufficient
Mean	0.26	84.81	561.80	High	24.50	Sufficient	10.70	Sufficient

When these values expressed as %, 53.86% of them contain excess and 46.15% contain sufficient phosphorus. Useful phosphorus is between 5.68 and 16.1 kgda-1, and 5 of the 26 soil samples are low and the rest are sufficient. When we look at the average of the soils of the region, extractable phosphorus is sufficient at the level of 10.70 mgkg-1. Of the variable cation contents of the soil samples, potassium (K) is between 0.61-5.40 cmolkg-1 and 1 (sample 26) is sufficient, 13 is high and 12 contains too much potassium. The average of soil samples is 2.7 cmolkg-1 and contains a lot of potassium. The proportional distribution of changeable potassium in soil samples was 3.85% sufficient, 50% excess and 46.15% very high. Calcium (Ca) in soil samples is between 8.78-22.28 cmolkg-1 and 6 of them contain excess and 20 of them contain sufficient calcium in the total number of samples. The average of the soil samples was 14.44 cmolkg-1 and contained sufficient levels of calcium. The variable (Mg) of soils is between 32.84-62.13 cmolkg-1 and the average is 62.49 cmolkg-1 and very high. The Mg content of soil samples is very high at the level of 100%. The sodium (Na) content of the soil samples is between 0.42-1.39 cmolkg-1 and the average is 7.81 normal. Considering its proportional share in the KDK, it is at a level that will not be a problem (Yıldız, 2012). The levels of micronutrients useful for the plant in the soil samples are given in Table 5. As can be seen from the examination of the chart; The microelement contents of the soil samples are between manganese (Mn) 8.56-26.35 mgkg-1 and an average of 17.49 mgkg-1 is sufficient, iron (Fe) is between 0.18-4.02 mgkg-1 and an average of 3.29 mgkg-1 is sufficient, copper (Cu) is between 2.32-9.90 mgkg-1 and an average of 2.25 mgkg-1 and zinc (Zn) is between 2.18-5.47 mgkg-1 and an average of 4.14 mgkg-1 is excessive. 5 of the Mn contents of the soil samples are low and the remaining samples are sufficient. 3 of the Zn contents are sufficient and the remaining samples are excessive. 16 of the Fe contents are at a low level, the remaining 12 are moderate, and all of the Cu contents are sufficient. In the proportional distribution of microelement contents of soil samples, Mn contents are 19.23% low and 80.77% sufficient. Fe content is 57.69% low and 42.31% medium is sufficient. Cu contents are 100% sufficient and Zn contents are 11.54% sufficient and 88.46% more. Farm manure generally contains 70-80% water, 15-20% non-organic substances, 0.05-0.7% N, 0.2-0.3% phosphorus (P_2O_5) and 0.4-0.6% Potassium (K_2O). In addition to these, farm fertilizers contain nutrients such as calcium, magnesium, sulfur and small amounts of trace elements such as manganese, zinc, copper, iron, boron and molybdenum (Anonim 2021).

Table 5. Microelement analysis results and evaluation of soil samples.

Soil sample	Mn $mgkg^{-1}$	Comment	Zn $mgkg^{-1}$	Comment	Fe $mgkg^{-1}$	Comment	Cu $mgkg^{-1}$	Comment
1	16.11	Sufficient	3.92	High	3.26	Medium	9.00	Sufficient
2	16.63	Sufficient	2.61	High	2.12	Low	6.69	Sufficient
3	18.27	Sufficient	3.26	High	2.13	Low	7.91	Sufficient
4	17.17	Sufficient	2.18	Sufficient	1.75	Low	2.82	Sufficient
5	19.50	Sufficient	3.78	High	2.81	Medium	9.90	Sufficient
6	21.23	Sufficient	2.55	High	0.18	Low	7.30	Sufficient
7	19.30	Sufficient	2.91	High	2.98	Medium	8.08	Sufficient
8	26.35	Sufficient	4.52	High	3.07	Medium	8.80	Sufficient
9	23.83	Sufficient	3.59	High	3.17	Medium	9.21	Sufficient
10	17.58	Sufficient	3.21	High	2.46	Low	4.14	Sufficient
11	14.85	Sufficient	2.63	High	1.53	Low	2.32	Sufficient
12	19.38	Sufficient	2.96	High	1.66	Low	5.95	Sufficient
13	19.15	Sufficient	2.88	High	1.22	Low	4.07	Sufficient
14	14.71	Sufficient	3.11	High	2.43	Low	4.68	Sufficient
15	9.92	Low	3.14	High	2.70	Medium	2.90	Sufficient
16	8.56	Low	2.54	High	1.69	Low	0.66	Sufficient
17	13.21	Low	2.97	High	2.10	Low	4.41	Sufficient
18	21.35	Sufficient	5.47	High	1.52	Low	3.97	Sufficient
19	12.01	Low	3.99	High	2.73	Medium	4.37	Sufficient
20	20.89	Sufficient	4.75	High	1.55	Low	4.06	Sufficient
21	18.63	Sufficient	3.80	High	2.63	Medium	4.48	Sufficient
22	19.89	Sufficient	2.36	Sufficient	2.14	Low	4.04	Sufficient
23	14.29	Low	2.85	High	1.74	Low	2.78	Sufficient
24	17.34	Sufficient	2.37	Sufficient	3.42	Medium	4.56	Sufficient
25	15.65	Sufficient	3.99	High	4.02	Medium	9.05	Sufficient
26	18.97	Sufficient	3.13	High	1.57	Low	5.53	Sufficient
Mean	17.49	Sufficient	4.14	High	3.29	Medium	2.25	Sufficient

[1]*Refers to the fertilizer samples used in the pot experiment.

Table 6. Some chemical analysis, moisture analysis results and evaluation of animal manure (bovine and ovine) samples.

Fertilizer samples	Animal manure type	pH	Comment	EC (dSm^{-1})	Comment	Miosture content (%)	Organic matter (%)		
							Smith-Weldon	Weight Loss Basis	Comment
1	Bovine (Fermented)	8.32	Slightly alkaline	4.74	Salty	3.85	40.12	64.50	High
2	Bovine (Non-fermented)	8.26	Slightly alkaline	3.5	Slightly salty	4.17	43.19	63.50	High
3	Bovine-Ovine (Fermented)	8.41	Slightly alkaline	4.10	Salty	5.54	60.33	77.50	High
4	Bovine (Fermented)	8.3	Slightly alkaline	2.52	Slightly salty	4.55	68.82	60.75	High
5	Bovine (Fermented)	8.11	Slightly alkaline	2.45	Slightly salty	4.99	64.09	66.00	High
*6	Ovine (Fermented)	8.14	Slightly alkaline	1.88	Unsalty	4.22	70.22	83.75	High
7	Bovine (Non-fermente)	8.52	Strongly Alkaline	4.71	Salty	4.22	65.76	69.75	High
*8	Bovine (Fermented)	8.13	Slightly alkaline	4.58	Salty	4.55	56.42	71.00	High
Mean		8.27	Slightly alkaline	3.56	Slightly salty	4.51	58.62	69.59	High

[1]*Refers to the fertilizer samples used in the pot experiment.

Table 7. Macro element analysis results and evaluation in farm manure (bovine and ovine) samples (%).

Fertilizer samples	Animal manure type	P (%)	Comment	K (%)	Comment	Ca (%)	Comment	Na (%)	Comment	Mg (%)	Comment
1	Bovine (Fermented)	0.07	Insufficient	5.89	High	1.70	High	0.25	Insufficient	11.83	High
2	Bovine (Non-fermented)	0.33	Insufficient	8.03	High	2.83	High	0.38	Much	13.75	High
3	Bovine-Ovine (Fermented)	0.33	Insufficient	8.95	High	2.20	High	0.20	Insufficient	10.97	High
4	Bovine (Fermented)	0.22	Insufficient	11.69	High	2.92	High	0.29	Much	16.78	High
5	Bovine (Fermented)	0.28	Insufficient	11.66	High	2.44	High	0.37	Much	9.90	High
*6	Ovine (Fermented)	0.42	Insufficient	10.86	High	2.12	High	0.55	Much	9.86	High
7	Bovine (Non-fermente)	0.31	Insufficient	13.27	High	2.52	High	0.52	Much	11.27	High
*8	Bovine (Fermented)	0.13	Insufficient	11.03	High	1.96	High	0.25	Insufficient	9.72	High
Mean		0.26	Insufficient	10.17	High	2.34	High	0.35	Much	11.76	High

[1]*Refers to the fertilizer samples used in the pot experiment.

Table 8. Microelement analysis results and evaluation in farm manure (bovine and ovine) samples.

Fertilizer samples	Animal manure type	Mn ($mgkg^{-1}$)	Comment	Fe ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Comment	Zn ($mgkg^{-1}$)	Comment
1	Bovine (Fermented)	283.15	High	4759.80	31.21	High	150.82	High
2	Bovine (Non-fermented)	209.75	High	4747.50	27.84	High	166.32	High
3	Bovine-Ovine (Fermented)	258.76	High	2204.90	18.86	High	162.77	High
4	Bovine (Fermented)	553.88	High	5901.43	36.69	High	193.99	High
5	Bovine (Fermented)	194.52	Insufficient	4094.79	23.65	High	147.08	High
*6	Ovine (Fermented)	228.15	High	3008.22	19.72	High	177.85	High
7	Bovine (Non-fermente)	197.83	Insufficient	2163.40	32.43	High	110.76	High
*8	Bovine (Fermented)	191.04	Insufficient	2274.29	22.14	High	142.26	High
Mean		264.64	High	3644.69	26.57	High	156.48	High

[1]*Refers to the fertilizer samples used in the pot experiment

Table 9. Analysis results and evaluation of the effect of different fertilizer (bovine and ovine) applications on total nitrogen content of plants.

Plant sample	Control (%)	Comment	*Ovine manure plant N (%)	Comment	*Bovine manure plant N (%)	Comment
1	0.49	Insufficient	1.16	Insufficient	1.89	Insufficient
2	4.11	Sufficient	4.43	Sufficient	4.60	Sufficient
3	1.24	Insufficient	3.95	Insufficient	3.41	Insufficient
4	4.57	Sufficient	7.37	High	8.35	High
5	7.49	High	6.02	High	10.17	High
6	6.65	High	7.96	High	8.07	High
7	5.20	High	5.98	High	7.80	High
8	4.53	Sufficient	4.15	Sufficient	4.13	Sufficient
9	5.93	High	6.91	High	9.99	High
10	6.53	High	12.51	High	9.47	High
11	4.68	Sufficient	5.01	Sufficient	8.50	High
12	7.47	High	6.53	High	9.47	High
13	9.64	High	7.40	High	6.44	High
14	8.38	High	5.60	High	8.66	High
15	9.84	High	7.26	High	10.17	High
16	4.72	Sufficient	8.06	High	8.73	High
17	9.80	High	9.71	High	10.66	High
18	4.90	Sufficient	4.88	Sufficient	4.22	Sufficient
19	13.02	High	7.93	High	7.98	High
20	4.68	Sufficient	5.68	Sufficient	7.57	High
21	11.90	High	8.07	High	9.71	High
22	4.91	Sufficient	10.50	High	7.47	High
23	5.74	High	11.69	High	12.27	High
24	12.09	High	9.50	High	8.56	High
25	10.55	High	8.07	High	10.03	High
26	12.25	High	10.16	High	11.89	High
Mean	6.85	High	7.21	High	8.08	High

[1]*Refers to the fertilizer samples used in the pot trial.

Table 10. Average total plant biomass (toppiece + root) dry weight (g/pot).

Plant sample	*Control Plant Dry Weight (g/pot)	*Dry weight of plant with ovine manure applied (g/pot)	* Dry weight of plant with cattle manure applied (g/pot)
1	0.91	0.39	2.24
2	1.77	0.49	1.07
3	1.97	1.33	0.82
4	3.80	4.35	2.44
5	0.99	0.99	0.64
6	2.47	2.24	2.52
7	0.31	1.59	1.46
8	2.68	2.02	1.73
9	3.76	2.21	2.71
10	2.06	1.72	1.38
11	0.52	0.27	0.80
12	3.20	2.01	2.36
13	0.97	1.10	1.41
14	2.02	2.70	1.51
15	0.74	0.67	1.10
16	1.09	1.04	2.06
17	1.61	2.39	1.63
18	2.38	1.45	2.23
19	1.09	1.82	1.90
20	0.99	1.04	0.67
21	2.72	2.44	2.04
22	1.01	0.30	1.59
23	1.46	0.14	1.14
24	0.56	2.85	1.69
25	0.99	1.00	1.47
26	1.14	0.74	1.35
Mean	1.66	1.51	1.61

[1]*Refers to the fertilizer samples used in the pot trial.

CONCLUSION and RECOMMENDATIONS

In the productivity and sustainability study carried out in Erenköy village of Yusufeli district of Artvin province, the pH value of the soils of the region is slightly alkaline and the average is 8.11. The EC (salt) content is low, with an average of 0.38 dS^{-1}. The lime content is medium, with an average of 7.31. The organic matter content is very high and is at an average level of 5.00. Among the macroelements, the average Mg content is 62.49 $cmolkg^{-1}$, the K content is 0.31 cmol kg^{-1}, the total nitrogen and inorganic nitrogen (NH_4 and NO_3) contents are 0.50 on average, NH_4 is 91.70 $mgkg^{-1}$ and NO_3 is 774.90 $mgkg^{-1}$, respectively. The average Ca content is 14.44 cmol kg-1 and the P content is 24.50 mg kg-1 and is sufficient. The Na content is normal with an average of 0.67 $cmolkg^{-1}$. The Zn content of microelements is 4.14 $mgkg^{-1}$ on average, which is excessive. Mn, Fe and Cu contents are

17.49 $mgkg^{-1}$, 3.29 $mgkg^{-1}$ and 2.25 $mgkg^{-1}$, respectively, and are sufficient. The texture class was found to be sandy-clayey-loam. 3.85% of the soil samples are loamy, 50% are sandy-clayey-loam and 46.15% are sandy-loam. Since the texture contains 21% clay, 24% silt and 55% sand, it is in the sandy-clay-loam class. The pH content of the soil samples is 15% mildly alkaline and 84% moderately alkaline. The salt content of the soil samples is 42% slightly saline and 57% moderately saline. Of the lime contents of the soil samples, 7.69% were slightly calcareous, 26.92% were calcareous and 65.38% were medium calcareous. 4% of the organic matter content of the soil samples is sufficient, 8% is low, 15% is high and 73% is very high. The total nitrogen contents of the soil samples were 3.85% very low, 3.85% low, 19.23% sufficient, 38.46% excess and 34.62% too much nitrogen. 53.86% of the available phosphorus content of the soil samples is high and 46.15% is sufficient. 3.85% of the exchangeble potassium content of soil samples is sufficient, 50% is high and 46.15% is very high. 23.08% of the Ca content of the soil samples is high and 76.92% is sufficient. The Mg content of soil samples is very high at the level of 100%. The sodium (Na) content of the soil samples is between 0.42-1.39 $cmolkg^{-1}$ and is at a normal level. In the proportional distribution of plant available microelement contents of soil samples, Mn contents are 19.23% low and 80.77% sufficient. Fe contents are 57.69% low and 42.31% moderate/sufficient. Cu contents are 100% sufficient and Zn contents are 11.54% sufficient and 88.46% excessive. The fact that the salt content of the soils of the research region is at medium levels and the pH value is in the slightly alkaline class does not pose a problem in terms of agricultural production. However; Controlled irrigation and fertilization are required in order to bring the pH value to a neutral level and to keep the salt level under control. Lime forms compounds with low solubility by reducing the P activity in the soil and prevents microelements such as Fe, Cu, Mn, Zn from being retained in the soil and taken up by plants. At the same time, excess lime negatively affects the activity of microorganisms. For this reason, fermented fertilizer should be used in soils containing excess lime. Organic matter, the organic matter content of the local soils is at the level of 5% on average. This value is above the presence of organic matter in Turkish soils. The reason for this is that the farm manure is regularly applied to the soil every year in the study area, the cold climate of the region, the high number of snow-covered days, the low number of sunny days, the formation of impermeable layers as a result of surface tillage and the temperature decreases in soils under poor drainage conditions. It can also be attributed to a decrease in microbial activity and mineralization rate due to soil temperature drop. The soils of the research area are in the sandy-clayey-loam texture class. Depending on the type of clay, the type of irrigation, the frequency of irrigation and the depth of tillage, soils in this structure cause compaction in the soil, the formation of a cream layer on the surface and limit root development. In order to prevent the negative effects of the soil texture class, the soil should be plowed at a deeper level than the active release depth and the mature organic fertilizer should be mixed with the soil. The high K content in soil samples prevents the uptake of Mn, Zn and Fe contents, especially Ca, by plants. Excess Mg in soil samples forms one of the basic building blocks of chlorophyll and plays an important role in photosynthesis. It may adversely affect the uptake of possible other cations. Since excess N will cause toxicity, it causes watery texture and growth in plant tissues in agricultural production, leaves to form a dark green, thick and fragile structure, limitation of plant root development, overgrowth of the above-ground parts, as well as regression of fruit development. Excess N in the soil causes nitrite accumulation in plant tissue and damage to humans and animals that consume these plants.

Additional Declaration

Both authers decleared no confilect of interst.

Author Contributions

The theoretical framework of the study was created by the Nesrin YILDIZ, the data collection and analysis process was carried out by the both authors, the article was written jointly by both authors and the final version was approved together. The contribution rates are Pınar Başıbüyük (60%) and Nesrin YILDIZ (40%).

Funding

This thesis work was supported within the scope of Atatürk University Scientific Research Project (BAP) rapid support project. Project no; FHD-2021-9728 We would like to thank Atatürk University BAP coordinatorship.

Responsible Artificial Intelligence Statement

No artificial intelligence support was received in any part of this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest related to the publication of this study.

Ethics Approval

In all processes of this study, the principles of Pen Academic Publishing Research Ethics Policy were followed.

This study does not require ethics committee approval as it does not involve any direct application on human or animal subjects.

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